Use Of Mining Tailings in The Manufacture of Ecological Bricks to Encourage the Construction of Sustainable Housing

Carlos Magno Chavarry-Vallejos[1*], Andrés Avelino Valencia Gutiérrez[2], Carlos Bancayán Oré[3], Liliana Janet Chavarría Reyes[4], Joaquín Samuel Tamara Rodríguez[5], Ítalo Andrés Diaz Hora[6], Enriqueta Pereyra Salardi[7], Jackeline Escobar Serrano[8]

[1,2,3,4,5,6,7,8]*Universidad Ricardo Palma; E-mail: carlos.chavarry@urp.edu.pe*

Abstracts: This work aimed to manufacture ecological bricks using mining tailings, by-products of mining activity, to contribute to sustainable housing development. The Peruvian technical standards E.060 and E.070 are used as a reference framework to achieve this. The study focuses on various aspects, such as mineralogical analysis, particle size distribution, plasticization, workability, and rheology. The research methodology adopted is deductive, with an applied and quantitative approach. A retrolective data collection instrument and descriptive, explanatory, correlational, and descriptive level approaches are used. The results obtained from this research reveal significant findings. It was observed that including 20% of an alkaline binder based on calcined clay improves the development of bricks in areas with severe climatic conditions. In addition, incorporating lime fibers reduces thermal conductivity and increases bricks' compressive and bending strength. Blocks containing 30% clay cork reinforce the bricks' bulk density, thermal conductivity, and strength. On the other hand, it was verified that tailings with lead-zinc sulfide, reduced by 47%, comply with the carbonization and contraction coefficient. Shale, fly ash, and cement tailings achieved a compressive strength of 26 MPa and a water absorption rate of 14.32%. The addition of steel filings by 3% improves compressive strength. Likewise, incorporating plastic waste increases the compressive strength to reach 37.5 MPa. As for geopolymers, it was observed that viscosity recovery is in a range between 65% and 82%. Finally, recycled aggregates, with a maximum nominal size of 3/8" and 1/4", meet the standard requirements, providing a compressive strength of up to 8 MPa. Finally, this study demonstrates the potential of using mining tailings and other recycled materials to manufacture ecological bricks for sustainable housing development in mining communities, offering viable solutions from an environmental and construction point of view.

Keywords: Ecological Brick, Inert Mineral Tailings, Mineralogical Analysis, Sustainable Housing, Mining Communities, Environmental Pollution.

1. INTRODUCTION

Currently, the construction industry seeks to innovate conventional materials by reusing various wastes that generate more significant pollution, such as mining tailings, due to their outstanding disposition and mismanagement, which leads to reusing them in the construction sector by implementing new materials [1]. With the development of technology, "green" and "sustainable" concepts, the efficiency of resource development in various countries has improved. Still, mining activities and production undoubtedly bring many environmental pollution problems. Over the years, as people emphasize safety and environmental protection, training and presentation will also cause significant environmental pollution in influence of the surrounding environment [2].

The main environmental hazards these tailings pose are their chemical components that can occur through windblown dust, erosion of surface water bodies, inhalation by humans and animals, and bioaccumulation and biomagnification by plants. The communities around these mines are exposed to the environmental hazards posed by tailings. Developing cost-effective technology using these tailings can reduce environmental risks and benefit communities by eliminating the dangers of storing tailings on the surface [3].

The search for new materials that benefit the environment and the diversification of materials for the construction sector, especially in the study of sustainable housing, makes the reason for reusing mining waste to generate construction materials for affordable housing adjacent to mining centers. Studies on mine tailings have determined that it is not a toxic waste but ground rock and water, so it is not considered harmful. Toxicity manifests later when certain tailings react with water and solubilize toxins that can be transported dissolved in water. Using indigenous plants and their associated rhizobacteria to restore contaminated sites would be an ecological solution to mitigate soil and metal toxicity [4]. Tailing’s disposal creates environmental impacts such as air pollution and the release of heavy metals into surface and groundwater. Integrated technologies include producing environmentally friendly backfill materials to improve mine operation and safety and for surface tailings deposits based on geopolymerization technology [5].

Peru's mining production for the year 2022 is described below:

Arsenic: In the measurement period, a total of 13,474.1 tons of arsenic were produced as a result of mining activity.

