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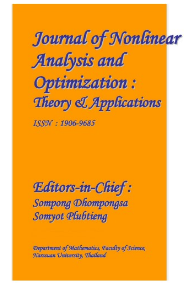

PARTIAL REPLACEMENT OF CEMENT IN CONCRETE WITHFOODWASTEBIOCHAR

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ABSTRACT:
This literature review examines the characterization and utilization of char producedfrom fast pyrolysis of food wastes**[1]**. Fast pyrolysis offers a sustainable method forconverting organic waste into valuable char, which can be utilized in variousapplications. The review explores characterization techniques such as scanningelectron microscopy, X-ray diffraction, Fourier-transform infrared spectroscopy, andBrunauer–Emmett–Teller analysis, highlighting their importance in assessing charproperties such as surface area, pore structure, elemental composition, andfunctional groups. The physicochemical properties of food waste-derived char arediscussed, emphasizing its potential applications in soil amendment, environmentalremediation, energy production, and other sectors**[2]**. Challenges associated withchar production, characterization, and utilization are identified, and future researchdirections are proposed to address these challenges and maximize the benefits offood waste-derived char in promoting sustainable waste management practices andresourceutilization.
Keywords:Foodwaste,Biochar,Biocharconcretecubes,Compressive strength

INTRODUCTION:

1. Foodwasteisapressingenvironmentalandsocietalchallengeworldwide,withsignificant implications for resource depletion, greenhouse gas emissions, andpublic health**[3,4]**. According to the Food and Agriculture Organization (FAO)of the United Nations, approximately one-third of all food produced for human consumption is lost or waste dannually,amountingtonearly1.3billiontons globally**[5]**. In addition to the ethical and economic concerns associatedwith food waste, its disposal contributes to environmental pollution, soildegradation,and climatechange.
2. Addressing the issue of food waste requires innovative approaches that notonly reduce waste generation but also utilize food waste as a resource tocreate value-added

products[6,7,8]. One such approach is the utilization offast pyrolysis technology to convert food wastes into char, a carbon-richmaterial with various potential applications.Fast pyrolysis involves heatingbiomass in the absence of oxygen at high temperatures (typically 400-600°C),resulting in the rapid thermal decomposition of organic matter and theformationofchar, bio-oil, and gases.

3. Char derived from fast pyrolysis of food wastes exhibits uniquephysicochemical properties, including high carbon content, porous structure,and surface functionality, making it suitable for a wide range ofapplications[9]. This literature review aims to explore the characterization and utilization of char produced from fast pyrolysis of food wastes,with a focus onunderstanding its potential as a sustainable solution for waste management and resourceutilization.

4. The review will begin by discussing the principles of fast pyrolysis technologyand its application in converting food wastes into char. Subsequently, it willdelve into the characterization techniques employed to assess the propertiesof food waste-derived char, including surface area, pore structure, elementalcomposition, and functional groups[10,11,12]. The physicochemical propertiesof char and their implications for various applications, such as soilamendment, environmental remediation, and energy production, will bethoroughlyexamined.

5. Furthermore, the review will address the challenges associated with charproduction, characterization, and utilization, including feedstock variability,scalability, and economic viability[13,14].It will also identify opportunities forfuture research and development to optimize char production processes,explore novel applications, and enhance the sustainability of wastemanagementpractices.

MATERIALSUSED:

Cement:

Cement,ingeneral,adhesivesubstancesofallkinds,but,inanarrowersense,the binding materials used in building and civil engineering construction[15]. Cements of this kind arefinely ground powdersthat, whenmixed withwater,settoahardmass[16]. Settingandhardening resultfrom hydration, which is a chemical combination of the cement compoundswith water thatyields sub microscopic crystals or a gel-like material with a high surface area.Because of theirhydrating properties, constructional cements, which will even set andharden under water, areoften called hydraulic cements. The most important of these isPortlandcement.

