IJIRAE::International Journal of Innovative Research in Advanced Engineering ISSN:2349-2163
Volume 13, Issue 03, March 2026 https://www.ijirae.com/archives
https://doi.org/10.26562/ijirae.2026.v1303.04

An Experimental Investigation on Cassava peel as Partial Replacement of Cement in Concrete

Dr.Seenirajan.M
Head of the Department, Department of Civil Engineering,
Sengunthar Engineering College (Autonomous), Tiruchengode, India
mseenirajan.civil@scteng.co.in
https://orcid.org/0009-0008-6871-7442
Reyashree ML
PG Students, Department of Civil Engineering,
Sengunthar Engineering College, Tiruchengode, India

Publication History
Manuscript Reference No: IJIRAE/RS/Vol.13/Issue03/AEMR26.MRAE10083
Research Article | Open Access | Double-Blind Peer-Reviewed |Article ID:IJIRAE/RS/Vol.13/Issue03/AEMR26.MRAE10083
Received:22,February 2026, Revised: 01, March 2026, Accepted: 16,March 2026,Published Online: 25, March 2026.
https://www.ijirae.com/volumes/Vol13/iss-03/04.AEMR26.MRAE10083.pdf
Article Citation:Seenirajan,Reyashree(2026), An Experimental Investigation on Cassava peel Partial Replacement of Cement in Concrete, IJIRAE: International Journal of Innovative Research in Advanced Engineering, Volume 13, Issue 03 of 2026 pages 115-123 Doi:> https://doi.org/10.26562/ijirae.2026.v1303.04
BibTeX Key: Seenirajan@2026Experimental
IJIRAE papers should be cited as IJIRAE (International Journal of Innovative Research in Advanced Engineering, AM Publications, India 2025, ISSN 2349-2163, https://doi.org/10.26562/ijirae.2026.v1303.04The journal's official abbreviation is IJIRAE. Orcid: https://orcid.org/0009-0004-9398-7488

Abstract: The cement industry is one of the largest contributors to global carbon dioxide (CO□) emissions, accounting for nearly 8% of total anthropogenic greenhouse gases. With the growing emphasis on sustainability and carbon reduction, this study explores the potential of cassava peel ash (CPA) as a partial replacement for cement in concrete. Cassava peels, an abundant agricultural waste, can be thermally treated to produce apozzolanic ash suitable for use in construction. The research aims to assess the environmental performance of concrete incorporating CPA by conducting carbon footprint analysis using Life Cycle Assessment (LCA) methodology in Sima Pro software. The functional unit for the study is defined as 1 cubic meter of concrete, with a cradle-to-gate system boundary that includes raw material extraction, processing, transportation, and concrete production. Concrete mixes will be designed with varying proportions of CPA (e.g., 5%,10%, 15%) replacing ordinary Portland cement (OPC). Physical and chemical characterization of CPA will be carried out, and emission data from both laboratory experiments and LCA databases such as Eco invent will be modeled in SimaPro. The impact assessment method, such as Recipe or CML, will be used to quantify the global warming potential of each mix. The study will compare the carbon emissions of CPA-based concrete to that of conventional concrete, aiming to demonstrate the environmental benefits of incorporating CPA. Expected outcomes include significant reductions in CO□ emissions, validating CPA as a sustainable supplementary cementitious material. This work supports waste valorization, promotes circular economic practices, and contributes to the development to flow-carbon construction materials aligned with global climate goals.
Keywords: Concrete, Cassavapeels, Compressive Strength, Work ability etc.,

