PRINCIPAL INVESTIGATOR

Name: Engr. Dr. Olakunle Olaleye Joseph

Institution: The Federal Polytechnic, Ilaro, Ogun State

Department: Mechanical Engineering

Telephone No.: 08154433866

Email: olakunle.joseph@federalpolyilaro.edu.ng

CO-INVESTIGATORS:

1. Engr. Sunday Samson Olowofela

   Institution: The Federal Polytechnic, Ilaro, Ogun State

   Department: Electrical and Electronics Engineering

   Telephone: 08035810039

   Email: sunday.olowofela@federalpolyilaro.edu.ng

2. Name: Engr. Dr. Samson Abiodun Odunlami

   Institution: The Federal Polytechnic, Ilaro, Ogun State

   Department: Mechanical Engineering

   Telephone No.: 08033806672

   Email: samson.odunlami@federalpolyilaro.edu.ng

3. Engr. Dr. Samuel Sunday Omopariola

Institution: The Federal Polytechnic, Ilaro, Ogun State

Department: Mechanical Engineering

Telephone: 08136561888

Email: samuel.omopariola@federalpolyilaro.edu.ng

DEVELOPMEMT OF STONE CRUSHING MACHINES FOR RECYCLING USED CONCRETE TOWARDS A TREASURE-CIRCULAR ECONOMIC SUSTAINABILITY

BY

[1] ENGR. DR. O. O. JOSEPH

[2] ENGR. S. S. OLOWOFELA

[1] ENGR. DR. S. A. ODUNLAMI

[3] ENGR. DR. S. S. OMOPARIOLA

[1] DEPARTMENT OF MECHANICAL ENGINEERING

[2] DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

[3] DEPARTMENT OF CIVIL ENGINEERING

THE FEDERAL POLYTECHNIC, ILARO

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FOR

RESEARCH COMMERCIALISATION PROPOSAL APPLICATION

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EXECUTIVE SUMMARY

Nigeria is a developing nation with a growing rate of urbanization and infracstructural developmrnt both in the rural areas and the cities across Ogun State and the country. The construction industry heavily relies on aggregates, which are becoming scarce and expensive. Hence, the goal of the proposal is to address the growing demand for the scarce aggregates through the use of Recycled Concrete Aggregates (RCA). Recycled Concrete Aggregates (RCA) offers a versatile, eco-friendly and sustainable alternative to virgin materials with a cost-effective advantage in the building construction indudtry. RCA also address the growing demand for sustainable construction materials, reduce environmental waste, and create a profitable business model by transforming construction and demolition waste into valuable inputs for new infrastructure. Nigeria generates thousands of tons of concrete waste annually from demolition, renovations and infracstructural upgrades. The economic viability of recycling and recovery of used concrete have not been harnessed in the building construction industry in Ogun State and Nigeria. The paradigm shift of Nigeria and the entire world to the Sustainable Development Goals (SDGs) demands strategic models for its achievement. The Sustainable Development Goals (SDGs) 9 and 13 are targeted at Industry, Innovation and Infracstructure and Climate Action to reduce environmental degradation and prevent the extinction of natural resources which can be exhausted. To achieve the objectives of this proposal, stone crushing machines will be deployed to process used concrete into hig-quality RCA for resale to individuals snd construction industries. Comprehensive integrity tests and characterization of process concrete materials will be conducted to address the challenge of market resistance and ensure its quality assurance. Natural resources will be preserved, some costs will saved in building construction work and the environment will be preserved. The concrete recycling site will be named Federal Polytechnic Ilaro-Recycled Concrete Aggregares Centre (FPI-RCAC). Employment will be created, manpower will be trained,

revenue will be generated by the institution and for the government. The project will cost fifty-five million and thirty thousand naira only (N55,030,000.00). The period of execution of the project is twelve months.

INTRODUCTION

Nigeria is a developing nation with a growing rate of urbanization and infracstructural developmrnt particular under the present administration both in the rural areas and the cities across Ogun State and the nation at large. Concrete is made of granites, sand, cement and water to form the bond. The concrete form the strong part of the building. Granite was the most produced solid mineral in Nigeria in 2017 being 38.12% of the total tonnage of solid minerals produced (Quarry Product, 2018). Stones provide the needed strength to concrete. The quarry provides granite stones for construction activities all over the globe.

Nigeria generates thousands of tons of concrete waste annually from demolition, renovations and infracstructural upgrades. Hence, used concrete is found in collapse building sites, construction sites, reconstruction sites, and many communities. Used concrete is mostly termed as waste that could not be further used except for filling purposes. The structural design of the concrete may probably have been compromised but the materials could be crushed, reclaimed, and reused for building and construction purposes with the same grade as virgin materials if it is upgraded with the addition of very minimal materials. The usability of the reclaimed stone can be determined through the petrographic evaluation, in addition to the physical, mechanical, and simulation tests carried out on it. Used concrete can be reused as a solution to several construction and landscaping problems (Cemex, 2023). Recycled Concrete Aggregate (RCA) offers a sustainable alternative to virgin materials with a cost-effective advantage in building construction (Jadon and Kumar, 2023).