Cadmium: Mining production of cadmium reached 162.2 tons during the analyzed period.

Copper: Copper production stood out, with a significant figure of 493,896.9 tons extracted from the mines.

Tin: Tin production amounted to 16,560.0 tons, indicating a significant contribution from this mining industry.

Iron: Iron ore was one of the leading mining products, with a massive production of 7,243,970.8 tons.

Manganese: Manganese production reached 568.6 tons, showing its contribution to the mining industry.

Molybdenum: During the period, 18,429.1 tons of molybdenum, a metal of importance in various industrial applications, were produced.

Gold: Gold production was especially noteworthy, reaching an impressive total of 54,239,163.6 tons, reflecting its value in the mining industry.

Silver: Silver mining generated 1,745,874.0 tons of this precious metal.

Lead: Lead production reached 145,212.0 tons, indicating a significant presence in mining activity.

Zinc: Zinc mining contributed 779,866.9 tons of this metal during the analyzed period.

Altogether, the mining production of all these metals amounted to an impressive total of 64,697,178.20 tons, underscoring the importance of the mining industry in extracting these natural resources. This information provides an overview of metal production over the specified period in tonnes, highlighting the most relevant metals and their contribution to the mining industry.

Approximately 65 million tons have been produced in just half a year (table 1), and to obtain them, rocks had to be drilled and ground, creating waste known as tailings. To extract metals, chemical substances are used that contaminate the area during the processing of minerals. Toxic chemicals used in mining include cyanide, mercury, sulfuric acid and mineral separation solvents, nitric acid, ammonium nitrate, and fuel oil [6]. It is understood that, depending on the metal being mined and the chemicals being used, the chemical composition of tailings is not the same. The optimal percentage of potassium hydroxide and the concentration in the leachate of chemical elements are potentially the pollutants regulated by the regulations; consequently, developing a sustainable material will promote construction with mining waste and thereby reduce the environmental impact on traditional products [7].

Currently, the waste that causes the most significant pollution is the mining tailings due to the outstanding disposition and poor management of these, which leads to the reuse of them as construction material that would benefit the mining industries in the management of these wastes and the construction sector implementing new materials that could be industrialized to meet the primary needs of the surrounding communities. Environmental and social impacts and risks are related to the large scale of mining waste, a fact that remains unrecognized. Third-party-led development remains elusive for many communities, and they are invariably left with significant social and environmental legacies that will last from decades to centuries [8].

The design of bricks, adding these wastes, can support buildings, facades, floors of civil works, sidewalks, parks, central squares, and even tracks and roads due to their excellent resistance. The reuse of mineral residues as aggregates to prepare concrete materials for road and bridge construction presents the state of development of mining community construction [1]. The industrialization of bricks requires the equipment of a tailings processing plant that sustains the transformation of tons of waste.

The country's economic activity is based mainly on the exploitation and extraction of minerals that inevitably cause degradation of the soil, surface and underground waters, and, in general, terrestrial and marine ecosystems with all living species, to the detriment of the health of the communities surrounding the mining companies. The mining sector generates considerable stone waste and tailings, substantially threatening the ecology. The most common disposal method of these industrial wastes is landfilling, which adds to soil deterioration and water pollution and takes up valuable land. Fortunately, it can be recycled in several ways, including the promising technique of geopolymerization, which converts waste into value [9].

The main environmental hazards caused by these tailings are associated with their chemical components. Exposure to chemicals occurs through wind-blown dust over crops, surface water pollution, inhalation by humans and animals, and bioaccumulation and biomagnification by plants. There is a need to develop cost-effective technology that can be used to reduce environmental hazards and benefit communities. Exposed communities have a higher prevalence of physician-diagnosed allergies (26.97%) than unexposed communities (22.69%). An association between an allergy diagnosed by a doctor and having fungi in the house should apply the precautionary principle to protect children's health, especially with the location of mining communities about sources of air pollution [10].