INTRODUCTION

Traditional concrete production is a major contributor to global carbon emissions, mainly due to the cement production process. Cement manufacturing involves burning limestone in kilns at 2,300° to 3,000° F (1,260° to 1,650° C), which requires a lot of energy and releases significant amounts of carbon dioxide (CO2). For every ton of Portland cement produced, approximately one tonofCO2 is emitted. Cement production accounts for about 7% of global carbon emissions. Concrete is responsible for 50-85% of the embodied carbon in building projects. Concrete is the most widely used construction material, but its production significantly contributes to carbon dioxide (CO□) emissions, primarily due to the manufacturing of cement. Portland Pozzolana Cement (PPC), which contains pozzolanic materials, offers a more sustainable alternative to Ordinary Portland Cement (OPC). However, further advancements are needed to enhance its sustainability by incorporating supplementary cementitious materials (SCMs) and innovative curing techniques. Nowadays, the greenhouse gases reduction is one of the biggest challenges for mankind. To face this problem, all the industrial sectors, responsible for the 25% global CO□, must be involved. This is particularly true for the cement industry, which produces about 7% of the carbon dioxide released in the atmosphere. To be more precise, 95% of this CO is due to the production process, where as the remaining 5% is related to the transportation of raw materials and cement-based composites. The CO2 emission from the concrete production is directly proportional to the cement content used in the concrete mix. On an average, the CO2 produced for the manufacture of structural concrete is estimated at 410 kg/m

MATERIALS CEMENT:

The experimental investigation utilized Grade53 Ordinary Portland cement, obtained from the open market for building materials. Portland cement is the most common type of cement in general usage. It is a basic ingredient of concrete, mortar and many plasters. It consists of a mixture of calcium silicates, aluminates and ferrites. Ordinary Portland cement of 53 grade of Ramco Cement. Test result is taken as it is as given by company. The cement shall be measured on the weight basis each bags weighing 50 kg which is equal to 35 liters in volume. All standard tests shall be carried out to ensure that the cement is of required quality shown

Fig. Cement

WATER

Water plays a crucial role as a component in the concrete mixture, influencing the mechanical, rheological, and durability properties. For The laboratory tests, we employed potable water that complies with the specifications outlined in ASTM C1602- 12 (2012) for concrete applications.

COARSE AGGREGATES

In this experimental study, we employed Manufacturing sand, as the fine aggregate. The fine aggregate can pass through a 2.36mm sieve. As for the coarse aggregate, crushed granite with well-graded properties and devoid of harmful substances. The coarse aggregate has a maximum size of 20 mm shown in Fig

Fig Coarse Aggregate

M SAND:

M-Sand is available alternative to natural river sand, offering consistent quality, texture, strength and durability. Grading must be uniform throughout the work and must pass through 4.75 mm sieve size which confirms to the code IS: 383-1970. Particles smaller than 0.125 mm are considered as fines which contribute to the powder content. Specific gravity of fine aggregate calculated and shown in fig.

Fig. M SAND

Cassavapeel ash (CPA)

The cassavapeel was subjected to sun drying. It was then incinerated in a controlled kiln at a temperature range of approximately 500°C to 850°C for 60 min to ensure environmental protection. The resulting burnt material was carefully gathered and sieved in the laboratory, using a 150 μm sieve size, to obtain finely divided ash material for the experiments. The picture of the cassava peel waste taken in the laboratory during the experiments along with the processed ash samples are shown in Fig

Fig Cassavapeel Ash

METHODOLOGY

PROCESSING OF CASSAVAPEEL ASH (CPA)

Drying: Cassavapeels are washed to remove dirt and then air-dried under the sun for several days.
Burning: The dried peels are burned in a furnace at 600°C for1hour to obtain fine ash
Grinding: The ash is ground using a ball mill to achieve a fine powder passing through a 150-micronsieve.
Chemical Analysis: The CPA is subjected to X-Ray Fluorescence (XRF) and X-Ray Diffraction (XRD) tests to determine its chemical composition (silica, alumina, calcium oxide, etc.).

