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ORIGINAL CONTRIBUTION

Optimization of Engineering Properties and XRD Pattern of the Conventional Brick by Recycling the Discarded Cigarette Butts

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Abstract— **Cigarette butts are one of the integral pollutants that severely crank the major public spots like streets, roadsides, seashores, river canals, etc. Apart from this, they have a secondary effect in which they provide space for other trash materials. If they are not properly disposed of then they will slowly burn for an out three hours. Thousands of kilograms of harmful waste are created annually from a few tones of cigarettes produced worldwide. Because cellulose acetate filters are not very biodegradable, Cigarette Butts (CBs) accumulate in the environment. A portion of the findings from an ongoing study on repurposing cigarette butts into baked clay bricks are presented in this report. Cigarette butts have been utilized to make bricks for this project. Based on the test findings, the bricks' compressive strength was found to be 37%, 53.2%, and 79.7% lower than that of typical bricks, with CB percentages of 4, 8, and 12, respectively. Also, water absorption of the brick was increased by 8%, 16%, and 48 % with CB percentages 4, 8, and 12 respectively than normal brick water absorption. Thermal conductivity of bricks was also reduced with using CBs much in amount and thermal insulation was improved by almost 50% on 4% of CBs dosage which is the optimum percentage. XRD pattern shows the Sio^2 quartz in maximum with some other ingredients like feldspar, hematite and orthoclase, etc. means that the results revealed amounts of heavy metals.**

Index Terms— **Clay bricks, Cigarette butts, Compressive strength, Thermal conductivity, XRD, SEM**

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I. INTRODUCTION

Brick is a tiny, firm block of backed clay that is used to construct buildings like homes as well as occasionally roadways, walkways, and other features [1]. Bricks are construction materials that are used to create walls, floors, and other interior building components. Clay, dirt, sand, and concrete components can all be used to make bricks [2]. Bricks are made in many classes, types of materials, and sizes that differ depending on the state and era, and they are made in large amounts [3]. Fired and non-fired bricks fall into two main groups. Bricks make up around 13% of the overall cost of the building materials needed for construction, making them a crucial fundamental material used in all areas of construction activity [4]. In terms of residential building, it has been demonstrated that using clay bricks results in a physically more pleasant living environment than using alternative materials [5]. In order to minimize shrinkage and increase strength, earth construction units are air-dried after production rather than being burnt like traditional bricks. Unfired clay bricks are comparable to other building methods in some traditional types of earth construction, where the bricks are bound together with mortar and most often coated with a finishing technique (paint or render) [6]. Conventional varieties of unfired clay bricks are often crafted by hand, leading to variations in their size and additional characteristics. Because the mortar has a low bond strength and the large walls have sufficient bulk to support them even against sideways loads in houses, traditional earth buildings often have thick walls—often more than 300 mm thick [7]. One of the strongest and longest-lasting construction materials is fired brick, sometimes known as fake stone. Often referred to as mud bricks, they are made with a mechanical binder like straw and have a longer history than burnt bricks [8]. Sun-dried bricks are used for temporary constructions since they are less durable. Clay molding and drying preparation for sun-dried bricks is done after which the bricks are cured using solar heat and exposed to sunlight behind the molding. Permanent buildings are not appropriate for these bricks. Common brick, which

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has no set quantity on its surface, is typically used for walls that will have plaster applied to them or for other purposes where the surface's beauty is not as important [9]. Concrete including materials like cement, sand, coarse aggregates, and water is used to industrialize the production of concrete bricks. These bricks may be produced in the desired sizes. Concrete bricks have several benefits over clay bricks, including the ability to be produced on building sites and the ability to produce a less amount of mortar needed to achieve a variety of colors by pigmentation during the manufacturing process [10]. Concrete bricks have a great visual presence and are used to create masonry, framed building facades, and fences. Because of its great compressive strength, engineering brick is utilised in unique applications that call for low porosity and good resistance to frost. These bricks are frequently used for damp-proof courses and basements where chemical or water aggression is widespread. A retaining wall made of engineering brick is a robust brick structure that is resistant to erosion, wall form, sewage, and burning bridge foundations [11].