Fineaggregate:

Usually, sand is used as fine aggregate. It varies in different sizes from 70 microns to4.75mm,the most common mineral in the sand is quartz–also known as silicon dioxide and itpossesseshighly resistant to weather[17-21]. This is formed when silicon and oxygencombine[22,23]. Feldspar is themost found group of minerals on the earth’s surface andformsabout65%oftheterrestrialrocks.Whenthewindandseawhipup ontheshores,they transport these teeny-tiny granulesto the beach and make up the sand with thiscombination. Sand is a non-renewable resourcewhich never happens twice. It is availablethrough various sources desert sand, river sand, lakesand, sea sand, volcanic sand, olivinesandetc.,withdifferentcolourslikewhite,black,red-orangecolour,white-greycolour, light-browncolouretc.,

Sand which is used for construction should in inert and does not reactive with otherconstitutesbecause of that sea sand is not used for concrete mainly river sand and lake sandareused**[24-29]**. Also,sandmakestheconcreteinuniformmixtureand fillsthegapsbetween the concrete whichincreases the strength of concrete. By using sand in concreteprevents the shrinkage and it givesbetter texture and gives smooth finishing. It increases thevolume of concrete thereby reducesthe cost of construction. Sand decreases the porosity inconcrete. This decreases the volume ofvoids hence reduces the development of cracks in it.Sand increases the permeability inconcrete, helps in escape of gases and heat out from theconcrete uniformly withoutdevelopment of build up pressure, thereby reduces the tendencyofdevelopmentofcracks init.

CoarseAggregate:

Gravel is the most used coarse aggregate. The size varies from 4.75 to 37.5mm**[30,31]**.Thereare2typesofaggregatesarethereroundedandangular,Rounded aggregatesrequire less

w/c ratio and byusing these aggregates it improves the workability of concrete but this typeof aggregates are notpreferred when strength is the primary requirement due to its lessinterlocking mechanism and weakbond strength**[32]**. Whereas by using angular aggregatesincreasescementcontentthey increasethe.

Coarse aggregates increase the density, strength, hardness, durability,toughness etc., thesize of aggregates has also impact on these properties. So, the size of aggregateswill varybasedonthedesignmix,placeofconstruction,requirementslikestrength,durabilityetc.,

And decreasing the voids in concrete by using different sizes of aggregates instead of usingsingle sizemakes concrete more effective**[33-36]**. The coarser the aggregate, the moreeconomical the mix. Larger piecesoffer less surface area of the particles than an equivalentvolume of small pieces. Use of the largestpermissible maximum size of coarse aggregatepermitsa reductionincementandwaterrequirements.

Using aggregates larger than the maximum size of coarse aggregates permitted can result ininterlock and form arches or obstructions within a concrete form**[37]**. That allows the areabelow to become a void,or at best, to become filled with finer particles of sand and cementonlyandresults inaweakenedarea.

MIXCALCULATION:

A. Designmix(M30for1m3)

1) Calculationoftargetmeanstrength

f’ck=f ck+1.65x(from IS10262-2009table-1 x=5)

= 40+ 1.65*5

=48.25 N/mm2

2) Water-cementratio

(From IS 10262, table-5,

severe)Adoptedwater-cementratio=0.45

3) Size ofaggregatesCoarse

aggregate =

20mmFineaggregate=4.75mmm

4) Selectionofwatercontent

Maximum water content for 20mm aggregate (from table 2, IS 10262)with

slumpvalueof 25to50=186litres

But considered slump value is

110mmEstimatedwatercontent=186+7/100*186

=199.02 litres
5) Calculation of cement
content(From table 5, IS
456:2000)Cementcontent
=199.02/0.45
= 442.267Kg/m3
6) Calculation of aggregate
content(From table-3 ofIS10262)
20mm size aggregates considering zone-1 =
0.60.5=0.6
Now,
Actual water-cement ratio = 0.45It
islessby(0.5-0.45)=0.05
Thecoarseaggregatein increasedatthe rateof0.01for everydecreaseinw/cratioof 0.05So,for
decreaseofevery0.05w/cratio =coarse aggregateincreased by0.01
Correctedproportionofvolumeof coarseaggregate =0.6+0.01
=0.61
Volumeof fineaggregate =1-0.61
=0.39
7) Mixproportion
Volumeofconcrete=1m3
Volumeofcement=massof cement/specificgravityofcement*1000
=400 /3.15*1000
Volume : 52, Issue 4, No. 4, April :
2023UGCCARE Group-1,32
= 0.126 m3
Volumeof water=massofwater /specificgravityofwater*1000
= 186/ 1*1000
= 0.186 m3
Volumeofentrappedair=2%for20mmcoarseaggregate
=2/100
=0.02m3
Volumeof allin aggregates(coarse +fine)
= volume of concrete – (volume of cement + volume of water
+volumeof entrappedair)
=1–(0.126+0.186+0.01)
= 0.678 m3
Mass of coarse aggregates = volume of all aggregates*volume of coarse
aggregates*specificgravity*1000
=0.678*0.63*2.74*1000
= 1170Kg
Mass of fine aggregates = volume of all aggregates*volume of fine
aggregates*specificgravity*1000
=0.678*0.37*2.65*1000
= 665Kg
8) Mix
proportionsCement = 400
Kg/m3Water=186 litres
Coarse aggregate = 1170 KgFine
aggregate=665Kg