Fig Cassavapeel Powder

Fig. Incinerator

Fig. Cassava peel ash

MIX PROPORTIONS

MIXPROPORTIONING- M30 OPC CONCRETE STIPULATIONS FOR PROPORTIONING:

Table Stipulations for Proportioning

Grade of Concrete	M30
Cement	OPC53
Exposure Condition	Severe
Workability	75cm
Maximum w/c ratio	0.45
Minimum cement content	320kg/m^3
Code for Mix Design	IS10262:2019 Concrete Mix Proportioning - Guidelines

TEST DATA FOR MATERIALS:-

Table Test data for Materials

Materials	Specific Gravity
Cement	3.15
Coarse Aggregate	2.74
Fine Aggregate	2.65

Table Sieve Analysis of Aggregate

FRESH PROPERTY TESTS:

The tests help assess fresh concrete properties, ensuring quality, ease of placement, concrete's workability and suitability for specific applications like
Slump Cone Test
Compaction Factor Test

SLUMP CONETEST (IS1199:1959)

The slump test measures the workability and consistency of fresh concrete by evaluating its deformation after removing a standard conical mould. A higher slump indicates higher workability, while a lower slump suggests a stiffer mix. Uses a standard conical mould (Abrams cone) with dimensions: base 200 mm, top100 mm, height300 mm. The results of the slump test on concrete are shown with varying percentage of CPA as replacement for cement. The results show that for all mixes, the slump type was 'true slump' except for mixes containing more than 15% CPA at 0.45 water-binder (w/b) ratios, where the mixtures were very viscous and stiff due to inadequacy of water. The slump decreases with increase in amount of CPA for the same water-binder ratio. This indicates that more water is required to maintain the same consistency as the CPA content increases. Cassava peelash has potential to absorb more water than ordinary Portland cement in the mix. The recent European standard states that the slump test is sensitive to changes in consistency corresponding to slumps between10 and 200 mm and the test is not considered suitable beyond these extremes. Slump and compaction factor values for cpa blended cement concrete are represented in Table.

Table –SLUMP AND COMPACTION FACTOR VALUES FOR CPA BLENDED CEMENT CONCRETE

CPA CONTENT (%)	SLUMP (cm)
0	5
5	5
10	10
15	15
20	20

Fig SLUMP CONETEST RESULT GRAPH

HARDENED PROPERTY TESTS COMPRESSIVE STRENGTH TEST (IS516:1959) – 7,14, AND 28 DAYS

Compressive strength is a critical property of concrete that measures its ability to with stand compressive forces. The compressive strength test is a widely used method to determine this property. It involves applying a gradually increasing compressive load to a concrete specimen until failure occurs. Compressive strength test is shown in fig.8.1.

- The compressive strength generally decreases with increase in the percentage of CPA content but increases with curing age.
- From above analysis, it is seen that CPA can successfully replace up to 15 % of cement in a concrete and still produce a normal strength concrete and hence 5% replacement of CPA has higher strength.

Fig COMPRESSIVE STRENGTH TEST

TABLE COMPRESSIVE STRENGTH TEST

CPA replacement %	Curing days	Compressive strength (MPa)
0	7	17.76
	14	26.51
	28	29.53
5	7	19.57
	14	29.35
	28	32.62
10	7	19.29
	14	28.95
	28	32.15
15	7	18.63
	14	27.54
	28	30.68

