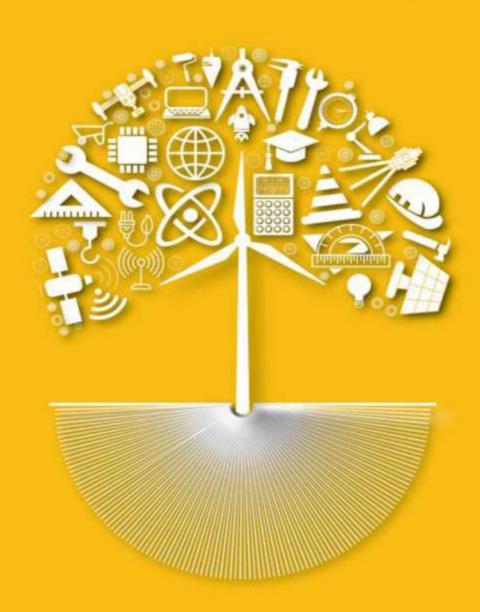


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## Deep Learning for Enhancing IoT Security using Multimodal Biometric Authentication

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#### **Abstract**

Today, the Internet of Things (IoT) connects billions of electronic devices into multilateral computer networks to provide advanced and intelligent services. These networks enable numerous devices to communicate with each other for exchanging data and information with minimal human-to-machine interaction. This phenomenon increases the security issues and triggers the risks at a higher level in IoT systems compared with other computing systems. In order to maintain the security necessity when attacking the physical surface of the IoT system and its devices is a crucial and challenging task. On the other hand, implementing security mechanisms such as user authentication and access control for the IoT enabled ecosystems is essential to ensure the desired security of the IoT system devices. Usually, the security key may be stolen, forgetten, forged or duplicated by someone for misuse. The keys can be easily regenerated by intruders or men in the middle in traditional security environments. Today, biometric security is also becoming a more advanced and sophisticated alternative with technological advancements and is used widely in authentication systems. Technologically, only one biometric characteristic can be used in unimodal biometrics, which cannot be applied to ensure the high end security of IoT systems. In this research paper, we used biometric authentication to ensure the security of edge devices in the IoT environmental ecosystems. We also used the face images and fingerprint images as multimodal biometrics systems for authenticating users to secure IoT devices in an IoT environment. In the experimentation phase, we used a Pi-Camera module and a fingerprint sensor to capture biometric images. Then we used CNN algorithms for feature extraction and model development. As an activation function, the RELU function was used in model development, such as softmax for image classification, and Max-pooling for image dimensional reduction. This aided the model in speeding up the training process of the model. Finally, the experimental results demonstrate that the accuracy of the face image is 92% and the fingerprint image is 89%, which is a highly promising result to ensure the achievement of the desired objective of the research.

Keywords: Authentication, CNN, Deep Learning, Internet of Things, Multimodal Biometrics, Fingerprint

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### I. Introduction

Technology is advancing at a fast rate. Technologies like IoTs are trying to integrate millions and billions

of electronic devices and networks to facilitate typically enhanced, advanced and intelligent user services. These systems usually help in minimising the human-machine interactions significantly. Usually, IoT architectures are complex and contain integrative component arrangements. Thus, ensuring the security needs while attacking the physical surface of the IoT system devices becomes a challenging task. This makes the security issue a higher risk in IoT environments than in other computing system environments. In such situations, the traditionally made solutions may be ineffective in handling the security issues. The desired solutions must be holistic considerations to meet the changing needs of the security systems in the environments. However, IoT devices are usually set in unattended environmental surroundings. Consequently, an intruder may additionally physically gain access to those gadgets. Usually, the IoT gadgets are typically connected over public or private Wi-Fi networks, in which an outsider might also have access to private facts from a communication channel with the aid of eavesdropping. Thus, IoT devices cannot support such complex security structures, given their limited computation and power resources [1]. Biometric authentication is a security process that relies on the unique biological characteristics of individuals to verify who they are [2]. Biometric authentication and recognition have become the new branch of exploration in the adoption of newer techniques in terms of security, higher accuracy, and high speed [3]. Unimodal biometric authentication structures got more interest from sensible programs [4] consisting of the Internet of Things (IoT), Automated Teller Machines (ATM), and cellular packages. Thus, one feature is neither completely green nor completely adequate to expect the proper subject, particularly for the accumulated photos in diverse conditions such as rotation, illumination, and occlusion conditions. Therefore, most of the researchers focus more attention on multimodal biometric recognition to improve identity performance and provide better protection. As stated in a study, most of the latest human-popularity works [5] utilized function-degree fusion to overcome the challenges of confined assets and to boost device

Artificial intelligence is the way of creating an intelligent system that thinks and acts like a human being. It is a way of using computer machines as a power of humans [6]. A system to be an intelligent system should have six disciplines of AI (NLP, computer vision, machine learning, knowledge representation, robotics, and logical reasoning). In the current era, AI is used in different areas like healthy cars, agriculture, education, and industry. In industry IoT and AI systems are commonly used to improve services and produce more products for customers.

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security and device overall performance.



In the IoT ecosystem, complex structures and heterogeneous components are interconnected. In the current era of globalization, most of the systems in industrial companies are migrating to IoT technology. Edge devices in IoT can exchange data with less human interaction. Ensuring security for the IoT ecosystem is necessarily needed to avoid unauthorized access to IoT systems.

Researchers explored different security mechanisms to ensure security in IoT systems. In the last decades, traditional security mechanisms were applied to secure edge devices in an IoT ecosystem. Traditional security mechanism has a drawback because the key used for the security method may get stolen, forgotten, or forged key may be created by intruders or a man in the middle, but in biometric security mechanism the character or the key can't be stolen by theft, forgotten, and fake character cannot be generated by the intruders. The biometric character may be physiological (face, fingerprint, iris, hand geometry, hand gesture) or behavioral (walking, typing, touchpad). Most researchers applied either of these biometrics to improve security issues in IoT.

Researchers were applying biometrics in two ways. The first one is a unimodal biometrics system in which only one biometric characteristic can be applied, which cannot be applied to ensure security in IoT systems. The second one is multimodal biometrics systems that can be applied to more than one biometrics characteristic.

## **II.** Literature Review

Research by Mohammed Ali Al-Garadi, Amr Mohamed, and Abdulla Al-Ali [7] proposed a review of the machine learning and deep learning methods and algorithms applied to the Internet of Things IoT security which is titled "Survey of security issues Machine and deep learning knowledge of techniques for Internet of Things". In this paper, the researchers tried to address all the methods and algorithms of machine learning and deep learning and how they are applied for ensuring the security of IoT.

Another study by Jasmeen Sharma, and Dharam Veer Sharma [8] proposed a multimodal biometrics authentication using face and fingerprint. They tried to address the drawback of unimodal biometrics and how the multimodal biometric system was very advanced than the unimodal biometrics. The researchers used principal component analysis (PCA), Bacterial Foraging Optimization algorithms (BFOA), Minute Extraction, and multilayer (MLNN).

In another paper, Sudip Vhaduri and Christian Poellabauer [9] proposed "Multimodal biometric-based implicit authentication of wearable devices users". They applied authentication mechanisms using combinations of three types of coarse-grain minute-level biometrics: behavioral (step counts), physiological (heart rate), and hybrid (calorie burn and metabolic equivalent of task). Their findings show that hybrid



biometrics perform better than other biometrics and behavioral biometrics do not have a significant impact, even during non-sedentary periods.

Very important research by Mohamed Hammad, Yashu Liu, And Kuanquan Wang [10] proposed a "Multimodal biometric authentication system using CNN based on a different level fusion of ECG and fingerprint". These authors developed two distinct authentication systems having different level 2 fusion algorithms, i.e., 1) feature level fusion and 2) decision level fusion. Further, the feature level extraction for users' numerous modalities was done using a CNN.

## III. Research Design and Methodology

A comprehensive overview of multimodal biometric authentication for enhancing IoT security systems with face recognition and fingerprint biometric data was discussed. For the experimental investigation, images were collected through the pi-camera and fingerprint sensor.

## A. Proposed Model Architecture

The proposed model contains two phases, the enrollment phase, and the authentication phase. Both phases have the same image-processing tasks. First digital face image and fingerprint images are acquired by using the Pi camera module and fingerprint sensor devices respectively. Then the image preprocessing technique is applied. The segmentation process was applied to the image which is then ready for the feature extraction process. The following Fig.1 shows the proposed model architecture.

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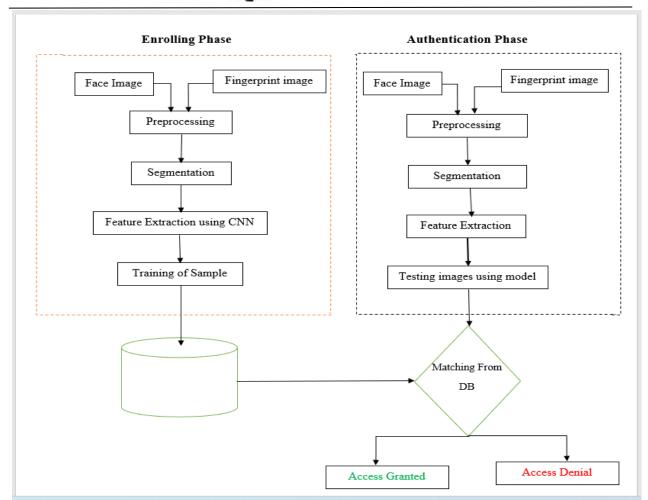


Fig. 1: Proposed Model Architecture

## IV. Experimental Setup, Result and Discussion

## A. The Tool Used for the Study

In this research study software and hardware tool was used for conducting an experimental activity. Software tools like Anaconda navigation and Jupiter notebook for the code editor, open-cv library for capturing images and then image processing tasks, Tensor flow, and CNN algorithms for creating the proposed model.

Different hardware tools are also used for experiments. Raspberry Pi is for implementing and controlling the research result, a Pi camera for capturing the user's facial image, fingerprint sensor devices for capturing fingerprint images, and jumper cables for assembling edge devices with a raspberry pi controller. The following Fig.2 shows a highlight of the hardware tools used.



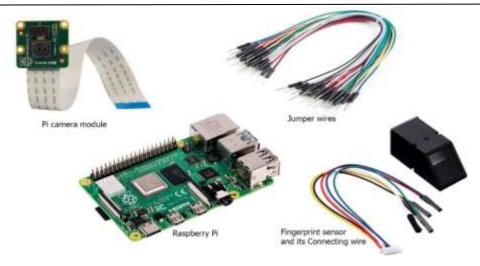


Fig. 2: Hardware tool used for the experiment

## B. Experimental Setup

In the previous section tools used for experimenting were discussed in detail. In this section, experimental activities were discussed in the following subsections.

1) Assembling hardware tools: As presented in Fig. 3, Jumper wires were used to connect edge devices with Raspberry Pi, the fingerprint sensor has four/six-pin wire (ground, voltage, transmitter, and receiver) was connected to the corresponding pin of Raspberry Pi, camera module ware connected to the camera port of raspberry Pi, HDMI cable to connect Raspberry Pi to displaying desktop screen and the USB cable connects raspberry Pi with direct current to provide power.

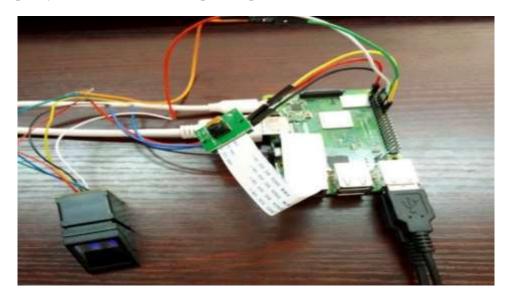


Fig. 3: Assembled hardware tools

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## C. Enrollment Phase

The main aims of the study were addressed in this enrollment phase. In this phase, how users' image was collected as a dataset of the study, image processing steps, and CNN layer were discussed in detail: -

1) Datasets (image acquiring): Datasets used in this research study were the image of the user's facial image and fingerprint image as presented in Fig. 4 and 5. Those images are captured by the Pi camera module and fingerprint sensor devices which means all the data sets used for the experiment were primary data. To get high accuracy in the proposed model prediction during the enrollment phase 50 users' face image with different (20) angle position was captured by the Pi camera module and two fingerprint images were captured by fingerprint sensor devices. The sample size of data is 50X20 = 1000 face images and 2X50 = 100 fingerprint images. The following Fig. 4 shows the collected data set of users.