In 2004, more than 5.5 trillion cigarettes were produced worldwide, which translates to an estimated 1.2 million tones of butt waste annually. By 2025, these numbers are predicted to rise by more than 50%, mostly as a result of an increase in global population [12, 13]. But Tout Australia Pty Ltd supplied the cigarette Butts (CBs) utilized in this study, which came in a variety of brands and sizes. After being heat-sterilized for 24 hours at 105 °C, the Cigarette Butts CBs were placed in plastic bags that were sealed [14, 15]. Samples of burned brick were made using four distinct mixtures. Bricks were made by mixing CBs (2.5, 5, and 10% by weight, or around 10–30% by volume) with experimental soil and firing the mixture. The produced bricks' density dropped from 2118 kg/m3 for the control samples (which had no CBs) to 1482 kg/m3 for the bricks that contained 10% CBs. When 2.5%, 5%, and 10% CBs were added, the brick density dropped by 8.3%, 23.9%, and 30% respectively. The amount of cigarette butts that should be added to the clay brick's composition during the production process may be estimated from the potential use of cigarette butts in lightweight fire clay bricks. Bricks will be used in the experimental testing that will be conducted on cigarette butt [16, 17].

The World Tobacco Development Report 2016 states that around 60 million cigarette boxes were sold worldwide in 2016. Cigarette butts are thought to be created in between 5 trillion and 600 billion pieces annually, making them the most common solid trash in the world [18, 19]. A firm in New Jersey, USA named "Tera Cycle" makes plastic transport pallets and wood-plastic composite flooring. This test chooses No. 70 bitumen by technical analysis and data search (the best asphalt content was 4.8% in the prior test, thus the asphalt content of the asphalt mixture in this study is 4.8% as well). After that, it was dried and chopped into a sizable tobacco segment, about 0.6 mm in diameter, three times per root and then afterwards baked at 105 degrees to dry. Making cigarette Bituminous Mixture Specimens with 1%, 3%, and 5% cigarette butts was the original test strategy. There were no 3% or 5% specimens created. Following that, a 2.5% content sample was created. Thus, the ultimate test plan was created with 1%, 1.5%, and 2% of the cigarette content, followed by the production of 5 mixture samples weighing 1,200 g, 1,213 g, and 1,215 g, respectively. These samples would then be chosen and exposed to the high level of modified asphalt mixture for 12 hours [20].

The mechanical characteristics of clay brick produced by baking and non-baking a clay-water mixture containing two natural fibers, such as Oil Palm Fruit (OF) and Pineapple Eaves (PF), were investigated. The following standards were followed: Malaysian Standards MS 76:1972 and British Standard BS3921:1985. These included compressive strength, water absorption, and efflorescence. The bricks' compressive strength met the minimal criterion of BS3921:1985, which is 5.2 MPa for traditional bricks, according to the results. To make ceramic bricks using clay and two kinds of foundry sand (core and green sand), a research was created. Bricks made of clay/green sand that have a 25% green sand and a 35% green core that are burnt at 1050°C have higher physical qualities, but the mineralogy is not greatly changed [21]. Cigarette butts (CBs) littering and disposal pose a major threat to the environment. Worldwide, trillions of cigarettes are generated annually, which leads to the disposal of millions of tons of harmful waste cigarette butts into the environment. Because of their low biodegradability, CBs can take a very long time to decompose. The study on the recycling of CBs into burned clay bricks is reviewed and some of the findings are presented in this publication. Bricks containing 2.5%, 5%, 7.5%, and 10% of CB by weight were produced, tested, and contrasted with control clay bricks that had no CB. The findings demonstrated that bricks containing 10% CBs had an 88% loss in compressive strength and a 30% decrease in dry density. Bricks containing 1% CBs had a computed compressive strength of 19.53 Mpa [14]. Performing agents, or waste materials, can be added to the bricks prior to burning in order to decrease thermal conductivity. Paper processing wastes are added to an earthenware brick to create pores, resulting in lightweight, porous bricks with decreased heat conductivity and adequate compressive strength. This categorization states that brick needs to have a minimum compressive strength of 3.5 N/mm2. Additionally, according to this guideline, bricks must absorb no more than 15% to 20% of their weight in water [22, 23]. The majority of the nutrient-rich materials left over after the wastewater sludge treatment process are known as bio solids. Sludge is a term for a liquid that is created during the wastewater treatment process and typically includes up to 8% dry particles. Clay bricks containing zero percent bio solids and clay bricks with 25 percent bio solids by weight were produced as controls. Prior to adding the bio solids samples to the brick soil, they were all oven dried for 24 hours at 105 LC. The ideal moisture contents from the Standard Proctor Compaction test were employed for the control bricks and bricks containing 25% of B1, B2, and B3; they were 17%, 18%, 18.5%, and 22.5%, respectively [24]. Studies show that about 450 million tons of paper is generated annually worldwide. Paper mills are predicted to produce 500 million tons of paper and paperboard annually by 2020. We are in need of these goods, and its use is not going to decline. The third-biggest industrial pollutants of the air, water, and soil are pulp and paper. The Environmental Protection Agency (EPA) estimates that each year, around 45% of the paper waste in the US gets recycled. This indicates that 48 million tones, or around 55%, of paper are disposed of in landfills, with the remaining portion being burned. Using waste papers (newspapers, invitation cards, magazines, etc.), this study aims to ascertain the weight, compressive strength, water absorption capacity, fire resistance, hardness, etc. of papercrete brick in order to assess its suitability as a building material [25].