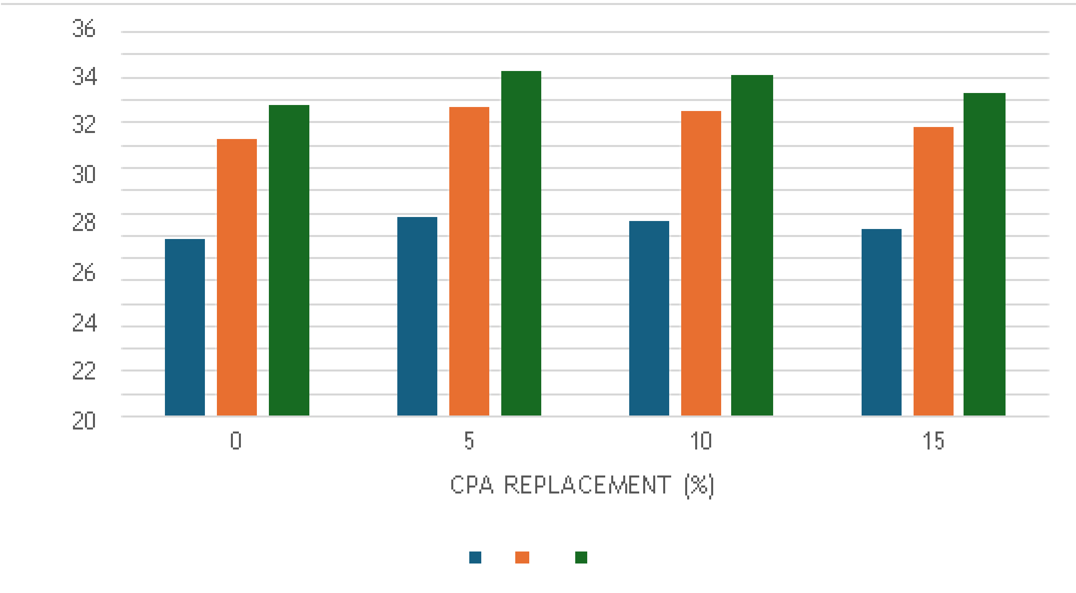


Fig COMPRESSIVES STRENGTH TEST GRAPH

SPLITTENSILE STRENGTH TEST (IS5816:1999)

The split tensile strength test is used to determine the tensile strength of concrete. This test involves applying a gradually increasing load to a concrete cylinder until it splits. The splittensile strength test provides valuable information about the ability of concrete to withstand tensile forces, which is essential for designing and constructing structures that can resist cracking and failure. Fig 8.3 represents Split tensile strength test.

Fig SPLITTENSILE STRENGTH TEST

CPA replacement %	Curing day	Tensile strength (MPa)
0	28	3.17
5	28	3.175
10	28	2.915

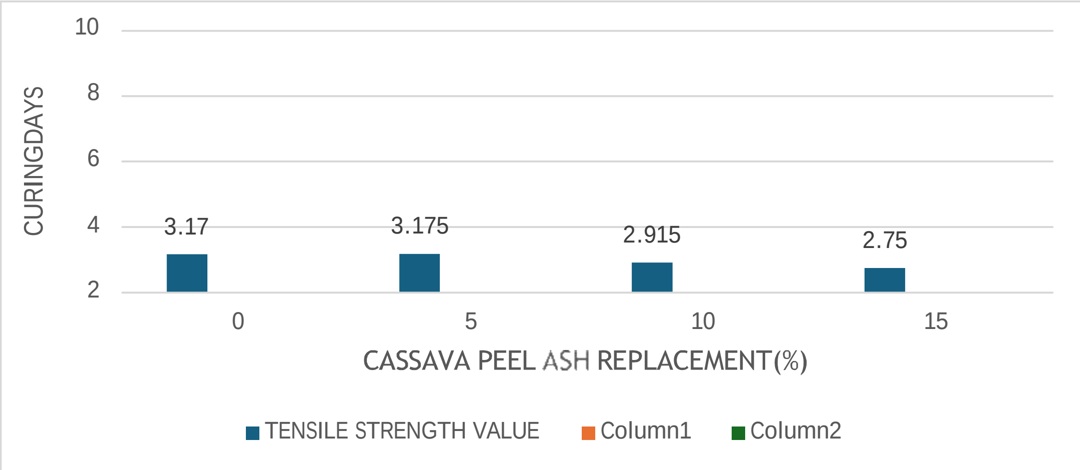


Fig TENSILES TRENGTH TEST GRAPH

SIMAPRO

SimaPro helps effectively to apply sustainability expertise and help to empower decision-making, change products' life cycles for the better, and improve company's positive impact Sima Pro is the leading LCA software solution, with a 30year reputation in industry and academia in more than 80 countries. Sima Pro is a source of science-based information, providing full transparency avoiding black-box processes. The main purpose of this software is to make conscious decisions throughout the analysis, to ensure the accuracy of your results. SimaPro is the professional tool to collect, analyse and monitor the sustainability performance data of company's products and services. The software can be used for a variety of applications, such as sustainability reporting, carbon and water foot printing, product design, generating environmental product declarations and determining key performance indicators.