B. Weightofingredients

Fromtheabovemixdesignobtainedmixratio is1:1.66:2.92

1) Volumeofcube=length*breadth*height

=0.1*0.1*0.1

= 0.001 m3

2) Weightofconcrete=volumeofbeam*densityofconcretein kgs

= 0.001*24000

=24Kg

3)Weightofcement=1/4.9*24(1+1.66+2.92=5.58)

= 27.33 Kg

4) Weightoffineaggregate =1.66/4.9*24

=8.13Kg

5) Weightofcoarseaggregate=2.92/4.9*24

= 14.30 Kg

6) Weightofsteelfibres=1%ofvolumeof concrete

= 1/100*24

=0.24Kg

METHODOLOGY:

1. **Production ofFoodWaste Biochar**:

- Collectfoodwastefromsourcessuchashouseholds,restaurants,or foodprocessingfacilities.
- Preprocess the food waste to remove contaminants and prepare it forpyrolysis**[38]**.Utilize a pyrolysis process to convert the food waste intobiochar. This can include slow pyrolysis, fast pyrolysis, or hydrothermalcarbonization.
- Characterize the produced biochar to assess its physical and chemicalproperties, including surface area, pore structure, elementalcomposition,and functionalgroups.

2. **Preparation of Concrete Mixtures**:

- Designconcretemixtureswithvaryingproportionsoffoodwaste biochar as a partial replacement for cement. Common replacementlevelsrangefrom5%to20%byweight of cement.
- Determine the optimal replacement level based on preliminary testsanddesired concreteproperties.
- Prepare control concrete mixtures without biochar to serve as referencesamples**[39]**.Ensure proper mixing of ingredients to achieve uniformdispersionofbiocharparticles intheconcretematrix.

3. **TestingofConcrete Properties**:

- Conductaseriesoftests to evaluatethefreshandhardenedproperties oftheconcretemixtures.
- Perform fresh concrete tests, including slump, flow, and setting time, toassessworkabilityand consistency.
- Test hardened concrete properties, such as compressive strength,flexural strength, density, porosity, and durability (e.g., waterabsorption, chloride ion penetration resistance).Age the concretespecimens under standard curing conditions (e.g., moist curing or aircuring)forspecified durationsbeforetesting.

4.**Analysis of Results**:

- Analyze the test results to assess the impact of food waste biochar onthepropertiesofconcrete.
- Comparethepropertiesofconcretemixtureswithdifferentlevelsofbiocharsubstitution tothecontrolmixturewithout biochar.
- Evaluate the effects of biochar on workability, strength, density, anddurabilityofconcrete.
- Investigate the microstructure of concrete using techniques such asscanning electron microscopy (SEM) and X-ray diffraction (XRD) tounderstandtheinteractionbetweenbiocharandcementitiousphases.

5.**Discussion andConclusion**:

- Discusstheimplicationsofthefindingsintermsofthefeasibilityand effectiveness of using food waste biochar as a partial replacement ofcementinconcrete.
- Address any challenges or limitations encountered during the study,suchaschangesinworkabilityorstrength.
- Highlight the potential benefits of incorporating biochar, such asreduced carbon footprint, improved waste management, and enhancedpropertiesofconcrete.
- Provide recommendations for future research and practical applicationsoffood wastebiochar inconcreteconstruction.
-

I.EXPERIMENTATION

A. Compressiontest

Compressionstrengthtestisusedtomeasuretheforcerequiredtocompressthe Material**[40]**. Compression tests are conducted by loading the test specimen between twoplates, and thenapplying a force to the specimen by moving the crossheads together. Duringthe test,thespecimeniscompressed,anddeformationversustheappliedloadisrecorded.It is oneofthe mostimportantpropertiesof concreteand mortar.