The investigation aims to achieve the following goals.

- To increase the engineering properties of the bricks.
- To avoid the efflorescence of the bricks.
- To decrease the porosity of the bricks.
- To clean the environment by utilizing the cigarette butt waste.
- To avoid cracks and shrinkage.

II. MATERIALS AND METHOD

Different materials were being used in this research and all the materials are discussed in detail as under

A. Soil sample (clay)

Clays are naturally occurring fine-grained soils that have the ability to change form. This is because clays absorb water, which makes them flexible; but, when they dry and burn, they become hard, brittle, and non-plastic. There is some water trapped in the mineral structure of geologic clay deposits. The color of clay varies depending on the composition of the soil it is found in, ranging from white to brown to a deep orange-red. The clay used in this study is a fine-grained natural rock or soil material that contains one or more clay minerals together with trace quantities of metal oxides and organic components.

Based on the percentage of mixed cigarette butts added to the dry soil by weight, four groups are formed from the soil used in research studies. A fine-grained natural rock or soil material containing one or more clay minerals together with trace amounts of metal oxides and organic materials is the clay utilized in this study.

Based on mixed cigarette butts added as percentages by weight of dry soil, four groups are created from the soil utilized in research projects. After being allowed to air dry for an entire night in big pans, the dirt was broken up to fit through a 3/8" screen. To get rid of the bigger particles, soil samples were wetly sieved using a #40 sieve in accordance with ASTM D 2216. Since the Atterberg restrictions call for material smaller than the #40 sieve, the #40 sieve was utilized rather than the #10 sieve. The material was split up and utilized for Atterberg Limits, sieve analysis, and other experiments.

B. Cigarette Butts (CB) additive

Every year, about a million tons of cigarette butts are generated worldwide. The main reason why cigarette waste accumulates in the environment is because fiber acetate filters don't biodegrade well. The enormity of the issue must be acknowledged in order to start solving it. Every year, almost 5 trillion cigarettes are smoked globally, and every one of them is disposed of in some way. On Earth, there are millions of locations of deposit. They are thrown on the ground, stuffed into garbage cans, and transported to landfills with little to no consideration for the environmental impact from smokers or the general public. No matter how CBs are disposed of these days, the environment may still be poisoned by any of them [26].

Cigarette butts are the addition that is utilized to stabilize and alter the brick soil. Additives were added to the soils with the reasonable assumption that they would improve their engineering qualities. 0%, 4%, 8%, and 12% by weight of additives were mixed with the soil.

Following are the methodology points of the research work. The soil sample was collected from Phandu, Ring Road, Peshawar which has a nominal strength.

- Cigarette waste additives will later be collected from the cigarette manufacturing producing industry.
- Additives were added to the soils with the reasonable assumption that they would improve their engineering qualities. 0%, 4%, 8%, and 12% by weight of additives were mixed with the soil.
- Investigatory tests were performed on the brick samples with different percentages in which the major experimental performances were Scanning Electronic Microscopy (SEM), Thermal Conductivity and X-Ray Diffraction (XRD), Direct Shear Test, and Compressive Strength while the minor investigations were Water Absorption and Atterberg Limits.
- Results of the different tests were performed on all the different samples and the results were compared.

The soil used in research is classified into four categories based on mixed Cigarette butts added as percentages by weight of dry soil.

- Class A: A sample of pure soil.
- Class B: Cigarette butts make up 4% of the dry soil's weight.
- Class C: Cigarette butts account about 8% of the dry soil's weight.
- Class D: Cigarette butts make up 12% of the dry soil's weight.