With SimaPro, you can:

- Easily model and analyse complex life cycles in a systematic and transparent way.
- Measure the environmental impact of your products and services across all life cycle stages.
- Identify the hotspots in every link of your supply chain, from extraction of raw materials to manufacturing, distribution, use, and disposal. Sima Pro is available as a desktop software with an option to use cloud-based modules. It offers a variety of licenses with no hidden costs to fit a wide range of business and educational needs.

DATABASES OF SIMAPRO

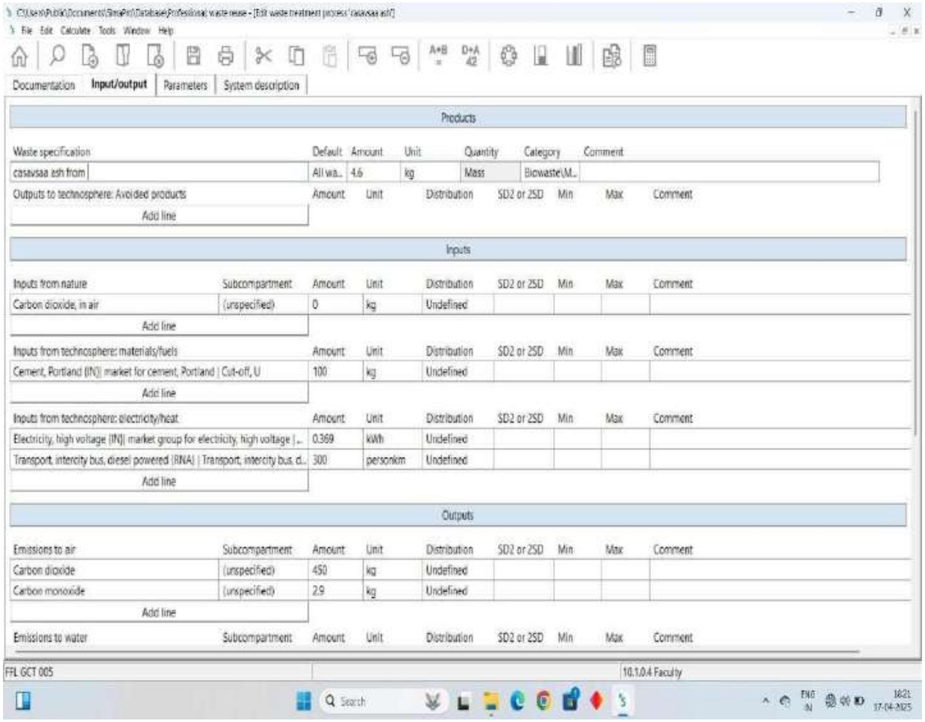
Simapro includes various databases

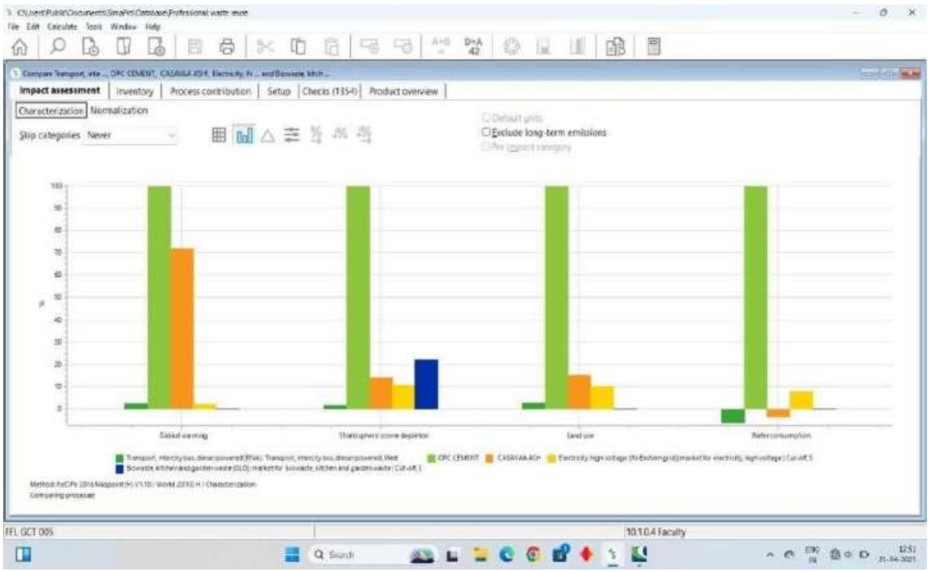
- Agra-footprint
- AGRIBALYSE (optional)
- Carbon Minds (optional)
- DATA SMART LCI package (optional)
- Ecoinvent (included by default, optional on request)
- Environmental Foot print database (optional) ESU world food LCA database (optional)
- European and Danish Input/output database
- EXIOBASE (optional)
- IDEA Japanese Inventory database(optional)
- Quantise World Food LCA Data base (optional)
- Social hot spots database (optional)
- US Life Cycle Inventory database
- WEEELCI data base(optional)
- Show methods
- Advanced modelling

Build complex, transparent, systematic models with Sima Pro. It can model from a life cycle perspective with uncertainty calculation, process and project parameters. The databases of Sima Pro are shown in figure Furthermore, it allows to gain insight into unit processes and the allocation of multiple output processes, conduct a weak point analysis and model complex waste treatment systems.

STEPS TO BE DONE

Step 1: Inspect goal and scope
Step 2: Inspect the processes in the database
Step 3: Analyse the environmental profile of a product
Step 4: Generate a process network
Step 5: Analyse a full life cycle
Step 6: Compare two products in the production stage
Step 7: Compare life cycles
Step 8: Perform sensitivity analysis on alternative assumptions