Fig. 4. Sample dataset user's face image



Fig. 5. Sample dataset of user's fingerprint image

2) Pre-processing: first activity of image processing is capturing the image as a dataset. The face region was detected and cropped then resized to 200 X 200 on the face image. Image enhancement and minutiae extraction was applied as a preprocessing task on the fingerprint image.



- 3) Segmentation: segmentation task on the face image is responsible for converting a colored image (RGB) into a grayscale image and then transforming the image into a numerical data array by using the NumPy library. The segmentation process in the fingerprint image was responsible to remove unnecessary or unwanted data from the image. And then ridge flow estimation and region of interest of minutiae were considered under this task.
- 4) Feature Extraction: The feature extraction process was done by using a supervised deep learning method called CNN. The collected dataset of the user's image was split into 70% of the dataset as a training dataset and 30% used as a test dataset. To train the model CNN passes the following four layers: -
- *a)* Convolution layer: In this layer, the preprocessed image with 200 X 200-pixel resolution was multiplied by 30 X 30 filter images magically generated by CNN. In this case, 1<sup>st</sup> filtered image output becomes 171 X 171.
- b) Normalization/Activation layer: In this layer, non-linear functions called RELU were used to train the dataset and speed up the training process and reduce computational time.
- c) Pooling layer: The main aim of this layer in CNN is to reduce the dimension of an image which highly probably reduces computational time and avoids overfitting of a proposed model. The max-pooling method was applied to a normalized image. To reduce the dimension of an image, 20 X 20 Max-pooling was applied. So, the first-round max-pooling result was 152 X 152 pixels.
- d) Fully connected layer: The output of the pooling layer which is a 3D image was converted to a 1D image by applying the flatten method on the image. The output of this layer was used as the input layer for a neural network. The following Fig. 6 shows the summary of feature extraction.

#### D) Authentication Phase

The main responsibility of this phase is to check whether the captured face image and fingerprint was matching it from the created mode during the enrollment phase and then make a decision based on the output result. In this authentication process, the first three steps of the image processing task are similar to that of enrolling phase, but the difference is that there is no need to train the captured image rather it tests and then matches it from the trained model. Another difference is that in the case of enrolling phase RELU functions were used as activation functions for training the model, but in the authentication phase Regression function as optimizer and SOFT-MAX were used as the activation function for classifying images to corresponding users.



Convolutional Layer

200 X 200 (Original)

Activation Layer (Non-Linear)

Pooling Layer (Max-Pooling)

20 X 20 Maxpooling

Flatten

Input Layer

Hidden Layers

Output Layer

Fig. 6. Feature extraction using CNN

## V. Conclusion

IoT system is a highly growing technology that improves the quality of our daily life. So, to ensure the physical security of IoT systems and their operating technology, multimodal biometric authentication systems were designed. In this research work, the unimodal and multimodal biometric system is discussed in detail after the multimodal system is implemented by using CNN algorithms on both face and fingerprint images. The Relu function was used as an activation function and a max-pooling method for dimension reduction on both images. The softMax function was applied for classification. Three parameters of performance analysis were considered (Accuracy, FAR, and FRR). The result shows that accuracy is 92% and 89% for the face and fingerprint respectively, FAR is 1.35%, and FRR is 1.5%.

**Future works:** From the results of the experiment, it shows that the accuracy of the fingerprint image is 89%, which still has scope to enhance. So, this research work may be extended for improving the existing accuracy of results or by adding another biometric system.



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## Design and Construction of a High-Efficiency Biomass Charcoal Kiln in Ethiopia

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#### **Abstract**

This study aimed at the design and construction of a high-efficiency biomass charcoal kiln in Ethiopia. Traditionally, local communities in Ethiopia use a premival and inefficient technique of charcoal making to which very little scientific study has been directed. This conventional charcoal making process hasnumerous downsides with regard to rate of carbonization, quality, yield, pollution, labor, and land costs. The current research, therefore, aimed at the design and construction of a high-efficiency biomass charcoal kiln that reduces the above listed problems. Charcoa produced by both the traditional erth mound kiln and the newly designed and constructed improved carbonization kild were compared for their properties. The results showed the moisture content as (2, 0.89) %, the volatile matter (8.84, 3.02) %, the fixed carbon content (81.09, 91.42)%, the heating value (29.982, 32.762)MJ/kg, bulk density (342.53, 434.5)kg/m<sup>3</sup>, shatter resistance (88.8, 91.12)%, water penetration resistance (26.34, 17.99)%, ash content (8.06, 4.660)%, efficiency(16, 31)%, and production time per cycle(3, 5) days for conventional earth mound kiln and improved carbonization kiln, respectively. Based on these results, the improved carbonization kiln's carcoal displaed higest shatter resistance of 91.12% faring well in mechanical strength, and it has high-water penetration resistance meaning it has improved water absorption and a decent heating value. The increased density means the volume is decreased due to the leakage of volatile contents and more fixed carbon content. Lastly, the modified carbonization kiln's production was enhanced by 48.38%.

Keywords: Biomass, Carbonization, Construction, Charcoal, Design, Kiln, Molecular Weight

#### I. Introduction

In developing countries, wood is the most common residential fuel. As most developing nations have an agriculture-based economy, biomass fuels remain the main supplies of energy for both homes and

industries. Loads of small businesses, workshops, and family homes—especially in rural areas—depend almost entirely on biomass (like wood or crop waste) for their daily energy needs [2]. During the colonial period, farmers and landless laborers generated abundant charcoal for home consumption in third world nations in pit kilns (pits excavated in the ground) or mound kilns (heaps of wood piled on the ground and enclosed with dirt). Pit produces (weight of charcoal/weight of wood) range from below 10 to 25 percent [1].

Various carbonization procedures have been used to produce charcoal for thousands of years across the world. As depicted in Fig. 1, society employs an age-old underdeveloped technique of charcoal making that very little studies tried to investigate and improve via experimentation. We discovered during the field evaluation that the present charcoal manufacturing process is mound kilns (wood piles placed on the ground and covered with grass). However, these production systems are recognized to have several limits and drawbacks with regard to quality, produce, pollution, labor, and land costs. To address such issues, more efficient charcoal manufacturing methods must be developed[1].

When rubbed and handled, charcoal generated under poorly regulated carbonization conditions might be hard and brittle, or soft and crumbly. During kiln discharge and shipping, around 5 to 10% of such charcoal is typically reduced to fines and loss [3].

If wood is burned in the absence of oxygen, the chemical reaction is incomplete combustion with the creation of carbon monoxide[4],[5].

$$C+ \frac{1}{2} O2 \longrightarrow CO$$

The average charcoal production output from static kilns might reach 35%, whereas the lowest charcoal production yield from an earth mound kiln may reach 10%[6]. The goal of this project is to enhance the carbonization kiln that is used to carbonize carbonaceous materials to generate high-quality charcoal. [3].



Fig. 1: Local charcoal making (earth mound kiln) and cover straw



## II. Materials and Methods

#### A. Experimental Work

Various places were investigated to determine the disadvantages of conventional charcoal production. During the field evaluation, downsides were identified by seeing and interviewing the producers, as well as determining which type of carbonized kiln is best for producing high-quality charcoal depending on environmental circumstances and carbonized material shown in Fig. 2. Because bricks have a greater temperature resistance (7000 - 15000 °C), good corrosion resistance, availability, durability (6-10 years), and cheap cost, as well as ease of assembly, economy, fire resistance, rain resistance, and sun resistance. As a result, we use clay bricks as the primary building material for our small-scale carbonization kiln.

1) Conventional Charcoal Production: The conventional method was applied as shown in the Fig. 2



Fig. 2: Conventional earth mound kiln charcoal production experiment procedure

2) Improved Charcoal Production: The geometry was designed using solid work software (v18). The capacity of the kiln was 60kg and the geometry was designed based on this value. The construction of a carbonization kiln suited for local charcoal producers took into account several parameters, and it comprises the following elements. Wall thickness, smoke exit chimney, top cover (head), intake air vents, and antidowndraft are all features of the carbonization chamber. The amount of air that enters the carbonization chamber determines how quickly biomass is carbonized. The air holes were placed around the outside of



the carbonization kiln and depicted in Fig.3. It was controlled by placing air intake vents in strategic locations throughout the kiln. Because the carbonization process uses a finite amount of oxygen, we must restrict air entry by closing air input ports. The quantity of air supplied was managed by shutting and opening the air intake while keeping an eye on the smoke output. As depicted in Table I, the amount of air was calculated to carbonize the wood based on the flow rate of air. Volume flow rate (Q) = A (area)\* (v) velocity of air

$$Q = Axv \tag{1}$$

As depicted in Fig. 4, the area of inlet air needed for the kiln was determined by using anemometer velocity determination (Testo420i) averagely measured was 0.05m/s. The individual area for each two sides air inlet and the opening area is circular,  $A = \pi D2$ / hole number.

Table I: Specification of Prototype Biomass Carbonization Kiln

	Component	Specification, cm	Material
1	Carbonization chamber	L=W=H=89cm	Clay brick
2	Wall thickness	12cm	Clay brick
3	Head of the kiln	R =44.5cm,L=89cm	Clay brick
4	Chimney	H=205cm,L=12cm,W=6cm	Clay brick
5	Inlet air vent	D=4.15cm	Clay brick
6	Loading and unloading door	H =88cm, W=40cm,	Metal sheet
7	Chimney cover	D =40cm,H=15.4cm	Metal sheet

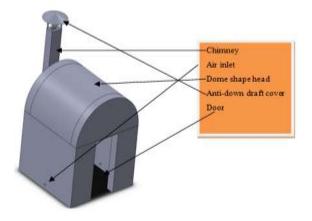




Fig. 3: (a) Model improved carbonization brick kiln. (b) Developed kiln

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Fig. 4: (a) Wood charging.

(b) Ignition

3) Performance evaluation: The performance of the kiln was performed using the following method tests the constructed kiln by producing charcoal.

## B. Mass Conversion Efficiency

$$Ek = \frac{MC}{MW} x 100 \tag{2}$$

Where Ek = kiln efficiency, MC = mass of charcoal produced, and MW = mass of wood put into the kiln

B. Bulk density

$$\rho = \frac{m}{v} \tag{3}$$

Where,

 $\rho$  = Bulk density of charcoal, kg/m<sup>3</sup>

m = mass of charcoal, (kg)

v1=Volume of charcoal inserted, m3

## C. Shatter Resistance and Weight Loss

The charcoal with known weight was dropped on the concrete floor from a height of one meter.

1) Weight loss (%):

$$W1 = \frac{w_1 - w_2}{w_1} x \ 100 \tag{4}$$

2) Shatter resistance, (%):

$$Sr = 100 - Weight loss$$
 (5)

Where: - w1 = Weight of charcoal before shattering (kg) and w2 is Weight of charcoal after shattering

#### D. Resistance to Water Penetration, %

Each charcoal sample was immersed in water for 30 seconds. The percentage of water gain was calculated as follows.