III. RESULTS AND DISCUSSION

This section includes the results of conventional (controlled) samples and modified samples prepared by adding different percentages of Cigarette Butts (CB). The tests performed were XRD, SEM, thermal conductivity, liquid limit, plastic limit, direct shear test, compressive strength, and water absorption. Different percentages of CBS are 0%, 4%, 8%, and 12% mixed with soil, and samples were prepared and being examined The results of conducted tests on modified samples are positive.

A. Liquid limit

Following are the results of the liquid limit test.

1) Pure soil sample

Total weight of sample =120g

TABLE I
OUTCOMES OF THE LIQUID LIMIT TEST PERFORMED ON A PURE SOIL SAMPLE

Serial No.	Container Weight, W1(g)	Container Weight + Wet Soil, W2(g)	Container Weight + Dry Soil, W3(g)	Moisture Content	No. of Blows
1	22.14	136.4	73	24.65	34
2	22.24	134.4	72	25.4	17
3	22.15	134.9	72.4	24.8	21
Liquid Limit			24.75		

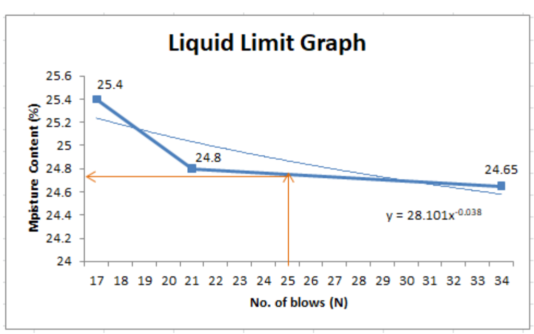

Fig. 1. Percent moisture content vs. Blows for the liquid limit

A soil with a liquid limit between 24 and 25 has a considerable degree of plasticity, meaning that, depending on the moisture level, it can fluctuate significantly in volume and strength. It indicates that the soil's plasticity index is within a certain range and that it has a modest capacity to hold onto water. When building foundations or determining the likelihood of settlement in construction projects, engineers must take this into account. In locations with such soil qualities, engineers might have to put in place the proper soil stabilization methods to guarantee the long-term stability of structures.

B. Plastic limit

Following are the results of the plastic limit.

TABLE II
OUTCOMES OF THE PLASTIC LIMIT TEST PERFORMED ON A PURE SOIL SAMPLE

Serial No.	Container Weight, W1(g)	Container Weight + Wet Soil, W2(g)	Container Weight + Dry Soil, W3(g)	Moisture Content
1	24.4	32.3	27.54	17.28
2	22.1	29.7	27.6	17.24
3	25.6	33.8	31.1	18.68
	Plastic Limit		17.73	

C. Plasticity index

The findings of the plasticity index, which measures the variation between the liquid and plastic limits, are listed below.

TABLE III
PLASTICITY INDEX VALUES

Serial No.	Liquid Limit	Plastic Limit	Plasticity Index (LL-PL)
1	24.8	17.73	7.07

D. Specific gravity

Following are the results of the plastic-specific gravity test.

TABLE IV
TEST OF SPECIFIC GRAVITY FOR A VIRGIN SAMPLE OF SOIL

S. No.	Observation Number	1	2	3
1	Weight of Empty Pycnometer (gram)	204	180	178
2	Weight of Pycnometer + Soil Sample (gram)	404	380	378
3	Weight of Pycnometer + Soil + Water (gram)	1442.3	1420.3	1424.3
4	Weight of Pycnometer + Water (gram)	1324.3	1306.3	1310
5	Weight of Soil Sample (gram)	200	200	200
6	Weight of Equal Volume of Water (gram)	1120.3	1122.3	1117.1
7	Specific Gravity	2.42	2.31	2.33
	Average Specific Gravity at 20°c		2.35	

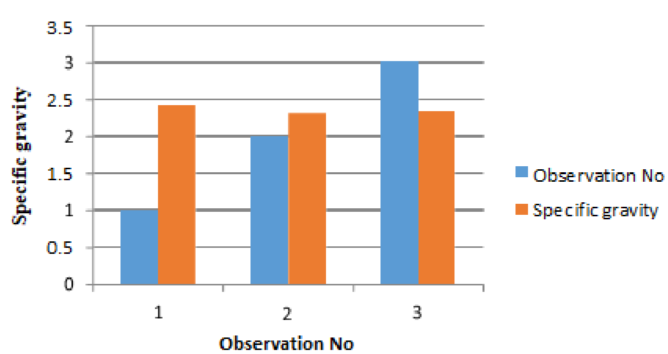

Fig. 2. Specific gravity value

A fairly thick soil is indicated by a specific gravity range of 2.3 to 2.4, which may support the structural integrity of bricks. A thorough examination of the soil's other characteristics, such as its plasticity, clay content, and particle size distribution, must be done in addition to this data. Using a comprehensive strategy guarantees that the soil is both dense and have the qualities needed to produce long-lasting, high-quality bricks.