Step 9: Inspect or select a method
Step10: Inspect the interpretation section





RESULTS AND DISCUSSION

The results demonstrate that incorporating CPA into concrete as a partial cement substitute significantly reduces CO_2 emissions. The reduction in emissions is mainly due to the high carbon intensity of cement manufacturing, which CPA helps to offset. Moreover, CPA is derived from an agricultural waste material, meaning its use contributes to circular economy goals and waste management solutions. From a practical standpoint, the use of CPA can be optimized at 5% replacement levels to balance sustainability benefits and concrete performance.

Additionally, the study highlights that local sourcing of CPA and use of efficient calcination methods can further enhance environmental performance. These findings validate CPA as a promising, eco-friendly material that can be integrated into green building practices.

COMPRESSIVE STRENGTH TEST (IS516:1959)–7,14, AND 28 DAYS

Compressive strength of the specimen for each set, up to 28 days hydration. The results show that the compressive strength generally decreases with increase in the percentage of CPA content but increases with curing age. The compressive strengthattainmentatcontrolfor7,14,28daysare17.56N/mm^2,26.52N/mm^2,29.53 N/mm^2.The compressive strength attainment at 5 % replacement for7,14,28daysare19.57N/mm^2,29.35N/mm^2,32.56N/mm^2.The compressive strengthattainmentat10%replacementfor 7, 14,28days are19.29N/mm^2,28.95 N/mm^2,32.15 N/mm^2. The compressive strength attainment at 15% replacement for 7, 14,28 days are 18.63N/mm^2,27.54 N/mm^2,30.68 N/mm^2.

SPLITTENSILE STRENGTH (IS5816:1999)

The Splittensile strength test of the specimen for each set, up to 28 days hydration. The split tensile strength attainment at control for 28 days is 3.17 N/mm^2. The splittensile strength attainment at control for 28 days at 5% replacement is 3.175 N/mm^2.