When this ptoject is executed natural resources will be preserved, the environment be safer, some costs will saved in building construction work and the environment will be preserved. The concrete recycling site will be named Federal Polytechnic Ilaro-Recycled Concrete

Aggregares Centre (FPI-RCAC). Employment will be created, manpower will be trained, revenue will be generated

STATEMENT OF THE PROBLEM

The high cost of granite stones is challenging in the building construction industry. The stress and energy expended in breaking concrete in the quarry into smaller sizes are all challenges in the building construction industry. Extraction of virgin material (granite) reduces the natural resources gradually. Used concrete is not fully utilized when used for filling purposes. The growing need for concrete aggregates in the construction industry has been fully met. Urbanization and infracstructural developmrnt need alternative concrete aggregates that is sustainable and cost-effective. Sustainable Development Goals (SDGs) 9 and 13, is also a call for sustainable materials in the construction industry.

Nigeria generates thousands of tons of concrete waste annually from demolition, renovations and infracstructural upgrades. The economic viability of recycling and recovery of used concrete have not been harnessed . Hence, this study has necessitated the need to develop and deploy stone crushing machines to process used concrete into Recycled Concrete Aggrfgates (RCA) for the constucction inducty and individuals for cost-effective infracstrucutural development, economic value, creation of employment, and promote circular economy practices in the construction industry.

OBJECTIVES OF THE PROJECT

The objectives of the project are to:

i. Evaluate the physical and mechanical properties and integrity of used concrete in comparison to virgin concrete.
ii. Develop a jaw crusher, stone crusher and stone screening machine for processing used concrete into various sizes
iii. Evaluate the viability of the Recycled Concrete Aggregates (RCA) materials for post production evaluation and certification
iv. Market the recycled concrete for cost-effectiveness and economic purpose in the construction industry.
v. Protect and preserve the environmental nature, promote circular economy and environmental sustainability

LITERATURE REVIEW

The durability of stones and building materials is a determining factor in the quality and integrity of the infrastructural products (Hamakareem, 2024; Ozinga, 2024). Cemex, (2023) reported that used concrete can be crushed down to specific sizes and reused as solutions to several construction and landscaping problems concerning the integrity of the used concrete. The recycling and viability of the used concrete materials will be underscored through the integrity tests and material characterization using both non-destructive and destructive tests in comparison to virgin materials. The stone-crushing sector (quarry) is a significant part of the building construction industry (Odunlami *et al.,* 2024).

The use of non-destructive, portable techniques is essential, for the assessment of the surface strength of the stone. Quality building stones should have characteristics such as appearance (fine, compact texture and light colour), structure (uniform texture free from cavity, cracks, and patches), and strength (strong, durable, strength in between 60-200 N/mm^2). Reiger, (2024) stated that when concrete recycling is done by crushing the concrete to reuse it as aggregates again, the concrete can only be used for certain applications as described in standards. The benefits of using recycled concrete include less concrete demolition waste going into landfills, increased nature preservation, saving natural resources, and reducing the amount of transport needed (Reiger, 2024).

High-quality sands and aggregates are becoming a scarce resource. Concrete recycling reduces materials scarcity and saves natural resources (Reiger, 2024). Concrete can be recycled by grinding it up, then using screens to separate fine and coarse materials, magnets to remove steel, and water floatation to remove other unwanted materials (Bearman, 2019; Bentley, 2022). This research aims to conduct integrity tests and characterization of used concrete to evaluate its viability for recycling, economic and environmental sustainability, and concrete waste management.

METHODOLOGY

The material and methods adopted in this project include the following:

i. Integrity Test and Materials Characterisation

Integrity tests and materials characterization will be carried out on the concrete and the research materials from selected geographical locations in Ogun state. The integrity tests include acid tests, attrition tests, crushing tests, crystalline tests, freezing and thawing tests, hardness tests, impact tests, water absorption tests, compressive tests, and durability tests.

Four categories of samples will be subjected to the tests which include; the used concrete, used concrete materials, new concrete, and new concrete materials.

ii. Determination of the Used Concrete Viability

The results of the integrity tests and materials characterization will be used to determine the viability of the used concrete for recycling toward economic and environmental sustainability.

iii. Construction of Crushing and Screening Machine

The construction of the jaw crusher, stone crusher and screening machine will be done with a high standard of safety, health, environmental compliance, and material selection. The crushing machine will break the used concrete into smaller pieces as required. The screening machine will separate the crushed concrete materials into different sizes as required by the end-users.

iv. Quality Control

Integrity test will be carried out on the recycled concrete to know the viability and economic value of the concrete. The quality assurance of the RCA will be ensured to prevent markets resistance and to give the right information to the public. The product will be commercialized for sustainability and economic growth and developmrnt.