The search for new materials that benefit the environment and the diversification of materials for the construction sector, especially in the construction of sustainable housing, is the reason for reusing mining waste to generate construction materials that can be useful in constructing affordable housing adjacent to mining centers. The central proposal is the integration of technologies to transform tailings into safe and sustainable building materials. The idea is to drastically reduce the volume of this waste in the environment; another objective of the designed solution is to offer materials at a friendly and competitive cost from tailings [11]. The study aims to solve the problem of transporting materials used in construction from the collection centers, which are located in the city, to the distant places where the mines are located. Likewise, a new brick made with mining waste guarantees the safety of sustainable housing in communities.

2. DEVELOPMENT

2.1. Mining and its Residues (Mining Tailings)

Mine tailings, also known as tailings, are solid, fluid materials that remain as waste after the mining industry's extraction and processing of bedrock minerals. These wastes mainly comprise fine particles of rock, water, and chemicals used to separate and extract minerals.

The generation of tailings as a by-product of mining occurs as follows:

Mineral Extraction: In mining, valuable minerals are extracted from bedrock. This often involves crushing and grinding the rock to release the minerals of interest.

Separation Process: Valuable minerals are separated from rock and other unwanted minerals by concentration techniques, such as flotation or leaching. These processes typically involve the use of chemicals to facilitate separation.

Tailings Generation: During the separation process, waste consisting of fine rock particles, waste chemicals, and water is produced. This waste accumulates in dams or ponds designed to contain the materials.

The importance of tailings as a potential resource for reuse in sustainable applications lies in several factors:

Waste Management: Mine tailings represent a significant amount of waste the mining industry generates. Proper management is essential to prevent environmental pollution and risks to human health.

Resource Recovery Potential: Many tailings contain residual minerals of economic interest that were not thoroughly mined during the initial process. The reuse of these minerals may be economically viable.

Environmental Impact Reduction: Tailing's reuse can reduce the need to extract and process new minerals, decreasing the environmental impact of mining, including soil degradation and destruction of natural habitats.

Contribution to the Circular Economy: Using tailings in new applications represents a circular economy approach, where waste becomes resources, promoting sustainability and resource efficiency.

Sustainable Building Materials: In the context of sustainable housing construction, the reuse of tailings in the manufacture of ecological bricks, as mentioned above, can contribute to the reduction of the demand for natural resources and the decrease of the environmental footprint in the construction industry.

2.2. Sustainable Housing: Description of sustainable housing, including sustainable construction practices, energy efficiency, responsible use of materials, and how these aspects relate to using ecological bricks.

A sustainable home, also known as sustainable housing or green housing, is a construction designed and operated in a way that has minimal impact on the environment and promotes a healthy and efficient lifestyle for its inhabitants. The following describes the key aspects that constitute sustainable housing, including sustainable construction practices, energy efficiency, responsible use of materials, and their relationship with the help of green bricks:

Energy Efficiency:

Thermal Insulation: Sustainable homes are usually designed with good thermal insulation to reduce heat loss in winter and heat gain in summer.

Efficient Windows: Energy-efficient windows reduce heat loss and block excessive solar radiation.

Efficient Heating and Cooling Systems: High-efficiency heating and cooling systems are installed that reduce energy consumption.

LED Lighting and Sensors: Energy-efficient LED lighting and motion sensors reduce electricity use in underutilized areas.

Responsible Use of Materials:

Sustainable Materials: Green and sustainable building materials are used, such as certified wood, recycled or recyclable materials, and products low in VOCs (volatile organic compounds).

Construction Waste Reduction: Waste reduction is practiced, and building materials are recycled whenever possible.

Durability: Durable materials that require less maintenance and replacement over time are sought.

Water Management:

Rainwater Collection: Rainwater collection systems are installed for reuse in garden irrigation or other non-potable uses.

Water Use Efficiency: Water-efficient appliances and plumbing fixtures are used, and awareness of responsible water use is promoted.

Renewable Energy Generation:

Solar Panels: Photovoltaic solar panels are installed on rooftops or other areas to generate renewable electricity and reduce dependence on conventional energy sources.

Indoor Air Quality:

Efficient Ventilation: Efficient ventilation systems are designed to ensure indoor air quality and reduce the concentration of pollutants.

Low Emission Materials: Building materials and products with low emissions of volatile organic compounds (VOCs) are used to maintain a healthy indoor environment.

Use of Ecological Bricks:

Eco-bricks are made from sustainable materials and often incorporate recycled waste, such as mining tailings, into their composition.