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Water gain (%):

$$Wg = \frac{w^2 - w^1}{w^2} 100 \tag{6}$$

w1 = Initial weight of charcoal (0.03kg) and w2 is the Final weight of charcoal

Heating Value (Hv)

$$HV = 0.3535FC + 0.1559VM - 0.0078AC$$
 (7)

Where:-FC is fixed carbon content, VM is volatile matter and AC is ash content [7]

## E. Fixed Carbon

The FC was calculated by subtracting the sum of percentage volatile matter (PVM), (PMC), and Percentage ash content (PAC) from 100.

$$FC(\%) = 100 - \% \text{ of } (MC + VM + AC)$$
 (8)

## F. Volatile Matter

After the sample was dried, it was left in the crucible, covered with a lid, and moved into the furnace, maintained at 950°C for 7 minutes. The crucible was first cooled in the air, put in aluminum foil, and weighed again. Loss in weight is stated as a volatile matter on a percentage basis.

$$(\%) = \frac{W2 - W3}{W2} 100 \tag{9}$$

Where, VM (%) = percentage volatile matter of charcoal, W2 = oven-dried sample weight of charcoal, and W3 =weight of the sample after furnace used.

#### G. Ash Content

The remaining sample in the crucible was reheated without a lid in the furnace at 750 °C for five hours. Then the crucible was removed, cooled first in the air, then weighed in mass balance.

$$Ash (\%) = \frac{W2}{W1} 100 \tag{10}$$

Where, W1 = Initial weight of the oven-dried sample (g), W2 = Wight of ash (g)

AC(%) = percentage ash content.

#### III. **Results and Discussion**

## A. Comparison of Charcoal by Proximate Analysis

It was observed that the volatile matter of the charcoal produced in the earth mound kiln and improved carbonization kiln were 8.84% and 3.02% respectively. These show that the volatile matter of conventional earth mounds was higher than the improved carbonization kiln. Former literature [8] states that good



charcoal has volatile matter below 30%. So, the results obtained agree with the literature. As the temperature increases the volatile matter decreases.

It was observed that the average ash content of the conventional earth mound kiln and improved carbonization kiln was 8.06% and 4.66% respectively. The average ash content in the earth mound kiln was higher than the improved carbonization kiln. From the literature, the recommended good-quality charcoal contains an ash content of less than 5% [8]. Improved carbonization kiln has lower ash content than conventional earth mound kiln.

It is observed that the heating value of charcoal produced in the earth mound and improved carbonization kiln was 29.982 MJ/kg and 32.762 MJ/kg respectively. The heating value of the improved carbonization kiln obtained was higher than that obtained in a conventional earth mound kiln. The higher result obtained was due to the low moisture content and low ash value. Using equation (6) the above results were calculated and summarized in Table II.

Table II: Average Proximate Analysis Value

No	Parameters	Earth mound	Improved kiln
1	Moisture content, %	2	0.89
2	Volatile matter, %	8.84	3.02
3	Ash content, %	8.06	4.66
4	Fixed carbon, %	81.09	91.42
5	Heating value MJ/Kg	29.982	32.762

#### B. Mass Conversion Efficiency

The percentage mass conversion efficiency shown in Table III was used to compare the performance of an improved carbonization kiln with a conventional earth mound model charcoal-producing method. The findings demonstrated the mass conversion efficiency of two different charcoal manufacturing processes. The mass conversion efficiencies of the earth mound traditional one was 31% while that of the improved kiln was 16%. The production cycle per batch was 3 and 5 days for the earth mound and improved kiln respectively. The result from the earth mound kiln was 16% which agreed with the literature [1],[2]. This reduces the amount of charcoal product because, in the combustion process, the main output is heat [9].

When compared to mound kiln charcoal, enhanced carbonization brick kiln charcoal had a higher shatter resistance (91.12 %), indicating its appropriateness for transportation. Water sprayed directly on charcoal reduces its mechanical strength, making it easily breakable. They have strong shock, impact, handling, and

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transportation resistance, as evidenced by their high shatter (91.12 %) and water penetration (17.99 %) as shown in Table IV. The cause for the lower Shatter resistance in the earth mound kiln (88.8%) was attributed to the spraying of cold water on the hot surface making the charcoal become cracked and easily breakable.

Table III: Charcoal Yields and Production Cycle

Kiln type	Mass of wood	Mass of	Conversion	Production cycle
	(kg)	charcoal (kg)	ratio,%	per batch
Conventional	60	9.6	16	4 day
Improved	60	18.6	31	5day

Table IV: Comparison of Charcoal Based on Physical Properties

No	Properties	Earth mound kiln	Improved carbonization kiln
1	Shatter resistance, %	88.8	91.12
2	water penetration,%	26.34	17.99
3	Bulk density kg/m <sup>3</sup>	384.6	434.5

## IV. Conclusion

Carbonization is a thermochemical process that involves heating biomass at a high temperature with a small quantity of oxygen to produce solid fuel, such as charcoal. The kiln was equipped with air vents around the perimeter, a carbonized material intake and exit, an anti-downdraft system, and an exhaust chimney. In this research, experiments were conducted to compare the performance of the enhanced carbonization kiln to that of the earth mound kiln. With regards to creating a solid fuel, the improved carbonized kiln was constructed from burnt clay brick and has been found to have greater conversion efficiency, high heating value, low moisture content, environmental adaptability, reduced labor force, non-seasonal intermittent, and low cost. In general, the yield or conversion efficiency of a conventional earth mound kiln is enhanced by 48.38 % when employing an improved carbonization kiln. In this, the improved brick kiln needed 2 days for carbonization and 1 day for cooling. An enhanced carbonization kiln had a bulk density of 434.5 kg/m³ while a conventional earth mound kiln had a bulk density of 384.6 kg/m³. This indicates that the improved carbonization kiln performs nearly twice as well as the traditional earth mound kiln. As a result, we concluded that an enhanced carbonization kiln is a viable option for carbonizing biomass in both local charcoal-producing communities and at home.

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## Adobe with Termite Mound Soil for Sustainable House Construction in Gambella

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#### **Abstract**

The Gambella community in Ethiopia uses their indigenous knowledge of mixing termite mounds soil with locally available straws to build their mud houses. Mud houses constructed with termite mounds are comparatively stronger than those prepared with other soils, but they have severe durability issues due to shrinkage cracks that necessitate regular maintenance which is not affordable by many. This research paper presents technology intervention to resolve these issues faced by the community by introducing an alternative method of house construction called adobe. As part of this research 144 blocks of adobes were cast by using locally available materials and their performance was evaluated by conducting several strength and durability tests. The experimental results revealed that adobe prepared with termite mounds soil, 1.5% straws, and 2.5% of binder provides excellent strength and durability. The compressive strength was measured to be 2.6 MPa. Enhanced durability in terms of reduced shrinkage (17%), a low initial rate of absorption (0.29), and water absorption (0.26) were found in the adobe blocks. This indicates adobe is certainly the best solution to the existing houses' durability issues and a best-class sustainable solution for the construction of houses in Gambella, Ethiopia.

Keywords: Adobe, Chikka Bets, Compressive strength, Durability, Mud Houses, Straw

#### I. Introduction

As per the indigenous knowledge of the Gambella community of Ethiopia, termite mound soils are the most suitable soils to build their traditional mud houses. Another perspective of the existing mud houses is the overconsumption of wood leading to large-scale deforestation thereby creating a negative impact on the environment along with soil erosion. There has been some research conducted in past to come up with Adobe blocks using locally available soil and straws along with a suitable binder [1], [2], [3] and the results are promising. So, in this research work an attempt has been made to make technical interventions to resolve

the issues faced by the Gambella community regarding their house construction. This research work also aimed at identifying the suitability of termite mound soil, optimum percentage of binder, and reinforcing agents for preparing the adobes to achieve the maximum strength and durability from the adobe houses along with avoiding the shrinkage cracks. The issues related to mud houses have been presented in Fig. 1.



Fig. 1: Major issues related to mud houses

#### II. Materials and Methods

The materials employed in this research were termite mound soil, straws, cement, and water available in the vicinity of the study site. All the tests were conducted as per Indian standards.

## A. Laboratory Tests on Termite Mound Soil and Local Straws

To make the adobe units, soil taken from the Nuer zone of Gambella town after consultation with the Gambella community for their most preferred soil to build houses were used as presented in Fig. 2.



Fig. 2: Material procurement

Soil tests were carried out by using ASTM standard procedures [4],[5] and soil classifications are identified according to the unified soil classification system (USCS) as presented in Fig. 3 below. The soil properties are a Natural Moisture Content of 19.21%, Air-dry Moisture Content of 15.25%, Specific Gravity of 2.64, Liquid Limit of 38%, Plastic Limit of 19%, Plastic Index of 19, Maximum Dry Density of 1.78gm/cc<sup>3</sup>, and Optimum Moisture Content 15.5%.





Fig. 3: Soil and straw properties testing in the laboratory

The locally available straws are agriculture wastes plentily available in Gambella and used as the roof material for traditional houses. Water content analysis, specific weight analysis, and water absorption rate analysis were done on the straw fiber. The experimental test results are Cross-section (Circular), Length 30mm, Range of Diameter 0.2-1.2mm, Specific Weight 0.67g/cm<sup>3</sup>, Natural Moisture Content 13.24%, Water Absorption in 5 minutes (g/min) 0.71, Water Absorption in 10 minutes 0.372(g/min), and Water Absorption in 1 hour 0.062(g/min).

PPC Dangote cement with a compressive strength of 32.5 MPa was employed in this study. It is highly durable cement with less cost and less emission of carbon dioxide compared to OPC cement. As the main ingredient in the production of the Adobe units., potable water without contaminants and taste that is odorless was used.

## B. Preparation of Adobe Units and Mix Proportions

All adobe units prepared for this research have a brick shape as presented in Fig. 4. One hundred forty-four (144) adobe units were prepared and cured by air-drying. The adobe unit samples were prepared with the dimension of 190mm x 90mm x 90mm. The mix of adobes has been presented in Table I.



Fig. 4: Preparation of adobe units



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Table I: Mix Proportion of Different Adobe Mixes

Sr. No	Denotation	Soil (%)	Cement (%)	Straw (%)
1	A	97.5	3.5	Nil
2	В	97.5	3.5	0.5
3	C	97.5	3.5	1.5
4	D	97.5	3.5	2.5
5	Е	97.5	3.5	3.5

## C. Strength Tests

- 1) Compressive strength test: The compressive strength test was done to find out the amount of compressive load the adobe units can bear without fracturing and to define the stress-carrying capacity of adobe units as shown in Fig. 5. The tests of compressive strength and stress-carrying capacity of theadobe unit specimens were done after 28 days of air curing and drying.
- 2) Water strength test: The water strength test determines the water strength coefficient for wet and dry compressive strength of adobe unit trial specimens. This test was carried out for all adobe unit trial specimens after 28 days of curing and air drying as presented in Fig. 6.

## D. Durability Tests

- 1) Shrinkage test: Before drying and after 28 days of dry curing, the shrinkage test is deone to determine the volume change of adobe unit trial specimens. The volume of the adobe specimens was measured immediately after the casting of the adobes and allowed to dry cure for 28 days. The volume of the adobes was again measured after 28 days.
- 2) Water absorption by capillarity: The water absorption properties of adobe are determined by conducting a water absorption test according to BS EN 772-11 as presented in Fig. 7.



adobe block



Fig. 5: Compressive strength test on Fig. 6: Adobe block for water Fig. 7: Adobe block for water strength test



absorption test



## **III. Results and Discussions**

## A. Soil Test Results for Optimum Stabilizer

Table II indicates the test outcomes of the standard proctor test of soil-cement mix differ with cement amounts of 0%, 2.5%, and 3.5%. Hence, the adding of 2.5% cement is an ideal value that will be employed in adobe mixes since it has provided maximum dry density.

Table II: Standard Proctor Test to Find Optimum Amount of Cement

Mixes	Maximum Dry Density (gm/cc)	Optimum Moisture Content (%)
Soil	1.74	15.6
Soil + 2.5% Cement	1.78	15.1
Soil + 3%Cement	1.72	15.8

## B. Compressive Strength Test Results of Adobe Units

From Table III, it can be clearly seen that with the inclusion of straws in the adobes, the compressive strength increases, and the maximum strength can be observed for Mix C (Soil+2.5% Cement+1.5% straw fiber). The compressive strength value demanded by international standards for traditional Mudbrick is 1 MPa and for Mix C it is 2.6 MPa. This implies that the locally available termite mounds soil and straws can serve as ingredients to produce adobe units for house construction.