E. Direct shear

Following are the results of the direct shear test shown in the table and figure.

TABLE V
DIRECT SHEAR TEST VALUES OF THE PURE SAMPLE

Serial No.	Soil + Additive (CB) (%)	Cohesion C	Angle of Internal Friction (φ)
1	100 + 0	0.075	26.13
2	96 + 4	0.059	28.08
3	92 + 8	0.037	30.56
4	88 + 12	0.015	25.93

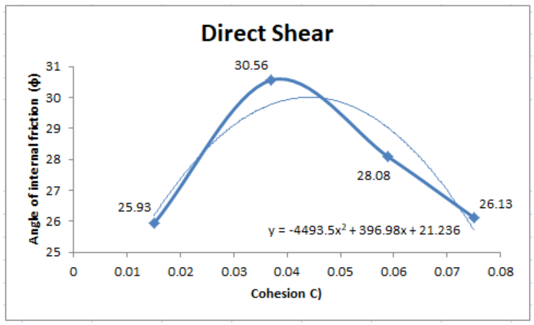

Fig. 3. Variation of the graph between the angle of internal friction and cohesion for multiple soil samples

It's a great step towards sustainability when brick makers use used cigarette butts to stabilize the soil. Careful consideration is necessary, nonetheless, given the reported decline in cohesion values with an increase in cigarette butt waste content. Engineers have to reconcile preserving the mechanical qualities necessary for long-lasting bricks with environmental considerations. Extensive experimentation and optimization research are necessary to determine the ideal ratio of soil to cigarette butt waste in order to achieve the necessary cohesiveness and stabilization for brick production.

An intriguing problem is the use of used cigarette butts in soil stabilization for brick manufacture, with different values of the angle of internal friction. Although the eventual decrease in friction calls for careful evaluation, the initial rise in friction implies possible benefits for stability. To find the crucial point where the benefits of reduced friction are maximized without sacrificing the stabilized soil's overall strength and cohesiveness, engineers should carry out comprehensive geotechnical testing. In order to achieve the ideal balance for profitable and ecological brick manufacture, this sophisticated approach is essential.

F. Compressive strength

Following are the results of the direct shear test shown in the table and figure.

TABLE VI
COMPRESSIVE STRENGTH TEST VALUES

Serial No.	Soil + Additive (CB) (%)	Dimension of Brick (cm)	Maximum Load (KN)	Compressive Strength (N/mm2)
1	100 + 0	22×10.5×7.2	392.12	16.9
2	96 + 4	22×10.5×7.2	227.47	10.6
3	92 + 8	22×10.5×7.2	148.17	7.9
4	88 + 12	22×10.5×7.2	58.642	3.43

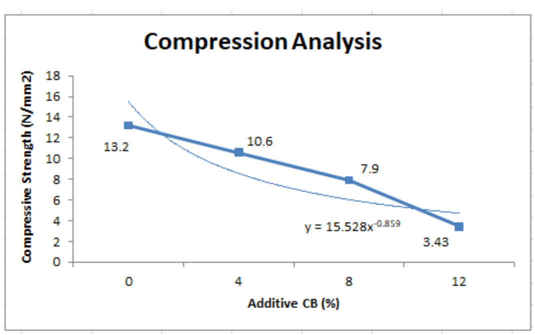

Fig. 4. Compressive strength values against the additive percentages

The structural performance of the bricks is challenged by the addition of waste cigarette butts to soil stabilization throughout the brick-making process, which lowers compressive strength values as trash content rises. This finding emphasizes the necessity of carefully weighing the trade-off between environmental sustainability and the stabilized soil's mechanical characteristics. But after assessing the results in detail inducates that the bricks are structurally enough sound to withstand the loadings but it can also be suggested that such bricks can be used in non-load carrying members of the frame structures or can be used in 1-storey structures.

G. Water absorption

The water absorption test findings that are displayed in the table and figure are listed below.