They contribute to reducing the extraction of natural resources by using recycled or alternative materials in their manufacture.

They can have thermal and insulating properties that improve the home's energy efficiency, reducing the need for heating and cooling.

Being manufactured sustainably, eco-friendly bricks fit nicely into a home's overall sustainable construction approach.

2.3. Environmental Sustainability

Environmental sustainability is a fundamental approach that seeks to ensure that human activities and using natural resources do not deplete or irreparably damage the environment, thus allowing present and future generations to enjoy a healthy and balanced planet. The main concepts of environmental sustainability are:

Natural Resource Conservation: Involves the prudent and responsible management of natural resources, such as water, land, minerals, fossil fuels, flora, and fauna, to ensure they are available for future generations. This includes protecting critical ecosystems and biodiversity.

Resource Efficiency: Refers to optimizing available resources, minimizing waste, and reducing unnecessary extraction or excessive consumption. Energy efficiency and responsible water use are examples of this concept.

Renewable and Sustainable Energy: The transition to renewable energy sources, such as solar, wind, and hydropower, is essential to reduce dependence on fossil fuels and greenhouse gas emissions.

Waste Reduction and Recycling: Involves minimizing waste by reusing and recycling materials. This decreases the amount of waste and reduces pressure on natural resources.

Life Cycle and Environmental Footprint: Evaluate a product's or process's environmental impact throughout its entire life cycle, from the extraction of raw materials to their disposal. This allows informed decisions to be made about how to minimize that impact.

Sustainable Development: Economic and social development must be balanced and sustainable in the long term. Economic growth must not deplete natural resources, degrade the environment, and equitably benefit all individuals and communities.

Climate Resilience: Environmental sustainability involves taking action to address climate change and reduce the vulnerability of communities and ecosystems to extreme weather events.

Individual and Collective Responsibility: Recognize that, both individually and collectively, we have the responsibility to make decisions and actions that promote environmental sustainability. This includes reducing overconsumption, adopting conscious consumption practices, and pressuring governments and businesses to adopt sustainable policies and procedures.

Environmental Education and Awareness: Environmental education is essential to raise awareness of environmental challenges and encourage greater participation in conservation and sustainability.

Global Collaboration: Environmental sustainability is a worldwide issue that requires collaboration and joint action at the international level. Agreements such as the Paris Agreement on climate change are examples of global efforts to address environmental problems.

3. MATERIALS AND METHODS

The variables used in this study are described below:

3.1. Independent Variable

Ecological brick: It is a construction material used in masonry walls that does not harm the environment because they are fired artisanal without using high temperatures in the manufacturing process or with any fuel or other element harmful to the ecosystem [12]. They are waterproof materials favorable for mining communities whose houses of adobe penetrate moisture and cold during frost.

3.2. Dependent Variable

Sustainable housing: considers environmental and social elements throughout the design and construction process. They are homes that are built thinking about the well-being of the environment. They use all available resources to reduce their energy consumption and mitigate the negative impacts on their inhabitants' health and social surroundings.

A mine tailings sample was studied for mineralogical analysis of particle size distribution, workability, rheology, particle size distribution, and mineralogical composition. The research uses the deductive method, applied orientation, quantitative approach, retrolective data collection instrument, descriptive, explanatory, correlational, and descriptive levels.

3.3. Sample

The sample has been selected according to the E.060 and E.070 standards, following the project's technical specifications. Sample selection is intentional non-probability sampling. The sample characteristics are established as indicated in Peruvian Standards E060 and E070.

3.3.1. Aggregate Testing

Fine aggregate testing

•Specific gravity and absorption: NTP 400.022

•Loose unit weight: NTP 400 017

•Compacted unit weight: NTP 400 017.

•Moisture content: NTP 339.158.

•Granulometric analysis: NTP 400.012.

3.3.2. Coarse Aggregate Testing

•Specific gravity and absorption: NTP 400.022.

•Loose unit weight: NTP 400 017.

•Compacted unit weight: NTP 400 017.

•Moisture content: NTP 339.158.

•Granulometric analysis: NTP 400.012.

3.3.3. Tailings Tests

•Specific gravity and absorption: NTP 400.022.

•Loose unit weight: NTP 400 017.