Table III: Compressive Strength of Adobe Units at 28 Days Curing Period

Sr. no.	Mix	Compressive strength in MPa
1	A	2.27
2	В	2.29
3	C	2.6
4	D	2.4
5	E	1.99

## C. Water Strength Test Results of Adobe

Water strength test results of the different adobe mixes have been presented in Table IV. The minimum permissible value of this coefficient is 0.5. The test results indicate that mix C (Soil+2.5% Cement+1.5% straw fiber) has the highest water strength value of 0.58. This indicates that the strength loss in adobes after exposure to wetting is lowest for Mix C.

Table IV: Water Strength of Adobe Units at 28 Days Curing Period

Sr. no.	Mix	Water strength
1	A	0.46
2	В	0.51
3	C	0.58
4	D	0.53
5	E	0.52

## D. Shrinkage Test Results of Adobe

Shrinkage test results of the different Adobe mixes are presented in Table V. It can be clearly seen from the test results that with the increase in fiber contents, the shrinkage is reduced. This indicates that the locally available straws have a positive influence on arresting the shrinkage cracks.

Table V: Shrinkage Test Results of Adobe Units

Sr. no.	Mix	Reduction in volume (%)
1	A	22.44
2	В	19.61
3	C	17.96
4	D	17.25
5	E	16.12

## E. Water Absorption Test Results of Adobe

Water absorption test results of the different adobe mixes are presented in Table VI. The test results clearly show that with the increase in fiber contents, water absorption is reduced. This indicates that the locally available straws have a positive influence on arresting the water absorption of mud blocks.

Table VI: Water Absorption Test Results of Adobe Units

Sr. no.	Mix	Absorption [Kg/(m² × min)]
1	A	0.46
2	В	0.52
3	C	0.44
4	D	0.26
5	E	0.32



## **IV. Conclusions and Recommendations**

Based on the experimental investigations of this research, the following conclusions have been made.

- The termite mound soils have better strength compared to other soils because of the high calcium content which is released from the termite saliva.
- Cement is the most suitable binder for the termite mound soils for adobe preparation.
- The optimum percentage of the binder for the termite mound soil is 2.5% by weight.
- The optimum percentage of straw for the preparation of adobe is 1.5% by volume of the soil mass.
- The optimum combination of adobe constituent materials from a strength and durability perspective is soil, 2.5% cement, and 1.5% straw.
- The introduction of straws as reinforcing agents enhances the shrinkage resistance capacity and water resistance capacity of adobes.

The utilization of Adobe as building construction technology is cost-effective and would help in reducing the dependency on wood for the construction of mud houses thereby reducing deforestation.

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## Designing a Framework for Cyber Protection based on Unique Identification to Improve the Security of Ethiopian Social Media Users over Facebook

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## **Abstract**

Social media platforms such as Facebook, which has over 2.6 billion monthly active users, play a major role in global communication. However, Facebook users often face various security threats, including impersonation and the spread of false information. In Ethiopia, these issues have become increasingly prevalent. Therefore, it is essential to develop effective countermeasures to address and mitigate such challenges. This research aims to develop a Unique-ID-based Cyber Defense Framework designed to strengthen the security of Facebook users and prevent the creation of fake profiles and impersonation by malicious actors. This study employed an exploratory and constructive research design, utilizing surveys and in-depth interviews, to develop a Unique-ID-based Cyber Defense Framework. The proposed framework leverages Addis Ababa's Digital Residential ID to authenticate users by cross-referencing their information with a resident database. A prototype was developed and tested, with 87% of respondents accepting the solution as a positive contribution to cybersecurity. The system is designed to verify user uniqueness during Facebook account creation, thereby preventing the establishment of fake or duplicate accounts.

**Keywords**: Country Code, Cyber Defense, Facebook, Fake Profile, Impersonation, Unique Id, Security Threat

## I. Introduction

Accessing information anywhere, any time, and in any condition without the restriction of location was one of the features of the 21st century. Social media is now among the most influential media for the transmission, dissemination, and exchange of information and knowledge. It is used by billions of users to network with other users [1] [2]. Social networking platforms, including Facebook, LinkedIn, and Twitter, have emerged as predominant global communication channels, experiencing exponential user growth. There are more than 3.81 billion active users of social media networks today. Of all social media, Facebook is the largest with 2.6 billion monthly active users. Users of the maximum social media network have more than 200 friends [3] [4]. In addition to its benefits, social media has several drawbacks including security risks. The key problem with social media is the presence of fake accounts and online impersonations [5],

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especially on Facebook. As there is a lack of effective identity-proving mechanisms, anyone can set up a fake profile in the name of someone else to post negative and offensive content through the account [6]. Fake accounts are created to access people's information and post fabricated content since not all Facebook users check and verify the accounts before accepting the request from them [2] [7] [8].

Social network operators use several authentication methods to ensure that the individual registered on the social network is a natural person. Methods such as CAPTCHA, recognition of friends' images, and multifactor authentication are used [5] [19] [11]. On Facebook, with multiple profiles, a single user can represent his identity because there is a lack of an effective identity verification process [12]. Facebook currently serves mainly as a channel for hate speech, intolerance, and increased discrimination against a specific ethnicity, religion, or gender [11]. In Ethiopia, Facebook's spread of hate speech and disinformation has grown exponentially in a couple of years. In January 2020, there were 6.20 million social media users in Ethiopia, as described by the study of world internet statistics 2020. Facebook is, therefore, the most prevalent use, and more than six million people use Facebook in Ethiopia [13].

There is a lack of methods for checking the source, which means it is difficult to trace the identity of the account owner [14]. Currently, there is a lack of effective Facebook user virtual identity verification frameworks. By using this chance bad users create fake accounts and impersonate someone to disseminate fabricated information that is targeted and discriminates against individuals or groups based on their ethnicity, religion, and gender. Ethiopia has also suffered from Facebook because it acts primarily as a channel for hate speech, intolerance, and increased prejudice against a specific race, religion, and gender. Thus, these issues are causing tension between governments and individuals. In 2016 the Ethiopian government blocked Facebook many times because it was causing extensive instability in the country. Because misinformation can spread quickly via Facebook, the government confirmed to block social media totally from the country to stop the spread of hate and ethnic cleansing propaganda messages. Therefore, this shows Ethiopia's internet control operates mainly outside of a formal regulatory framework by blocking the internet totally from the country. And this is not effective, efficient, or productive. For example, Brookings Institution's report shows that Ethiopia, between mid-2015 and mid-2016, lost t \$9 million US dollars due to internet shutdowns.

Therefore, this researcher motivates the researchers to build a system that can improve the verification of user identity on Facebook by developing an improved framework for enforcing the users to create their accounts with their genuine information. The implementation of the unique identification of user identity on Facebook for account creation and login is addressed in this research paper.



## **II.** Literature Review

Table I: Review of Related Works with Critical Remarks

No	Authors	<b>Significant Contributions</b>	Critical Remarks
1	Michail Tsikerdekis and Sherali Zeadally [18]	The researchers tried to discuss how to decrease identity deception by securing social media design and applying psychological pressure to deceivers. To prevent deceivers, they recommended different techniques like biometric authentication is one of them.	This paper tried to discuss how to decrease identity deception by securing social media design and applying psychological pressure to deceivers. To prevent deceivers, they recommended different techniques like biometric authentication is one of them. The study was very relevant to our paper. However, it failed to explain how to verify the authenticity of the user identity, especially for Facebook, to prevent fake or forgery account creation and they missed explaining how to evade social media problems
2	Nadir AI Naqbi, Nail AI Momani, and Amanda Davies [19]	This paper explored the influence of social media as a threat to national security-related issues like social, Economic, and political disorders. This paper suggested the community awareness	This paper is relevant to our study. This research explored Arab Emirates data to discuss how to decrease identity deception by securing social media design and applying psychological pressure to deceivers. To prevent deceivers, they recommended biometric authentication.
4	Amitvikra m Nawalagatt i [20]	This study discusses the adverse impact of social media on users' privacy and security. In this paper, researchers tried to explain that social media are not suitably monitored and accounts are not properly verified. The study revealed many threats created by social media and proposed solutions	This study was very focused and found interesting to our research. The solution proposed by this research is very shallow and does not provide any concrete solution to secure the users' privacy like creating a strong password by complex combinations of alphabets, characters and special characters along with strong authorization on network access etc.



## III. Research Methodology

This study employed a mixed-methods research design, combining exploratory and constructive approaches. Both qualitative and quantitative data were collected to gather comprehensive and relevant evidence. Therefore, a structured questionnaire and In-depth interview were prepared and distributed among selected social media users, and interviews were conducted with INSA.

#### A. Data Collection Procedures

The summary of data collection methods from both primary and secondary data sources is described in the following Fig. 1.

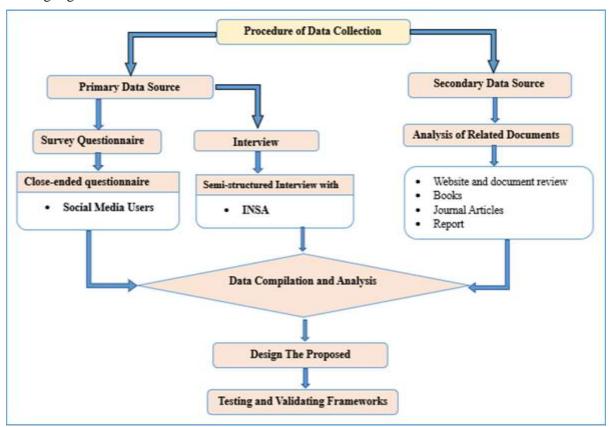


Fig. 1: Summary of data collection methods

## **B.** Sampling Design

This study used the purposive sampling method. The person who does use social media in Ethiopia had the chance to be included in the study. This research study's sample size was 342. Three hundred thirty-eight (338) social media users were chosen for the survey questionnaire and 4 for the interview to collect the primary data.



#### IV. Data Analysis and Discussion

#### A. Demography of the Respondents

Fig. 2, shows the data of the respondents' demography like gender, age, occupation and education levels.

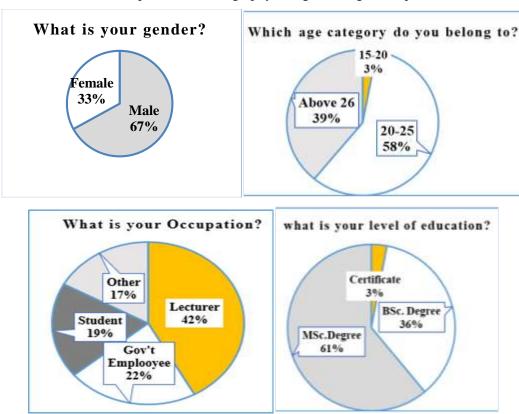


Fig. 2: Respondents' Demography Pie charts

#### How do you rate your participation in discussions on social media, especially Facebook?

As illustrated in Fig. 3, a majority of users do not participate in discussions on Facebook. This lack of engagement can be attributed to several factors.

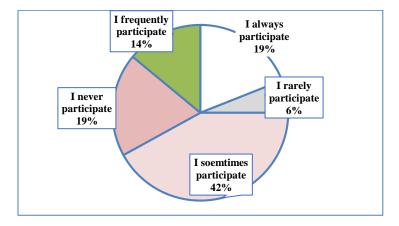


Fig. 3: Participation rate of respondents on Facebook



If your participation in discussions is minimal, what prevented you from engaging in discussions on Facebook?