TABLE VII
WATER ABSORPTION TEST OUTCOMES

Serial No.	Soil + Additive (CB) (%)	Weight of Wet Brick, W2 (Kg)	Weight of Dry Brick, W1 (Kg)	Water Absorption (%)
1	100 + 0	3.57	3.2	15
2	96 + 4	3	2.65	16.2
3	92 + 8	3.05	2.6	17.4
4	88 + 12	2.75	2.25	22.3

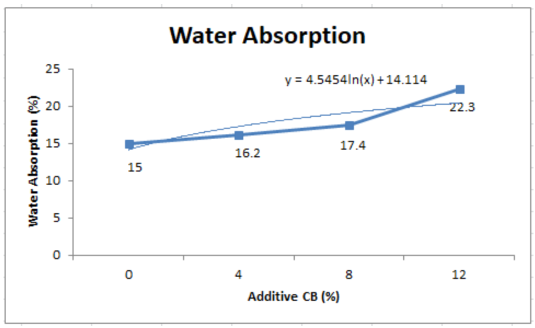

Fig. 5. Graph with water absorption

H. Thermal conductivity

Following are the results of the water absorption test shown in the table and figure.

TABLE VIII
THERMAL CONDUCTIVITY VALUES

Serial No.	Soil + Additive (CB) (%)	Density (kg/m^3)	Thermal Conductivity (Wm-1k-1)	Diminishment of Heat Conductivity (%)
1	100 + 0	1927	1.02	0
2	96 + 4	1596	0.67	34
3	92 + 8	1566	0.56	43
4	88 + 12	1355	0.51	50

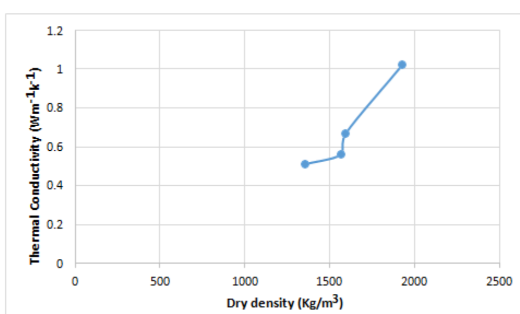

Fig. 6. Effect of CB content on dry density and thermal conductivity of clay brick

The observed decrease in thermal conduction values with an increase in waste cigarette butt content in soil stabilization for brick manufacturing is a noteworthy finding. While this may raise concerns about the thermal properties of the stabilized soil, it could have advantages in certain applications where insulation is desired.
This can be used in many rural areas where the temperature is high and have problems to access the utilities or cannot afford the electrical appliances to minimize the room temperature and usage of heat insulator bricks in the construction can be the solution to such issues.

I. X-Ray Diffraction (XRD)

Following are the results of the X-Ray diffraction test shown in the figure. X-ray diffraction (XRD) is a technique that may be used to examine and compare the crystal and microstructure of CBs and the modified CBs binder at varying absorption of the polymer.

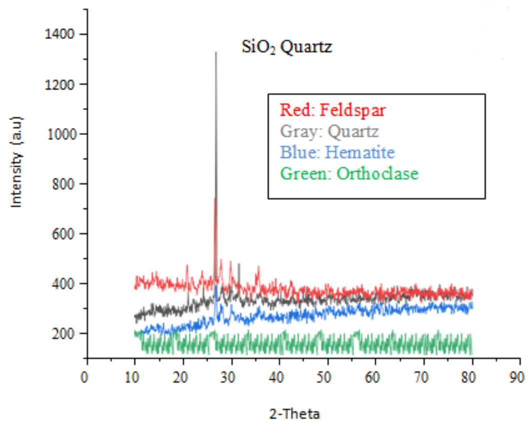

Fig. 7. Graphical representation of the X-ray diffraction test

In x-ray asphaltene structural studies, the peak location occurs where the x-ray beam is diffracted by the crystal lattice. Particles with an ordered arrangement of carbon aromatic atoms are present in the region between 20ƀ and 26̧ (Sio^{2}quartz); this peak coincides with the graph that is observed for the (002) reflection from the carbon atom parallel layer. Precipitated Sio^2 powder diffraction pattern by X-ray analysis was done and graphically shown. As the heating temperature increased, this peak moved to a lower 2Θ value.

J. Scanning Electron Microscopy (SEM)

Following are the results of the scanning electron microscopy test shown in the images/figures.