EXPECTED RESULTS

The expected results will produce accurate data regarding the integrity, properties, material characterization, and viability of used concrete for recycling and recovery. It will reduce waste generated from construction sites. The research will save costs in building construction

industry, with respect to concrete aggregates and materials. Used concrete will be converted to useful resources, viable alternative concrete materials (local content). Revenue will be generated by institution and for the government. Natural resources will be preserved for an eco-friendly environment. However, efficient, jaw crusher, stone crusher and stone screening machine will be developed for the process. A concrete recycling and recovery site will be established for concrete waste management economic growth and environmental sustainability.

WORK PLAN/TIME FRAME

S/N	**Activity**	**Outcome**	**Duration (month)**
1	Pre-research study and design of machine	Design of the project	2
2	Sourcing for materials and parts	Purchase of materials	2
3	Construction and processing	Completion of the machine construction	4
4	Experimentation and testing,	Completion of the machine testing and performance evaluation	2
5	Data collection and analysis	Results collation	1

6	Writing of project report	Completion of project report and journal publication	1
	Total		12 months

GANTT CHART

MONTH												
Task name	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Activity 1	←	→										
Activity 2			←	→								
Activity 3					←	→	→	→				
Activity 4									←	→		
Activity 5											←	→
Activity 6												← →

BUDGET

1. **Jaw Crushing Machine (Primary crushing)**

S/N	ITEMS	PROCEDURE	FUNCTION	QTY	COST (NAIRA)
1	Jaw crusher	Purchasing/Fabrication	Stone breaking	1	7,600,000.00
2	Tools and accessories	Purchasing	Installation and maintenance	1	610,000.00
3	Linking plate	Fabrication	Connect machine to conveyor	1	258,000.00
	Sub-total				8,235,000.00

2. **Crushing Machine (Secondary crushing)**

S/N	ITEMS	PROCEDURE	FUNCTION	QTY	COSR (NAIRA)
1	Pillow Bearing	Purchasing	Support the shaft	2	320,000.00
2	Solid shaft	Fabrication	Support hammer plate	2	380,000.00
3	Solid shaft	Fabrication	Rotates hammer plate	1	180,000.00
4	Wire mesh	Fabrication	Screening of materials	4	380,000.00
5	Hammer plate	Fabrication	Breaking of concrete	24	600,000.00
6	Machine body	Fabrication	Machine covering	2	480,000.00

7	Electrodes	Purchasing	Welding materials	3	60,000.00
8	Machine frame	Fabrication	Support machine covering	5	350,000.00
9	Guiding plate	Fabrication	Guide hammer plate	28	320,000.00
+10	Cutting Disc	Purchasing	Cutting of materials	2	20,000.00
11	Grinding disc	Purchasing	Finishing	2	30,000.00
12	Bolts and nuts	Purchasing	Joining parts	30	90,000.00
13	Gasoline engine (7 hp)	Purchasing	Prime mover	1	350,000.00
14	Base shaft	Fabrication	Support tyres	2	250,000.00
	Guiding ring	Fabrication	Separate hammer plate	26	260,000.00
15	Tyre and wheel	Purchasing	Machine mobility	4	320,000.00
	Sub-total				4,390,000.00

3. Stone Screening Machine

S/N	ITEMS	PROCEDURE	FUNCTION	QTY	COST (NAIRA)
1	Stone screening machine	Purchasing	Screen/separate stones	1	7,380,000
2	Machine installation	-		1	220,000.00
3	Conveyor system	Purchasing	Convey stone	3	1,620,000
4	Tools and accessories	Purchasing	Installation and Maintenance	1	520,000.00
	Sub-total				9,740,000.00

4. Concrete Integrity Test

S/N	INTEGRITY TEST	INTENDED USE	QTY	UNIT COST (NAIRA)	TOTAL COST (NAIRA)
1	Specific Gravity Test	Determination of Specific Gravity of Aggregate	3	20,000.00	60,000.00
2	Water Absorption Test	Determination of Water Absorption of Aggregate	3	20,000.00	60,000.00
3	Flakiness Test	Determination of Flakiness Index of aggregate	3	20,000.00	60,000.00