This follow-up question asks respondents to explain their minimal participation on Facebook, as indicated in Fig. 3. Fig. 4 result implies that the reason why respondents' participation is minimal was that Facebook became the Media on which fake information can be propagated.

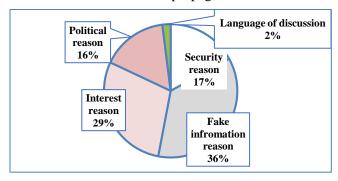


Fig. 4: Reasons that prevent the respondent from participating on Facebook

#### What kind of information do you give to open a Facebook account?

As Fig. 5 shows the maximum number of respondents are not providing truthful information, and this specifies the existing security checking gap on Facebook. 62% (real/genuine) is greater than 38% (fake) but when we see the effect level of this amount, it is very big.

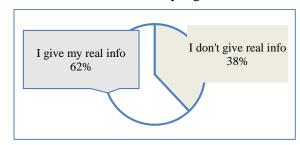


Fig. 5: Rate of access behavior of Facebook by Respondents

#### Do you trust the information you get on social media especially on Facebook?

The phenomenon on Fig. 6 confirms that the source of information propagated on Facebook was not trusted as verified and authenticated.

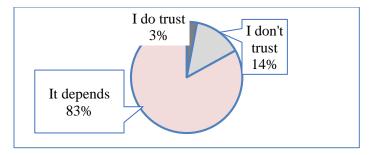


Fig. 6: The rate of trust in the information from Facebook



#### Can you believe that the current Facebook page verifies the real identity of the users?

As demonstrated in Fig. 7, existing Facebook security requires an immediate framework to enhance user protection. The primary recommendation is the implementation of a system that solves identity verification and authentication, thereby preventing identity theft by ensuring a strict match between a user's physical and digital identity.

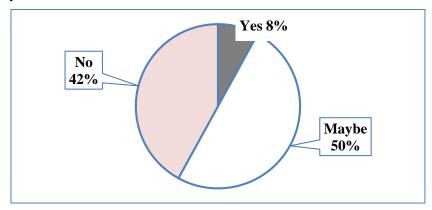


Fig. 7: The rate of identity verification of Facebook

## Can you believe that the required information to create an account on Facebook is enough to avoid fake accounts and duplicate account creation?

As Fig. 8 shows, the highest number of respondents responded with "NO," which means the current Facebook page was easy for creating a fake or duplicate account as described in the literature review part.

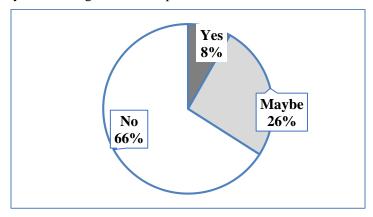


Fig. 8: Rate of respondents on duplicate and fake accounts inhibition way of Facebook

Can Facebook features such as anonymity and ease in having fake accounts, names and identities facilitate the discourse of hate speech as these features help the abusers go undetected and unpunished in our country?

The result on Fig. 9 shows that Facebook can be the instrument of hate speech dissemination and does facilitate and become a safe port for individuals, groups, and activists who intend to post toxic or offensive ideas. 61% of respondents have responded by agreeing.

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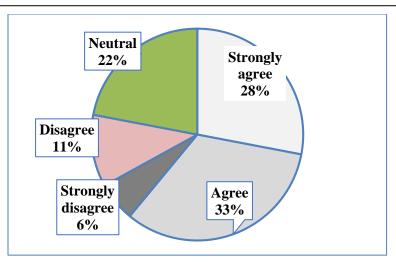


Fig. 9: Rate of respondents on the facilitation of hate speech by Facebook.

## Currently, in our country, are there political activists with an interest to destabilize the country that are going to abuse Facebook features for getting speedy and vast audience connectivity?

Fig. 10 result specifies that there was a significant and vital need to develop an improved security framework that enhances the existing unique verification mechanism of Facebook accounts to satisfy the user's requirements. This can be done by bringing in a suitable alternative to control and prevent those who use Facebook for illegal activity from abusing Facebook features.

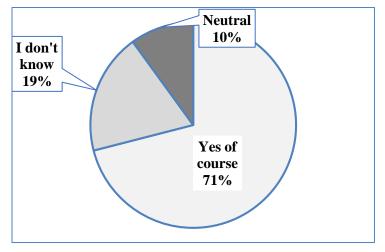


Fig. 10: Rate of respondents on the facilitation of political activists with an interest to destabilize the country by abusing on Facebook.

#### Why did the government block Facebook and other related media in the past few years?

The phenomenon on Fig. 11 indicates a strong need by Facebook users to develop an advanced framework that enhances the security on Facebook to prevent Facebook from becoming the media on which hateful information was propagated and to achieve stability and security for society.

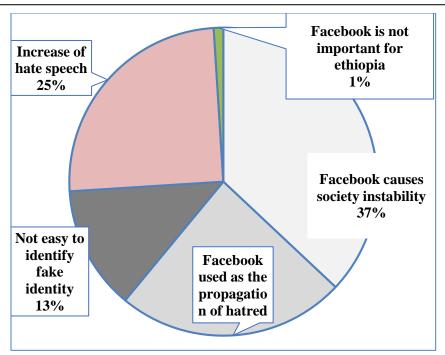


Fig. 11: Rate of respondents on the reason for blocking the Facebook site

#### How often do you use Facebook?

As per the results on Fig. 12 below, the maximum number of people are using Facebook as media in which they post their everyday thoughts, feelings and activities.

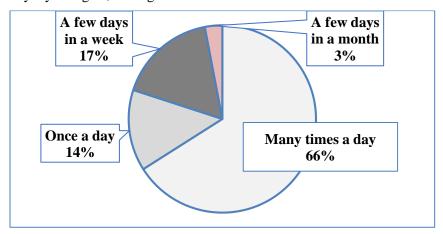


Fig. 12: The rate of how often the respondents use Facebook.

#### For what purpose are you using Facebook?

The phenomena on Table II indicate that the maximum number of respondents are using Facebook for the excellent purpose that was appreciated. Still, some respondents use Facebook for illegal purposes like posting about political discrimination, posting information on touching others' religion, and negatively criticizing the government using the account created by Fake evidence.





Table II: Purpose of Using Facebook By Respondents.

Purpose of using Facebook by respondents	Frequency (%)		
To read news	32.65%		
To know about a friend's life	25.49%		
To share political, dissect	19.44%		
To criticize the government	3.04%		
To present political ideas	6.13%		
Discuss the issue of cultural identity	5.10%		
Commenting on people who are impacting my religion	8.15%		

### Do you check the source of the message before liking, reacting to, sharing or commenting on the post when using Facebook?

Fig. 13 indicates that the maximum number of users on Facebook accept the content without checking the truthfulness of the posted information.

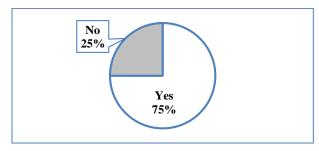


Fig. 13: Rate of respondents that are checking the source of content on Facebook

Do you agree that Facebook plays a substantial role in catalyzing hate speech, discrimination in society, increasing instability, and lack of peace in our county?

The phenomenon on Fig. 14 suggests a strong need for an urgent mechanism to restrict scammers from fake information dissemination on Facebook.

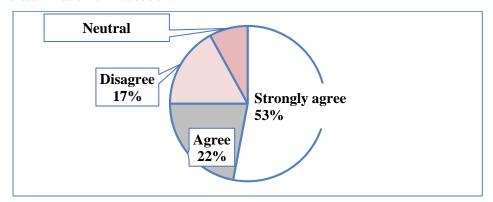


Fig. 14: Rate of Respondents on Facebook used as the publication of the dangerous idea

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### Would you need improved frameworks that enhance the security checking for verifying user identity on Facebook?

The percentage on Fig. 15 indicates that the highest number of respondents or the highest number of Facebook users need an urgent development of a better-quality regulatory and control framework to enhance users' security and to prevent Fake accounts and duplicate account creation.

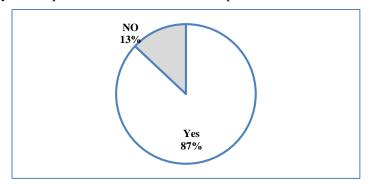


Fig. 15: the need for improved security Frameworks on Facebook

#### V. Developing a Regulatory and Control Framework

#### Proposed Solution and its functionalities

This research paper introduces an innovative solution to protect and prevent creating a fake profiles, duplicate or redundant accounts, and impersonation. This research study presents a new concept to identify whether the users are providing factual personal information uniquely or not. The items that can be used to verify the user's identity should be unique.

#### VI. Results Discussion

#### Creating a Profile on Facebook

First, the user accesses the Facebook platform through the internet and completes the registration form. In addition to the standard information typically required, two additional attributes are introduced to verify whether the user's input matches the official data stored in the country's digital residential ID card database. After filling out the form, the user submits the information to the Facebook server by clicking the registration button.

Next, the Facebook server performs data validation before allowing the account to be created. Server-side authentication and verification processes are carried out to confirm the accuracy of the user-provided information. The submitted data is cross-checked against the national digital residential ID database to determine whether the individual exists in the system. This verification process uses a unique ID as the primary key and the country code to identify the user's location during account creation.

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for giving proper unique identifiers.



This takes place every time a new user tries to create an account on the Facebook server. Generally, as everybody cannot provide an identity card independently, the institutions that have authority are responsible

#### Login to Profile

The login process was similar to the existing one.

#### Significant Components of the Proposed Framework

Fig. 16 illustrates the general framework for enhancing Facebook account security through digital ID verification. The architecture is divided into two primary sides—the User Side and the Server Side—each comprising specific components with distinct functions, as detailed below.

#### **User Side Components:**

- User: An individual attempting to access or use the Facebook platform.
- **Internet:** The global network facilitating communication between the user and online services.
- Facebook Website: The social networking site where users connect and share content.
- **Sign-Up Form:** The interface for new account registration, which in this framework collects essential details including name, country code, phone number, Unique ID, gender, date of birth, nationality, and password.

#### **Server Side Components:**

- Facebook Server: The central repository for storing and managing user account data.
- Server-Side Authentication & Verification Module: The core security component that validates user-provided information.
- Addis Ababa City Digital Resident Database: The official registry containing the digital residential information for all persons living in Addis Ababa.
- **Middleware:** System software that enables seamless integration and communication between the Facebook server and the external resident database, resolving issues of platform heterogeneity.

#### **Authentication Process & System Responses:**

- **Verification SMS:** A one-time password (OTP) sent to the user's registered phone number to confirm profile ownership as a final verification step.
- Authentication Success (Ok): A confirmation message returned if the user's provided personal information matches a record in the Digital Resident Database.
- **Authentication Failed:** An error message returned if the user's provided information does not match any record in the Digital Resident Database, preventing account creation.

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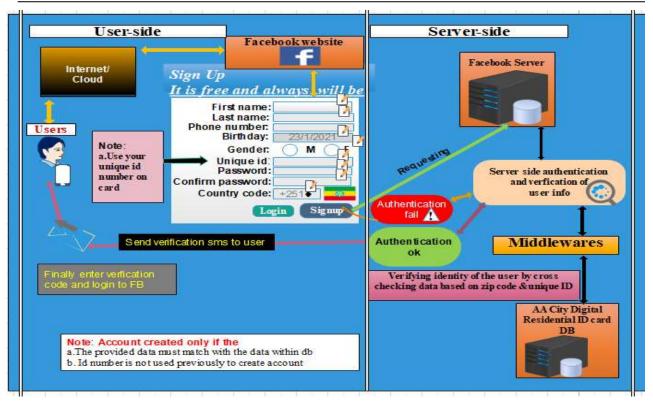


Fig. 16. Unique-ID-based cyber defense framework for enhancing the security of Ethiopian Facebook users.

#### Prototype Development

In this part, the developed system framework's functional prototype was presented. Fig. 16 shows the screenshots of the demonstrated prototype and Fig. 17 shows the Login page.