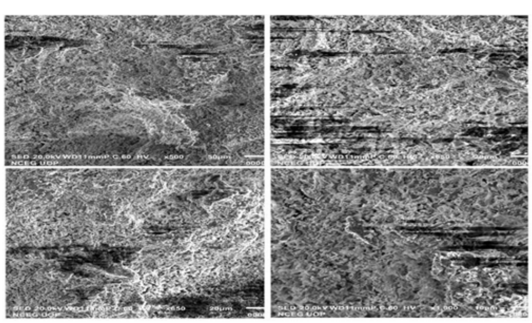

Fig. 8. SEM CB content 0% control sample image

The SEM of unmodified and modified CBs was examined. The microstructure of the prepared specimen with electronic microscope scanning was observed. These control sample images show very clear and nothing operable just show silicon.

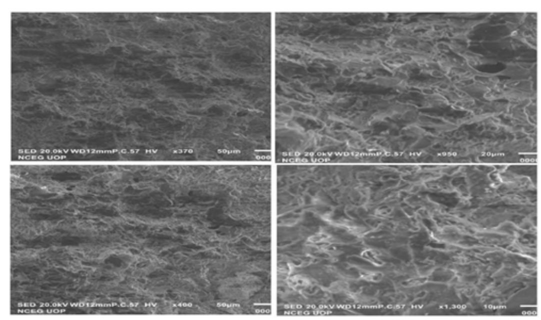

Fig. 9. SEM 4% CB content sample image

In contrast, the micro structure of the sample prepared by modification of flocks appears and the hard straight appears in the figure in the magnification of (x400).

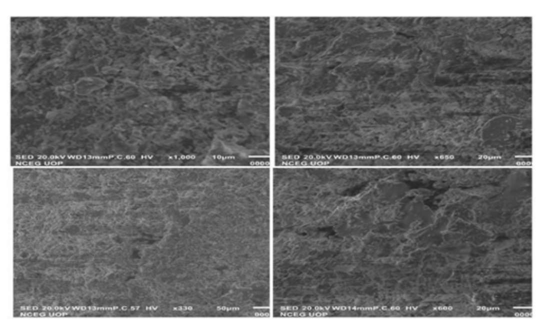

Fig. 10. SEM 8% CB content sample image

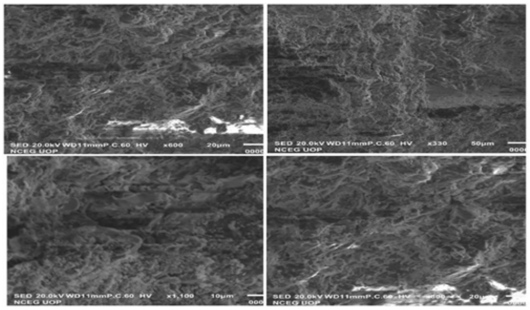

Fig. 11. SEM 12% CB content sample image

The microstructure of this specimen, consisting of the needle appears. The sample prepared by modification of CBs is shown in the figure in magnification of (x1300) seems to be evident here.

IV. CONCLUSION

The possibility of incorporating cigarette Butts (CBs) into burned clay bricks was examined in the study. With 0, 4.0, 8.0, and 12.0 percent by weight of CBs, four distinct clay CB mixtures are used. Also, the usage of cigarette butts had an inverse relationship with the bricks' compressive strength. Their compressive strength decreased when the cigarette butts were utilized more. Besides this, cigarette butts enhanced the brick's ability to absorb water. Their water absorption increased with the number of bricks used in place of cigarette butts.

By using cigarette butts, the bricks' thermal conductivity is decreased while using cigarette butts reduced the weight of the bricks as well. It is very important to note that the preliminary results, which are so dramatic, indicate that cigarette butts may be seen as a potential addition to raw materials used in the light-fired brick sector.

A. Recommendations

Cigarette butts could be used in bricks for different other major investigations related to strength and composition analysis. Cigarette butts should be used in the blocks and other different masonry units utilized in the construction as building material same as bricks.

B. Limitation of the research

Over time, further research is required to determine how well bricks built from used cigarette butts work. Monitoring elements like weathering, deterioration, and pollution discharge is necessary to evaluate the approach's sustainability and practicality. Public opinion may also have an impact on whether or not bricks constructed from used cigarette butts are accepted. Concerns over the hygienic and safety of these bricks can exist, and gaining market approval might be difficult.

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