B. Apparatus

Specimen(concretecube),CTM(Compressiontestingmachine)

C. Procedure

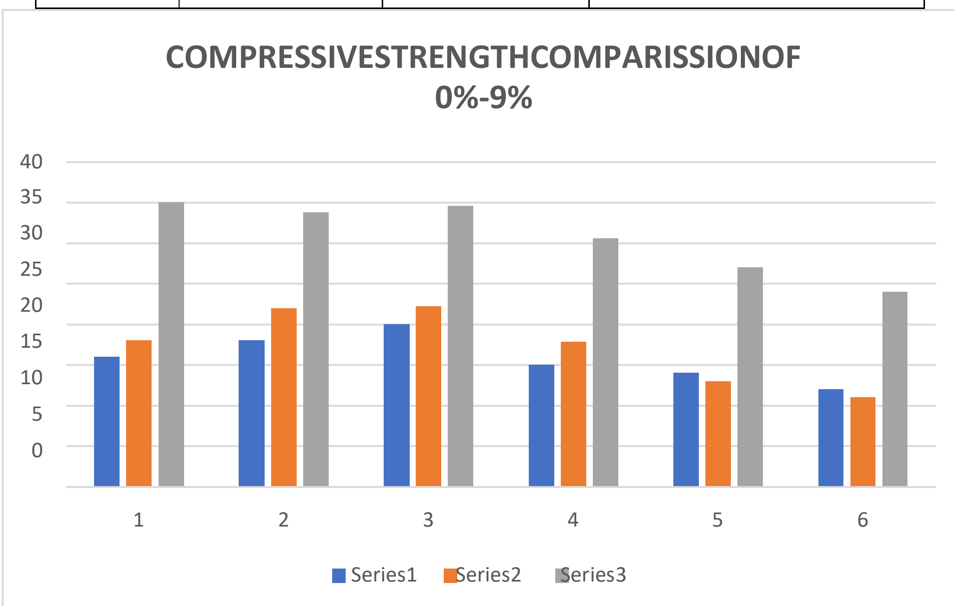
1) Cleanthecubewithdryclothtoremovewatercontentonthesurfaceaftercuring.
2) Removeexcessconcreteonthesurfacebytrowelandmake thecubeeven.
3) Liftthecubecarefullyandplaceit inthemiddleoftheCTM.
4) Settheloadedspringtomakeincontactwiththesurface.
5) Aftercontactismadesettheloadingdegree to0.
6) Thenapplytheloadgraduallyontothecube.
7) Note the readings when the first break (crack) formed and final breakage (ultimate load)was.

Loadappliedonthespecimen =240KN.

@7 day – curing, compressive strength = 24 N/mm2 , @28 day – curing, compressivestrength=39N/mm2

Table –1: Compressive strength of concrete cubes when biochar is partially replaced with cement indifferent percentages

%of Biochar	Compressiv estrength for 3days of curing (inN/mm2)	Compressiv estrength for 7days of curing (inN/mm2)	Compressivestrength for28days of curing (inN/mm2)
0	16	18	35
1	18	22	33.73
3	20	22.25	34.57
5	15	17.85	30.6
7	14	13	27
9	12	11	24



CONCLUSION:

- Biocharisdonebythefoodwastetoshowsthestrength.
- The efficient use of biochar in cement concrete cubes are maximum at1%,3% of its weight, then by adding more than 3% of biochar in cementconcretecubesit loses it original characteristicstrength.
- The above table show us the characteristic compressive strength ofcement concrete cubes(150mmX150mmX150mm) With some %replacement of biochar of its weight,

The cement concrete cubes with 1% ,3% replacement of biochar with itsweight(25gmand75gm)help togain its original characteristiccompressive strength, if we add more than 3% biochar in cementconcrete,theconcretecubeloses its original strength.

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