#### Design Description of a Prototype for Mobile Devices



Fig. 17: Facebook login through Mobile on Prototype

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#### VII. Conclusion

The main objective of this study was to identify and analyze, from a security perspective, the deficiencies and challenges of the current state of social media, particularly in Facebook, and then develop a regulatory and control framework to improve the security checking technique for Facebook users. After primary data was collected using a survey and interview and analyzed together with secondary data, the researcher concluded that there are problems in Facebook user identity authentication and verification in our country and worldwide. Then the researchers' domain professional interview and social media users' survey responses concluded that the problems and challenges are destructive issues and require earnest and robust solutions by adding some functionality to the current Facebook user framework to save the generation from the act of unethical and malicious usage. The finding shows that the current Facebook user authentication and verification are vulnerable. They need strong attention to improve through scientific solutions. The current practices' challenges are identity theft, fake information dissemination, hatred of information propagation, impersonation, etc. In general, the recent Facebook security practices are found to be insecure. There is a lack of user identity proofing. It was used as the media in which fake accounts can be easily generated and used to disrupt society.

Based on the findings, the researcher designed the Unique-ID-based cyber defense framework for enhancing the security of Ethiopian Facebook users. The proposed Frameworks use a unique item or attribute representing only one person like the country code and UNIQUE ID number issued for the residents. This could be tremendous and significant to resolve the issues mentioned above and challenges with immediate effect on ground reality. Generally, this new framework that uses the unique user attribute, UNIQUE ID number on digital residential ID by the city and country code of the country, can restrict the user from creating a fake and duplicate account and impersonation problem via cross-checking the user-provided data with already stored data on the city database. The newly developed framework to enhance Facebook users' security by checking can do this task and ensuring that only verified users could be able to create an account and that user who provides unreal or fake information cannot create Facebook accounts. In the future, the researchers can focus their attention on user data security and privacy issue and come up with additional items that uniquely identify the users. Additionally, it is also recommended that upcoming researches have to focus on the more profound and broader inquiry of preventing identity theft happening by wrong Facebook users locally and worldwide.



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## Synthesis and Characterization of Mechanical and Physical Properties of False Banana ('ənäsätə) Fiber Reinforced Composite Material

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#### **Abstract**

The use of environmentally friendly materials has recently been promoted due to increased awareness of environmental issues. To offer a better world for future generations, we must decide what we will utilize and serve today. As resources and products reach the final stage of their usability, the preservation of remaining materials and reduction of degradation emerge as challenges that must be addressed. Biodegradable materials produced from recyclable resources deal with these issues. This study intends to make a recyclable resource of false banana ('ənəsätə) fiber as reinforcement with polyester resin composite material produced by hand lay-up method at room temperature. The mechanical and physical properties of the produced sample were investigated. include tensile, flexural, impact strength, and water absorption. The fiber surface was treated with NaOH alkaline in distilled water solution. In composites, the fiber orientations were 0°, 90°, 45°/-45°, 0°/90°, and chopped, at 40% fiber volume fraction. The sample's manufacturing process was accomplished fruitfully. A chopped sample is a simpler production process compared to the other. As the result, 0° fiber direction scored the highest tensile strength, which is 181.41MPa. In the flexural and impact strength test, a 90° oriented fiber was observed with the highest value, which is 81.43 MPa and 9.75 joules, respectively. The samples were immersed in distilled water until saturated. The highest percentage of water absorption was 45°/-45° oriented fiber. Many researchers have recently shown interest in natural fiber composites material for aerospace and automotive applications, such as aircraft radomes and interior cabin components, as well as remarks on natural fiber composites' future trends and problems. This article provides readers with a positive perspective and piques industry players' interest in the potential of using natural fiber composites in aerospace applications to improve current aerospace material performance, particularly in terms of lightweight and environmental sustainability.

**Keywords:** Composite, Fiber, Manufacturing, Matrix, Reinforcement, Sustainability

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#### I. Introduction

According to [1] composite material is basically a combination of at least two different materials, engineered to create superior properties—the whole being much better than the individual pieces. These materials are primarily chosen for manufacturing parts because they offer outstanding weight savings combined with impressive stiffness and strength [1]. The composites industry is constantly pushing limits by developing new products and processes, such as combining brand-new fibers with recycled ones and moving toward faster, more automated production [1]. However, like any engineered material, composites come with unique advantages and disadvantages that must be carefully weighed during the design and selection process [1]. Fiber extraction has been done from 'enesate (False banana), sisal, jute, and banana for producing new ecofriendly and recyclable composite materials referred to as 'Green Composites' [2]. Recent research in natural fiber composites has resulted in a major change in renewable-source fabrics and increased support for global sustainability. These natural fiber composites possess moderate strength and thermal stability when they are recyclable, but they need specific application deals with particular places.

The need for renewable fiber reinforcement composites was increased in the last decade. The literature contains several studies on the manufacture of composite boards using particles or fibers from a different source and synthetics binder for bonding the fibers. Composite materials focused their attention on a lightweight natural fiber composite to create economical and lightweight engineering applications. Natural fibers were found in large amounts in nature, and their biodegradability features, their contribution to global environmental sustainability, the fact that they are economical, and have a good balance between mechanical properties and lightweight makes them preferable [3]. The treatment of composite materials is aimed at improving the mechanical properties of alkali-treated fabric composites compared to untreated fabric composites [4] [5]. The effect of fiber concentration and fiber size was conducted on mechanical properties. According to the result, small-size rice husk fibers have maximum tensile strength, and largesize rice husk fibers have a minimum tensile strength. The composites were prepared by the hand layup method [6]. The Fourier transform infrared spectroscopy spectra analyzed the corresponding peak of cellulose fiber and Urea Formaldehyde resin composite for a mechanical property of compressive strength and water absorption test, and it was found that fiber loading increased the mechanical strength of composites up to 30% of fiber loading. Additionally, the cellulose fiber loading is increased while the water absorption of the composite increases. Because of this, the composites were more biodegradable and ecofriendlier [7]. The effect of alkaline treatment of soaking time on the natural fiber surface and the mechanical property of tensile strength was presented [8]. Fiber dispersion was identified as a major factor influencing the characteristics of short fiber composites and a particular challenge for Natural Fiber

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Composites (NFCs), which commonly have hydrophilic fiber and hydrophobic matrices. The use of longer fibers can increase their tendency to agglomerate. Good fiber dispersion promotes good interfacial bonding by reducing voids by ensuring that fibers were completely surrounded by the matrix [9].

This paper explored the technical properties of a new product produced from 'ənäsätə fiber. The product was tested to determine its usefulness as new composite material and analyze its mechanical characteristics (such as tensile strength, impact strength, and flexural strength) to the convenient production of eco-design methodology based on the inherent product of 'ənäsätə fiber, which is extremely abundant in South Nations Nationalities and Peoples Regional State, Ethiopia.

#### II. Research Methodology

The hand lay-up technique is the easiest way to process composites. This approach has a low infrastructure requirement as well. By using this technique, samples were manufactured and their mechanical and physical properties were analyzed. 'ənäsätə fiber as reinforcement and unsaturated polyester resin as a matrix were utilized as a composite material.

#### A. False Banana ('ənäsätə) Fiber and Preparation

'Ənəsätə plant is used to produce foods like 'qoč'o' and 'bula', mainly in the southern Ethiopia. 'ənəsätə fiber is removed from the pseudo stem of the plant in the procedure of extracting edible food from it [1] as indicated in Fig. 1. The false banana plant is drought resistant and grows in tropical countries between elevations of 1000m-1600m [1]. It needs a warm climatic condition. The lengths of the strands differ considerably based on the fiber's specific source and handling during fiber removal [1]. Fiber strands from the middle sheaths can be as long as 15 ft or more if stripped from the whole length of the sheaths, as in hand or machine stripping; normal length ranges from 3 to 15 ft [10]. Polyester resin is used as a matrix. This resin is used as a critical matrix material for a wide variety of applications [11]. Alkaline treatment is among the dominantly used treatments of natural fibers when employed as reinforcement in thermoplastics and thermosets [1]. In this study, sodium hydroxide (NaOH) was chosen because of its low cost and effectiveness [12],[13]. 'ənäsätə fiber is used in Ethiopian house construction for an interior part by mixing with gypsum. Therefore, based on its properties, it is chosen for the production of composite material because it has high mechanical strength and availability. The physical properties of the fiber are as follows:

- a diameter is 0.2-0.26mm, Density is 1.38g/cm³, and specific gravity is 0.9.





Fig. 1: Fiber production, A) Plantation, B) Fiber production, and c) Dried fiber

#### B. Sample Preparation Method

The manufacturing of this composite material used false banana ('ənəsätə) fiber and polyester resin as ingredients [1]. The size of the molding profile was 350mm in width, 400mm in length, and 4mm in thickness produced by cast iron [1]. NaOH solution was employed for fiber surface treatment [1]. After immersing the fiber for 24 hours, it was sun dried, and the fiber orientation was prepared [1] as shown in Fig. 2. Then, the release agent (wax) was covered on the mold exterior to avert the polymer stitched on the surface [1]. Fibers were cut and placed as per the size of the mold in the form of a chopped components [1],  $0^0$ ,  $90^0$ ,  $45^0$ , and  $0^0/90^0$  as shown in Fig. 3. Then, the fluid polyester resin was prudently combined with a hardener in a 10:1 ratio [1] based on a manual prescription of hardener and dispensed onto the strengthening board. The resin was regularly spread with a roller brush; it is applied to eliminate air and surplus matrix [1]. The thickness of the composite panel was  $4\pm0.15$ .

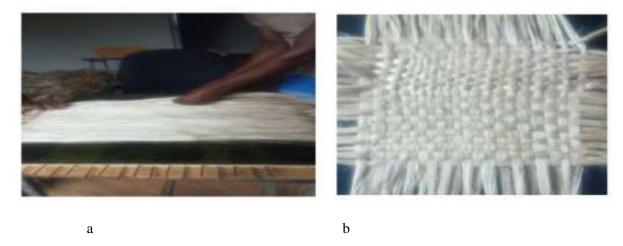


Fig. 2: Preparation of fiber orientation, a) Unilateral and b) Bilateral

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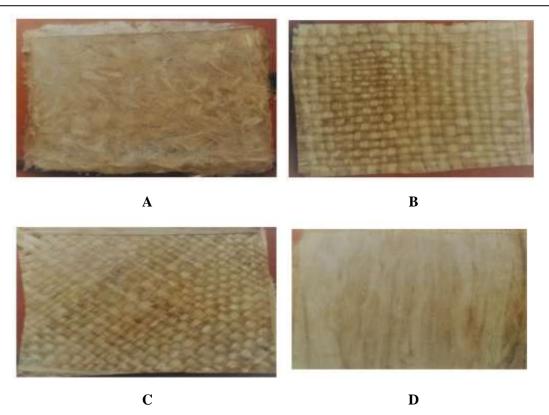


Fig. 3: Composite Products, a) Chopped type, b) Bilateral  $(0^{\circ}/90^{\circ})$ , c) Bilateral  $(45^{\circ}/45^{\circ})$ , and d) Unilateral  $(0^{\circ}$  or  $90^{\circ})$ 

#### C. Mechanical Properties

The mechanical and physical behaviors of the constructed composites of the natural fiber-reinforced composite material were investigated. These are tensile strength, flexural strength, impact strength, and water absorption. The investigated product of composites was cut as per ASTM standards dimension that is D638 for a tensile test, D790 for a flexural test, D256 for an impact test, and D5229M-12 for a water absorption test [1].

#### III. Results and Discussion

Produced composites of the 'enesäte fiber are the strengthening while the polyester resin forms the matrix, which cross-links the strengthening fiber and provides its shape with distinct oriented reinforcement. Furthermore, the influence of the strengthening fiber positioning was investigated. As shown in experiments, changes in the fiber orientation angle can decrease the strength of the material in specific test directions that significantly improved the mechanical properties of oriented reinforcement composite materials [14].