4	Shape and Surface Texture Test	Determination of Shape and Surface Texture of aggregate	3	20,000.00	60,000.00
5	Soundness Test	Determination of Soundness of aggregate	3	20,000.00	60,000.00
6	Aggregate Abrasion Value Test	Determination of the Abrasion Value of aggregate	3	20,000.00	60,000.00
7	Specific Gravity Test	Determination of Specific Gravity of Aggregate	3	20,000.00	60,000.00
8	Aggregate Crushing Value Test	Determination of Aggregate Crushing Value of aggregate	3	20,000.00	60,000.00
9	Aggregate Impact Value Test	Determination of Aggregate Impact Value of aggregate	3	20,000.00	60,000.00
10	Rock Strength Test	Determination of Rock Strength of aggregate	3	20,000.00	60,000.00
11	Acid test	Determination of Acid Content of aggregate	3	20,000.00	60,000.00
12	Crystalline test	Determination of Crystalline Value of aggregate	3	20,000.00	60,000.00
13	Freezing and	Determination of Freezing	3	20,000.00	60,000.00

	thawing test	and thawing of aggregate			
14	Flat and elongated particle Test	Determination of Flat and elongated particles of aggregate	3	20,000	60,000.00
15	Petrographic Analysis Test	Determination of mineralogical and chemical characteristics	4	50000	250,000.00
	Sub-total				1,090,000.00

5. Other Items and Transportation

S/N	ITEMS	PROCEDURE	FUNCTION	QTY	COST (NAIRA)
1	Land	Acquired from institution	Site for centre	1	Not applicable
2	Building	Construction	Houses centre	1	14,600,000.00
3	Sand bucket (Metal)	Purchasing	Extinguish fire	2	30,000.00
4	Fire extinguisher	Purchasing	Extinguish fire	6	540,000.00
5	Testing and quality control	Purchasing	Product integrity	10	680,000.00
6	Logistics	Operation	Pre-breaking operation	-	100,000.00

7	Licensing and permits	Seek approval	Operations	1	1,050,000.00
8	Pollution control system	-	Prevent pollution	-	1,410,000.00
9	Lister generator (15KVA)	Purchasing	Power supply	1	6,400,000.00
10	Maintenance	Operation	Equipment maintenance	-	980,000.00
11	Transportation	-	Transportation	-	1,850,000.00
12	Report documentation	-	Documentation	3	320,000.00
	Su-btotal				26,550,000.00

6. Consumables

S/N	ITEMS	PROCEDURE	FUNCTION	QTY	COST (NAIRA)
1	Liquefied Petroleum Gas (LPG)	Purchasing	Firing furnace	500 L	650,000.00
2	Used concrete	Purchasing	Raw material	50 tons	300,000.00
3	Utilities	Purchasing	Operations	-	475,000.00
	Sub-total				1,425,000.00

7. Research Personnel

S/N	NAME	DESIGNATION/ QUALIFICATION	ROLE IN RESEARCH	AFFILIATION	HONORARIUM (NAIRA)
1	Joseph O.O.	Senior Lecturer, HND, PGD, M Eng., PhD (Mech.), MNSE, COREN	Principal Investigator	The Federal Polytechnic, Ilaro, Ogun State	490,000.00
2	Olowofela S.S.	HND, B Eng. M Eng. (Elect/Elect), MNSE, COREN	Co-Investigator	The Federal Polytechnic, Ilaro, Ogun State	390,000.00
3	Omopariola S. S.	Principal Lecturer, HND, PGD (Tech. Edu), PGD, M Eng., PhD, (Civil Engineering), MNSE, COREN	Co-Investigator	The Federal Polytechnic, Ilaro, Ogun State	390,000.00
4	Odunlami S. A.	Chief Lecturer B.Eng, M Sc. (Mech) PhD (Industrial),	Co-Investigator	The Federal Polytechnic, Ilaro,	390,000.00

		MNIMechE, MNSE, COREN		Ogun State	
		Sub-total			1,660,000.00

8. Labour

S/N	STATUS	NUMBER	QUALIFICATIONS	ROLE IN CENTRE	WAGES (NAIRA)
1	Procurement Officer	2	ND (Purchasing and Supply Technology)	Concrete procurement	300,000.00
2	Operator	3	ND (Mechanical Engineering)	Machine operation	600,0000.00
3	Utility Officer/Supervisor	2	ND (Mechanical Engineering)	Utility procurement	260,000.00
4	Quality Assurance Officer	2	ND (Civil Engineering)	Concrete certification	200,000.00
5	Cleaner	2	SSCE	Centre cleaning	100,000.00
	Sub-total				1,460,000.00

9. Budget Summary

S/N	ITEMS/DESCRPTION	COST (NAIRA)
1	Jaw Crushing Machine (Primary crushing)	8,235,000.00
2	Crushing Machine (Secondary crushing)	4,390,000.00
3	Stone Screening Machine	9,740,000.00
4	Concrete Integrity Test	1,090,000.00
5	Other Items and Transportation	26,550,000.00
6	Consumables	1,425,000.00
7	Research Personnel	1,660,000.00
8	Labour	1,460,000.00
	Grand Total	55,030,000.00

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