FLEXURAL STRENGTH TEST (IS516:1959)

The flexural strength test of the specimen for each set, upto 28 days hydration. The flexural strength test attainment at control for 28 days is 4.5 N/mm^2. The flexural test strength attainment at control for 28 days at 5% replacement is 4.2 N/mm^2. The flexural strength test attainment at control for 28 days at 10% replacement is 3.8N/mm^2. The attainment at control for 28 days at 15% replacement is 3.2N/mm^2.

CONCLUSION

Based on the research work carried out, the following conclusions were made: The Slump values for the concrete shows that the slump increased at 10% cassava peel ash replacement and decreased at 15% cassava peel as replacement.

1. The Initial and final setting time of the OPC/CPA mixes (at 5% and 10%) was found to increase with increasing replacement. This means that CPA concrete is not susceptible to the problem of false set.
2. The specific gravity of the CPA obtained is less than that of the OPC that it replaced which means a considerably greater volume of Cementous materials will result from mass replacement.
3. It was discovered that the cassavapeel ash contains all the main chemical constituents of cement though in lower percentage compared with that of OPC which means it can serve as a suitable replacement if the right percentage is used.
4. The compressive strength of concrete specimens increased with10%, 8% and 4% at 5%,10%,15% cassavapeel ash replacement compared to control mix based on curing days.
5. The durability and acid resistance improved considerably at 10% replacement for cement with cassava peel ash.
6. Concrete with cassavapeel ash can be used for light construction works where high strength is not major requirement but where durability is a major concern.

REFERENCES

1. Optimization of Cassava Peel Ash Concrete Using Central Composite Design." Scientific Reports, vol. 12, no. 1, 2023, pp. 1-12.
2. Ofuyatan,O.,Ede,A.,Olofinnade,R.,Oyebisi,S.,Alayande,T.,&Ogundipe, J,"Assessment of Strength Properties of Cassava Peel Ash-Concret", Journal: International Journal of Civil Engineering and Technology
3. Familusi,A. O.,etal. "Effects of the Partial Replacement of Cement with Cassava Peel Ash and Rice Husk Ash on Concrete." Covenant Journal of Engineering Technology, vol. 3, no. 2, 2019, pp. 45-54.
4. "Effects of Cassava Peel Ash as Alternative Binder in Concrete." International Journal of Constructive Research in Civil Engineering, vol. 1, no. 2, 2017, pp. 1-6.
5. "Compressive and Flexural Strength of Cement Mortar Blended with Cassava Peel Ash." Engineering Today, vol. 2, no. 3, 2018, pp. 80-85.
6. Iro, U. I. et al. Optimization and simulation of saw dust ash concrete using extreme vertex design method. Adv. Mater. Sci. Eng. https://doi.org/10.1155/2022/5082139 (2022).
7. Abdellatief, M. et al. Characterization and optimization of fresh and hardened properties of ultra-high performance geopolymer concrete. Case Stud. Constr.Mater.19, e02549. https://doi.org/10.1016/j.cscm.2023.e02549 (2023).
8. Raheem, S., Arubike, E. & Awogboro, O. Effects of cassava peel ash (CPA) as alternative binder in concrete. Int. J. Constr. Res. Civil Eng. 1(2), 27-32 (2020).
9. Schmidt, W., Msinjili, N. S., Pirskawetz, S. & Kühne, H. C. Efficiency of high performance concrete types in corporating bio-materials like rice husk ashes, cassava starch, lignosulfonate, and sisal fibres. In First International Conference on Bio-based Building Materials (eds Sonebi, M. et al.) (RILEM, 2015).
10. Alaneme George,U. & Elvis, M.Modelling of the mechanical properties of concrete with cementratio partially replaced by alu-minium waste and saw dust ash using artificial neural network. M.SN Appl. Sci. 1, 1514. https://doi.org/10.1007/s42452-019-1504-2 (2019).