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#### A. Tensile Strength Analysis

The definitive tensile strength test analysis is reliant on the fiber positioning as shown in Fig. 4 set up of the Universal Material Testing Machine [1]. The 0°-oriented sample is the highest definitive tensile strength with a score 181.41MPa because fibers are positioned parallel to the direction of applied force as shown in Fig. 6b similar to the findings of [1]. Concerning fiber orientations, tensile strength will be greatest in the loading direction [15], [16]. Similar to the findings of [1], not all specimens broke in mid-section as indicated in the failure mode of the specimen. When the experiments were executed, a substantial difference was observed between specimens with the same build parameters [1]. However, in the same building parameter of the specimen, no significant difference was performed [17].

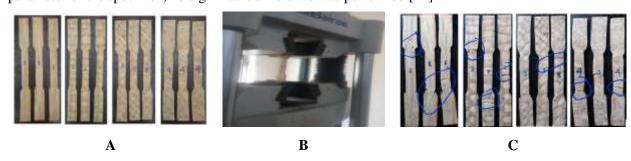


Fig. 4. Tensile test, A) specimen, B) Universal Material Testing Machine (Bairoe, Model No. HUT-2000) (Federal Technical and Vocational Education Training Institute lab, Addis Ababa, Ethiopia), and C) The failure mode of the tensile-tested specimen (ware 1, 90 deg.; 2, 0/90 deg.; 3, 45 deg.; 4, Copped fiber)

#### B. Flexural Strength Analysis

A flexural strength property test was carried out in terms of the force-deflection relationship using the standard method of testing ASTM D790 [18]. Universal Testing Machine (hydraulic universal Amsler testing machine) as shown in Fig. 5 performed the test. Similar to [1], the results have documented the force and deflection with a permanent speed of 0.6 mm/min at room temperature by loading a maximum load cell of 25kN. Flexural strength was improved due to the orthogonality of the fibers loading with a force direction rise [1] as shown in Fig. 6a; similar to [1], the 90° specimen of loading fiber composite was noted for its highest value of 81.43 MPa. The perpendicular direction of loading with the fiber orientation was the higher flexural strength compared to the other [19]. Therefore, as the angle of the fiber loading direction lowers, the flexural strength also lowers. Chopped fiber is created from a maximum 50mm length randomly but still consistently spread as a strand. This is a simpler production method compared the other. Moreover, good strength was noted. Especially, it is very important for preventing surface cracking because it is a control of three-dimensional force [20]. Similar to [1], the failure mode of flexural-tested specimens was noted near the center, but some samples were different due to the thickness and fiber distribution difference over all surfaces. The thickness of the whole area differs by  $\pm 0.25$ mm.

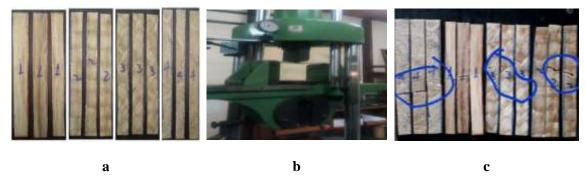


Fig. 5: Flexural test, a) Specimen, b) Universal testing machines (hydraulic universal Amsler testing machine) Ethiopian environment and forest research institute lab, Addis Ababa, Ethiopia, and c) The failure mode of flexural-tested specimen

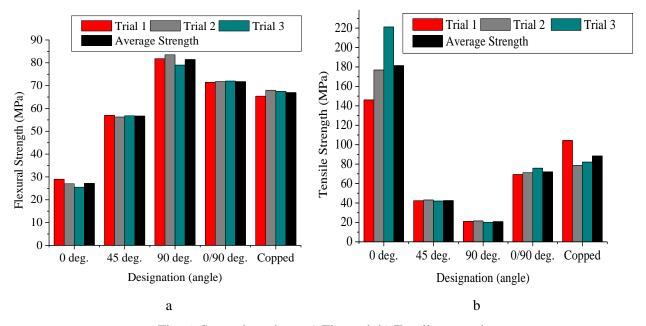


Fig. 6: Strength analyses a) Flexural, b) Tensile strength

#### C. Impact Strength Analysis

The Izod impact test is carried out to find out and compare the hardness or toughness of a material V-notches are used on Izod specimens (Fig. 7) to avoid deformation due to energy [1]. The dimensions of a machine are executed at 30J (model; EKE MAT 20) impact on the specimen in this study. The orientation of fibers is the perpendicular direction from a direction of impact force on the specimen having the highest value [21]. Therefore, the sample 90° oriented fiber scored the highest value which is 9.75 joules. The



 $45^{\circ}/45^{\circ}$  and chopped fiber positioning showed an elevated energy absorption ability than the  $0^{\circ}/90^{\circ}$  orientation as shown in Fig. 8.

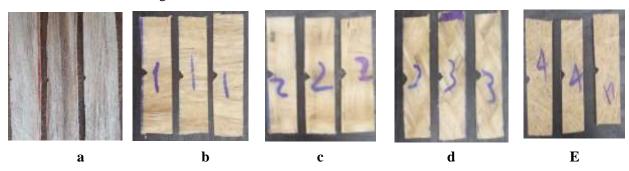


Fig. 7: Impact testing specimen, a) 90° with force direction, b) 0° with force direction, c) 0°/9° fiber orientation, d) 45°/45° fiber orientation, and e) chopped fiber

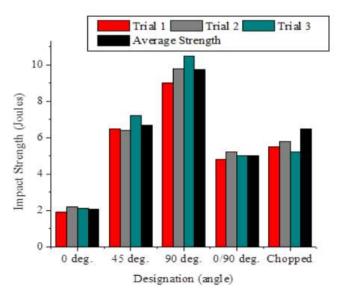


Fig. 8: Impact strength tested analysis

#### D. Water Absorption Analysis

As suggested in [1] the trial specimens were drenched in cleansed water for 120 hours to examine water absorption property. The water absorption test is used to measure material quality and strength [22]. The 45° oriented fiber's mechanical strength is found to be lower. As depicted in Fig. 8, the biggest proportion of water absorption was by the 45° oriented overlapped fiber portion, which is 15.67% within formed porous portion in the middle part of overlapping fiber and rest portion fiber is not getting wet easily [23]. Water absorption for 'ənəsätə fiber with unsaturated polyester resin composite was continuous after 72 hours. Wood plastic composites absorb more water as a result of hydrophilic content factors [24] and depicted in Fig. 9.

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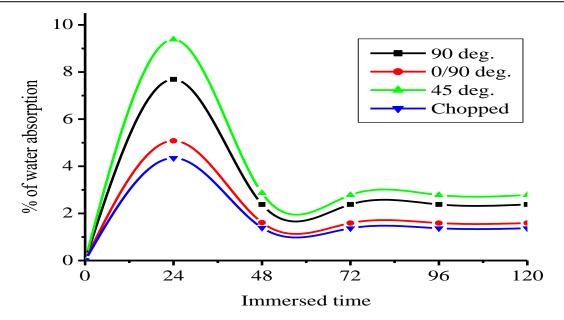


Fig. 9: Rate of water absorption

#### IV. Conclusion

Samples were efficaciously manufactured by the Hand Lay-up method. The research revealed that even if the quantity of fiber in the composite is identical, they have varying mechanical behaviors because of varying fiber positionings similar to the findings of [1]. The mechanical properties examined are tensile strength, flexural strength, impact strength, and water absorption rate. The results showed that the mechanical behaviors of the composites declined as the degree of fiber positioning rose from the direction of exerted force. The maximum score of tensile strength was 0° positioned fiber which was 181.41MPa due to the orientation of fibers analogous to the path of exerted force. The maximum score of the flexural strength specimen of 90° positioned fiber loading composite was noted at 81.43 MPa, similar to [1]. The chopped fiber was found to be a simpler production procedure compared to the other in agreement with the findings of [1]. Furthermore, decent strength was detected. Particularly, it is highly vital for averting surface cracking since it is a control of three-dimensional force as similarly observed in [1]. The V-notch's impact strength score when arranged in an orthogonal alignment is bigger than the longitudinal alignment of the fiber. The sample of the  $90^{\circ}$ -positioned fiber functioned at the maximum score of 9.75 joules. The  $45^{\circ}/45^{\circ}$ and sliced fiber orientations showed a better energy absorption ability compared to the  $0^{0}/90^{0}$  orientations. The analysis of water absorption was carried out in distilled water for 120 hours up until it reached the saturation phase. The maximum proportion of water was absorbed in the trial specimen of  $45^{\circ}/45^{\circ}$ positioned fiber.

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## Effective Use Bagasse Ash of Omo-Kuraz Sugar Factory as a Sustainable Partial Substitute of Cement in Concrete for Constructions in Ethiopia

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#### **Abstract**

This study deals with the recycling of sugar cane bagasse ash of the Omo-Kuraz sugar factory of Ethiopia as a substitute of cement in concrete that provides appropriate remedy to waste disposal and greenhouse gas emission related environmental challenges. The influence of bagasse ash as a cementing material in concrete was examined by performing several strength and durability experiments. From a strength perspective, compressive and splitting tensile strength were tested. As part of durability properties, carbonation and chloride penetrability of bagasse ash concrete was studied. Bagasse ash-based concrete mixes were made with varying cement replacements (10% - 40%) and were tested at various curing periods. As per the strength and durability test results, bagasse ash can be utilized as a cementing material in concrete with 10% cement replacement as the optimum quantity. The durability test results revealed bagasse ash doesn't have adverse effects from carbonation and chloride penetrability perspective on concrete. This indicates that the Ethiopian construction industry can consider bagasse ash as non-conventional cementing material.

**Keywords**: Bagasse Ash, Compressive Strength, Sorptivity, Tensile Strength, Workability, Ethiopian Construction Industry

#### I. Introduction

Sugarcane iia a major agricultural product cultivated in approximately110 countries and providing as estimated annual production of 1500 million tons. In the case of Ethiopia, data from the Ethiopian Sugar Corporation reveals that the nation currently operates eight sugar factories: Wonji Shoa, Metehara, Finchaa, Tendaho, Arjo-Dedesa, Kessem, Omo-Kuraz II, and Omo-Kuraz III. Jointly, these factories produce between 3.5 and 4 million quintals of sugar each year. Five additional sugar factories are under in various phases of construction. These are part of Omo-Kuraz (specifically Omo-Kuraz I and IV), Tana Beles (Tana

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Beles I and II), and Welkayte Sugar Development Projects. Once these new development and expansion projects are finalized, Ethiopia will boast a total of 13 sugar factories, providing it with the capacity to produce 2.25 million tons of sugar every year. As a result, sugarcane plantations are expanding with current area coverage of over 102 thousand hectares [1].

Sugarcane bagasse ash (SCBA) is produced as a byproduct of sugar production factories. Extraction of all economical sugar from sugarcane result into 40-45% fibrous residue is obtained which is reused in the same industry as fuel in boilers for heat generation which turns behind 8 -10 % ash as waste which is also known as sugarcane bagasse ash (SCBA) [2] [3]. Currently in Ethiopia, the overall sugarcane crushing capacity of the eight factories combined is about 74,350 tons per day which produces an estimated 2,677 tons of SCBA per day or 977,105 tons per annum. The expected SCBA obtained from 13 factories will be 1.97 million tons yearly when the expansion and development of new projects is finalized.

The SCBA comprises large quantities of silicon, un-burnt matter, calcium oxides and aluminum. The ashes produced straight from the mills are not responsive as they are not burnt in controlled conditions. The ash, therefore, becomes industrial waste and poses disposal concerns. A few studies have been carried out in the past on the utilization of bagasse ash obtained directly from the industries to study pozzolanic reactivity and their aptness as binders by partially replacing fine aggregate [4], [5]. It has been found that under a controlled burning below 700° C incinerating temperature for about 1 hour it converts the silica material of ash into amorphous silica. The responsiveness of this amorphous silica is exactly proportionate to the specific surface of the ash. The SCBA formed after the controlled burning condition is ground or pulverized to the required fineness before mixing with the blended concrete.