•Compacted unit weight: NTP 400 017.

•Moisture content: NTP 339.158.

•Granulometric analysis: NTP 400.012.

Mixing Design:

•Tailings mix design.

•Design of tailings mixes.

Mixture dosage:

•Dosage 1: Concrete with tailings (10% coarse sand), coarse sand, confit + naphthalene additive + kyarel addition (Andean Cement Type IP and Cement Yura Type IP or Yura Type HE).

•Dosage 2: Dosage 2: Concrete with tailings (25% coarse sand), coarse sand, confit + naphthalene additive + kyarel addition (Andean Cement Type IP and Yura Cement Type IP or Yura Type HE).

•Dosage 3: Dosage 3: Concrete with tailings (50% coarse sand), coarse sand, confit + naphthalene additive + kyarel addition (Andean Cement Type IP and Yura Cement Type IP or Yura Type HE).

3.4. Data Collection Instrument

Data collection sheets: Instrument to collect the information needed in the different cases since the variable will be the affected and the scope.

Instrument techniques: Observation (Examining the different phenomena to study their behavior of properties and characteristics).

Validity: The variables will be measured by certified calibration equipment

Reliability: Data collection will be obtained through specialized programs in each of the tests carried out in the laboratory. Each laboratory equipment will be calibrated at the National Quality Institute and justified by certificates issued by the same entity.

3.5. Tools And Techniques

Laboratory tests

•X-ray diffraction (XRD) powder: Bruker D8 ADVANCE; angle range: 2θ 3-65°, step size: 0.015°, time/step: 1.0s (BL).

•Particle size distribution (PSD) determination by laser diffraction: Sympatec HELOS, wet dispersion in distilled water (QUIXEL).

Brick testing

•Masonry units. Dimensional variation: NTP 399.613 and 399.604.

•Masonry units. Warping test: NTP 399.613.

•Masonry units. Absorption test: NTP 399.604 and 399.613.

•Masonry units. Endurance test: NTP 399.613 and 339.604.

•Masonry units: Test methods: NTP 399.604.

4. RESULTS

4.1. Findings of the Literature Review

The main results found in the literature review are shown in Table 1.

Table 1. Results of the literature review

Author/s	Key Findings
Idriss et al., (2022) [13]	- Incorporation of alkaline binder based on calcined clay increases resistance to bending and compression.
	- The resistance values at 25°C are 3.0 MPa (bending) and 18.1 MPa (compression), and at 70°C they are 3.6 MPa (bending) and 20.0 MPa (compression).
	- Loss of resistance in humid environments of about 55%.
	- Bricks with 15% and 20% stabilizers improve development in areas with severe weathering.
Wardi et al. (2021) [14]	- Use of lime fibers and sheep's wool, in addition, content results in lightweight compounds with lower thermal conductivity and higher resistance to compression and bending.
	- Reinforced clay-cork blocks with 30% lime content and 2% sheep wool fibers have a density of 583 kg/m3, thermal conductivity of 0.155 W/m/K, flexural strength of 1.55 MPa and compressive strength of 3.91 MPa.
Zhou et al. (2021) [15]	- Study of preparation of construction materials with leaching residue of lead-zinc sulfide tailings (LRT).
	- Adding LRT less than 47% with ordinary Portland cement (OPC) and fly ash (FA) meets sterilized lime sand brick standard.
	- Carbonization coefficient of 0.79 and drying contraction less than 0.42, indicating chemical reaction with additives to form stable minerals.
	- Shale tailings, fly ash, and cement as raw materials.
	- Optimal compressive strength in shale tailings: fly ash: cement = 5: 2: 3 (wt%) with 7-day curing at room temperature and 1-day kiln curing.

	- Compressive strength of 26 MPa and water absorption rate of 14.32%.
	- Valuable for production of type III cement with high blast furnace slag content (81% to 95%).

4.2. Evaluation Of the Physical and Mechanical Properties Of Brick

• In the research led by Koppula [16], they obtained tests by adding plastic waste to make bricks without affecting the environment and ecological balance. They evaluated the quality of the bricks, such as compression tests, water absorption, and efflorescence. These bricks had a compressive strength of 37.5 MPa, which is exceptionally strong. Efflorescence and water absorption tests showed that the bricks were almost devoid of alkalis and absorbed practically no water. The bricks obtained are light in weight and cost-effective compared to conventional bricks.