11. Uwadiegwu, A. G. & Michael, M. E. Characterization of bambara nut shell Ash (BNSA) in concrete production. J. Kejuruteraan 33, 621-634. https://doi.org/10.17576/jkukm-2021-33(3)- 21 (2021).
12. Nwachukwu,K.C.,Oguaghamba,O.,Ozioko,H.O.&Mama,B.O.Optimization of compressive strength of concrete made with partial replacement of cement with cassava peel ash (CPA) and Rice Husk Ash (RHA) using scheffe's (6,3) Model. Int. J. Trend Sci. Res. Dev. (IJTSRD) 7(2), 737-754 (2023).
13. Ogbonna,C.,Mbadike,E.&Alaneme,G.Characterisation and use of Cassavapeel ash in concrete production. Comput. Eng. Phys. Model. 3(2), 11-20. https://doi.org/10.22115/cepm.2020.223035.1091 (2020).
14. Salan,M.A.&Olonade.K.A.PozolanicpotentialsofCassavaPestAsh/EngRec. 7.9-12 (2011). Osande. E.E.Ukeme, U&Orule, M.O.An assessment of the compressive strength of concrete made with cement partially 1
15. Olubunmi, A.A.,Taiye.1.A.&Tobi, A. compressive strength properties of cassava pod ash and wood sali in concrete production. bit 1.N.Pract Managing 11:01), 31-40. https://doi.org/10.1776/jnemev11101171(2022)
16. Erzurumlu,T.&Oktens,H. Comparison of response surface model with neural network in determining the surface quality of optimization, the preparation condition of vinyltrieth oxysilane modified silicate/polydimethy lst intane hybrid pervaporation membranes. Sep Pury homol. 71. 252-262 (2020)
17. Priyan,M.V.oral Recycling and sustainable applications of waste printed circuit board in concrete application and validation using reponse surface methodology. Sci. Rep. 13, 16509, https://doi.org/10.1038/841595-023-43919-9 (2023)
18. Bekta, S. & Bekta, S. B. A. Analyzing mix parameters in ASR concrete using response mirface methodology. Constr. Build. Mater 66. 299-305 (2014).
19. Alaneme,G.L.Olonade,K.A.&Exenogho,E.Criticalreviewontheapplication of artificial intelligence techniques in the production of geopolymer-concrete. SN Appl. St. 5. 217. https://doi.org/10.1007/642452-023-05447-(2023)20.
20. Alaneme,G.U&Mbadike.E. M. optimization of strength development of bentonite and palm bunch ash concrete using fuzzy
21. Ali, M.,Kumar, A., Yuvaz, A. & Bashir, S. Bashir Salah, Central composite design application in the optimization of the effect of pumice stone on lightweight concrete properties using RSM. Case Stud. Constr. Mater., 18, 201958. https://doi.org/10.1016/j.cscm.2023.001958 (2023).
22. Habert, G., et al. (2010). Environmental impact of cement production: Detail of different processes and cement plant variability evaluation. J. of Cleaner Production.
23. Flower, D. J. M. & Sanjayan, J. G. (2007). Greenhouse gas emissions due to concrete manufacture. IJLCA. Joshua,O.,etal.(2018). Effect of cassavapeel ash on the mechanical properties of conCrete.
24. Ettu, L.O., etal. (2013). Strength of blended cement concrete containing cassava peel ash. IJES.
25. Gursel,A.P.,etal.(2014).Life-cycleinventoryanalysisofconcreteproduction:A critical review. Cement & Concrete Composites.
26. Colangelo,F., et al. (2018). Use of Sima Pro to evaluate environmental impacts of geopolymer cement. J. of Cleaner Production.
27. Onchiri,R.O.,etal.(2014).Cassavapeel ash as a pozzolanic material in concrete.
28. Chen,C.,etal.(2010). LCA of emerging technologies for concrete production.
29. J.of Environmental Management.