The present experimental investigation was done to examine the use of SCBA as a fractional substitute of cement in concrete. This would help in resolving the matters related to the disposal of SCBA and reduce the greenhouse gases emitted due to the use of cement in concrete which possess a serious threat to our environment and ecology. This experimental research investigates the workability properties of fresh concrete like slump and compressive strength and tensile strength of concrete at 7, 28 and 90 days with 0%, 10%, 20%, 30% and 40% substitution of fine aggregate with bagasse ash by weight.

#### **II. Materials and Methods**

#### A. Materials

A 42.5 grade Portland Cement (OPC) and SCBA from Omo-Kuraz II sugar factory, Ethiopia, were the materials used for this study. The SCBA was burnt further at 650° C for sixty minutes to decrease its carbon

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matter and was additionally milled to fine particles that pass through a 90 µm sieve. A sample of SCBA from the Omo-Kuraz II sugar factory is shown in Fig. 1. The physical and chemical behaviors of cement and SCBA are presented in Table I and II [6], [7].

Table I: Physical Properties of Cement and SCBA

Material	Density	Specific gravity	Fitness (μm)	Specific surface $(m^2/kg)$	Mean grain size
OPC	1.15	3.15	82	300	21
SCBA	0.42	1.71	90	890	5.2

Table II: Chemical Properties of Cement and SCBA

Material	$SiO_2$	$Al_2O_3$	$Fe_2O_3$	CaO	Mg0	$Na_2O$	K <sub>2</sub> O	$SO_3$	LOI
OPC	21.55	5.69	3.39	64.25	0.85	0.33	0.59	2.47	1.8
SCBA	87.4	3.6	4.9	2.56	0.69	0.15	0.47	0.11	8.25

Angular crushed granite metal found in the study area with a highest dimension of 20 mm served as the large aggregate fraction with an average fineness of 7.63 and sp.gr of 2.65, apparent density of 1468 kg/m<sup>3</sup> at the compressed state and water absorption of 1.2%, respectively [8]. A gravity 2.5 river sand with a 2.8 and 1700 kg/m<sup>3</sup> bulk density at the compacted state and 2.04% water absorption, respectively served as fine aggregate. Potable water that was clean and free from any impurities (acids, alkalis and oils, etc.) was utilized for concrete mixing and curing.



Fig. 1: SCBA from Omo-Kuraz II sugar factory

The mix design was done and numerous materials were designed based on the code book ACI 211. To identify the ideal proportion of SCBA in concrete as a fractional substitution of cement, five types of combinations (BA0, BA10, BA20, BA30 and BA40) were prepared by fractionally substituting cement



with SCBA from 0% to 40%. Concrete test specimens of the above-mentioned mixes of size 150mmx150mmx150mm were cast and tested for their compressive and tensile strength at 7, 28, and 90 days. The proportions of mixture are shown below in Table III.

Table III: Mix Design and Proportion of C35 Grade Concrete

Grade	Cement $(kg/m^3)$	Fine aggregate $(kg/m^3)$	Coarse aggregate $(kg/m^3)$	W/C ratio	Water $(kg/m^3)$	Mix proportion
C-35	452	793	910	0.42	190	1:1.754:2.013

#### B. Experimental Procedure

For the effective concrete production, the key determinants are proper blending, compaction, and adequate curing which were employed in the preparation process of the trail specimens [9]. The mixing was done using a pan mixer within 3 – 4 minutes. Test was carried out to investigate the workability behaviors of a fresh concrete slump. The trial samples were de-molded 24 hours after casting and sufficiently cured with potable water. The compressive strength of the trial samples was examined at three dissimilar ages i.e., 7 days, 28 days, and 90 days by using cube specimens of size 150 mm x150mmx150mm [5]. The rapid chloride permeability test (RCPT) was done with concrete discs of size 100 mm dia. x 50 mm ht [9] [10]. Each test score was averaged out from three separate trial specimen test scores. The sample of fresh concrete and trial specimen casting is displayed in Fig. 2 and Fig. 3, respectively.



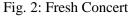




Fig. 3: Preparation of test sample



#### **III. Results and Discussions**

#### A. Impacts of SCBA on Fresh Properties of Concrete

The consequence of the substitution of cement by bagasse ash fractionally from 0% to 40% on the workability of concrete is indicated in Table IV.

Table IV: Slump values of different Concrete Mixes

Sr. No.	Proportions of SCBA	Concrete slump (mm), to nearest 5mm
1	0%	45
2	10%	40
3	20%	40
4	30%	35
5	40%	28

Table IV shows that there is no considerable loss of workability by replacing SCBA with cement by up to 20%. Increased water requirement has been described previously [9] when SCBA replaces cement, which is mostly due to the porous nature of the fine particles, high surface area and the un-burnt carbon content. Furthermore, the irregular shapes and angularity of the SCBA also increase the water requirement by providing particle catch points that need extra water to permit them to unlock hydraulically.

#### B. Effects of SCBA on Compressive Strength of Concrete

The results of the substitution of cement by SCBA fractionally from 0% to 40% on compressive strength (in MPa) of concrete at varying days of curing is indicated in Table V below.

Table V: Effect of SCBA on Compressive Strength of Concrete

Mix	% SCBA	Dansity (leg /m3)	Compressive strength at different age		
IVIIX	replacement	Density $(kg/m^3)$	7 days	28 days	90 days
	0%	2359	25.30	40.78	46.20
625	10%	2360	26.90	45.66	48.70
C35	20%	2351	20.32	35.57	38.22
	30%	2461	18.65	20.63	32.62
	40%	2335	8.78	11.62	16.22

As shown in Table V above, the compressive strength of concrete is increasing from ordinary concrete (0% replacement) to concrete with 10% of SCBA as fractional substitution of cement similar to the study done

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with rice husk ash by [9]. By additionally increasing the SCBA content as a substitution for cement, the compressive strength decreases again similar to the case of the rice husk ash study [9]. An identical propensity of strength variation is noted at various ages of testing i.e., 7 days, 28 days, and 90 days similar to [9]. It is also observed that, when the days of curing increase from 7 days to 28, and 90 days, the compressive strength simultaneously increases for all types of mixes mainly due to the delayed pozzolanic effect of SCBA in concrete [9]. The reasons for compressive strength growth in SCBA mixed concretes and the increase in compressive strength for up to 10% cement substitution of SCBA may be because to the high silica content, amorphous phase, fineness, degree of reactivity of SCBA, particular surface area, and pozzolanic reaction between reactive silica in SCBA and calcium hydroxide in an alkaline setting as in the case of the rice husk ash study [9]. According to these test results, it can be deduced that 10% of SCBA from the Omo-Kuraz sugar factory is ideal to be employed as a fractional substitution of cement in the production of concrete as far as compressive strength is concerned.

#### C. Effects of SCBA on Tensile Strength of Concrete

The consequence of the substitution of cement by SCBA fractionally from 0% to 40% on tensile strength (in MPa) of concrete at various ages is shown in Table VI.

Table VI: Effect of DCBA on Tensile Strength of Concrete

Mix	% SCBA	Density (kg/m3)	Tensile streng		
replacement		Delisity (kg/ilis)	7 days	28 days	90 days
	0%	2359	2.89	3.36	3.54
~-	10%	2360	2.90	3.81	4.11
C35	20%	2351	1.70	2.38	2.68
	30%	2461	1.49	2.09	2.21
	40%	2335	1.45	1.58	1.84

Table VI clearly shows that the tensile strength of concrete is increasing from ordinary concrete (0% substitution) to concrete with 10% of SCBA as fractional substitution of cement similar to the rice husk substitution study by [9]. By additionally increasing the SCBA content as a substitution for cement the tensile strength is decreased similar to the case of rice husk ash [9]. An identical propensity of strength difference can be seen at varying ages of testing i.e., 7 days, 28 days, and 90 days just like the rice husk ash case [9]. It is also observed that, when the age increases from 7 days to 28 and 90 days, the tensile strength increases for all categories of mixes mainly due to the delayed pozzolanic effect of SCBA in concrete again similar to the findings of the rice husk ash study by [9].

It can be concluded based on these results that 10% of SCBA from the Omo-Kuraz sugar factory is ideal to be employed as a fractional substitution of cement in the production of concrete with regards to tensile strength.

#### D. Relationship between Compressive and Tensile Strength of SCBA Concrete

We developed mathematical formula to describe split tensile strength and compressive strength of concrete (in MPa) with varying proportions of bagasse ash. Fig 4. indicated the association between split tensile strength and compressive strength at 28 days. The formula derived is as shown below:

For 0 up to 40% replacement of bagasse ash,

$$TS = 0.056* CS + 0.8175$$
 and 'R2' = 0.8935

Where, TS = Tensile Strength, CS = Compressive Strength,  $R^2 = Correlation Coefficient$ 

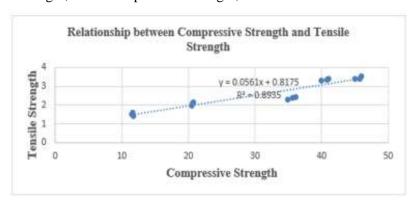


Fig. 4: Relationship between Compressive Strength and Split Tensile Strength

#### E. Effects of SCBA on Chloride Permeability of Concrete

The result of the substitution of cement by SCBA fractionally from 0% to 40% on charge passed by Columbus and chloride permeability of concrete at 28 days curing period [9] is indicated in Table VII.

Table VII: Chloride Penetration in Concrete Mixes

Type of mix Charge passed coulombs		Chloride ion penetrability ASTM C1202		
RCPT-0	2637.77	Moderate		
RCPT-10	1885.61	Low		
RCPT-20	1384.64	Low		
RCPT-30	2121.05	Moderate		
RCPT-40	2823.25	Moderate		

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It can be understood from Table VII that with fractional substitution of cement with bagasse ash of up to 20%, the porousness of concrete is declining relative to the unconstrained concrete. Nevertheless, over 20% of cement substitution with bagasse ash, there is an increase in permeability relative to the unconstrained concrete. When the amount of bagasse ash in concrete goes up, the amount of electrical charge that can pass through the concrete goes down. This happens mainly because the bagasse ash has a pozzolanic effect, which means it chemically reacts with the calcium hydroxide in the concrete. This reaction effectively "plugs the pores" and makes the concrete much more impermeable (water-tight). The level of chloride ion penetration for concrete with bagasse ash of 10% and 20% as partial replacement of cement remains in the "Low" range as per ASTM C1202 [9] and thus demonstrates that these have a good ability to resist chloride ion penetration. It is also anticipated that with the rise in the days of curing when the majority of the hydration of concrete with bagasse is done, the chloride porousness of concrete will decline considerably.

#### F. Effects of SCBA on Carbonation of Concrete

The carbonation test was done for different blends and no carbonation depth was observed. This shows the blends are not influenced by the local environmental circumstances. Fig. 5. displays the concrete tubes put to carbonation test.



Fig. 5: Concrete Cylinders Subject to Carbonation Test

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#### **IV. Conclusions and Recommendations**

Based on the results of the experimental investigation done in this study, these conclusions can be drawn.

- The use of SCBA as a fractional substitution of cement in concrete assists in dealing with the waste management problems of sugar factories and lessens their environmental effects similar to the finds of [9] in case of rice husk ash.
- The ideal proportion of SCBA in concrete as a fractional substitution of cement in concrete is 10% with from the outlook of strength similar to the case of rice husk ash [11].
- Water demand for SCBA mixed concrete rises with rise in the SCBA content.
- With the inclusion of bagasse ash as a cementing material in concrete by up to 20%, the porousness of concrete declines relative to the unconstrained ordinary concrete.
- There is no effect of carbonation in SCBA-based concrete.

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