•The maximum 28-day compressive strength (82.5 MPa) and flexural strength (9.28 MPa) for mortars based on blast furnace ground granulated slag and metakaolin, respectively, were approximately 29% and 41% higher than those of the counterpart Portland cement mortar. From an ecological standpoint, geopolymer and alkali-activated mortars exhibited about 50% (on average) less carbon footprint and were 25% (on average) lower in energy demands. The findings highlight the superiority of alkali-activated mortars and geopolymers over their Portland cement counterparts for lightweight applications due to their improved workability, higher initial strength, and lower environmental impact [17].

• Wang [18] indicated that compressive strength, water absorption, bulk density, and ignition loss exhibit different correlations with clay content, formation moisture, and sintering parameters. The optimal process parameters for preparing sintered brick have a clay content of 35%, formation humidity of 25%, firing temperature of 1030 °C, and maintenance time of 105 min.

• In the study led by Wahane [19], they designed a brick with 25% plastic waste content, obtaining a maximum strength of the bricks of 52 MPa. The plastic brick penetrates about 7 mm after 32 minutes of complete setting, getting about 4% water absorption and improving the plastic brick's strength value with other masonry bricks.

• Ilcan [20] showed the viscosity recovery yields of geopolymers with variable activator content were between 65% and 82%. Ram extrusion showed that the mixtures were extruded without showing any faults, although some of them had different types of failures in the extruded sample with a longer quiescent time beyond 60 min. However, except for mixtures activated with 15 M, each variety was extrudable even after 120 min.

4.3. Solids Contents of The Paste in The Compressive Strength Maintaining the Same Workability

Table 2 presents the contents of the solids and the authors who confirm who were considered for this study.

Table 2. Contents of paste solids in compressive strength

Author/s	Characteristics of the contents
Liang et al. (2010) [21]	- Preparation of porous ecological concrete.
	- Aggregates should be wrapped with clean cement paste.
	- Recommended fluidity of cement paste: 200~235 mm.
	- With the increase of the aggregate-cement ratio:
	- Porosity: 38.93%.
	- Water absorption: 11.39%.
	- Compressive strength: 1.14 MPa.
Dai et al. (2018) [22]	- Molybdenum tailings-cement and brick system.
	- Pressure molding process and pigment addition.
	- Parameters for firing the brick:
	- Cement/tailings ratio: 0.18~0.25.
	- Water/solid raw materials ratio for pressing: 0.10.
	- Pressing force: 25 MPa.
	- Press maintenance time: 30 sec.
	- Improvement of the brick with the step style pressure mode.

4.4. Manufacture Of Bricks with Recycled Components

• The rheological results of concrete without recycled aggregate had a more significant change in the first 45 minutes than those of recycled aggregate concrete, with 10%–30% having a limited effect on the characteristics over time of the rheological properties of fresh concrete due to the ultra-high water absorption rate in the first minute after contact with water [23].

• Rojas-Valencia and Aquino [24] showed that ecological bricks manufactured with the cementation mixture with recycled aggregates with a nominal maximum size of 3/8 and 1/4 inch meet the standard requirements, providing compressive strength values of up to 8 MPa; in addition, the use of ficus-indica extract as a natural additive significantly improves the workability of the mixture.

• Gitari [25] indicates that tailings must be mixed with Al2O3-rich feedstock to develop maximum strength and particle size, indicating potential application as fine brickmaking aggregates.

• Shaqour [26] investigated the effect of using steel filings from blacksmith shop waste on clay brick mixing to improve the compressive strength of bricks. They observed that increasing the filling proportions increases the prototypes' compressive strength. The highest percentage increase in compressive strength occurred for the sample with 3% steel filings.

In addition, the bibliography revealed what is exposed in Table 3, noting a wide variety of brick-making.

Table 3. Manufacture of bricks with recycled material

Recycled Component	Manufacturing Process	Advantages
Construction and Demolition Waste (CDW)	- Shredding and grinding of CDW to obtain recycled aggregates.	- Reduction of the amount of waste in landfills.
	- Mixing of recycled aggregates with other materials such as cement and water.	- Lower demand for natural resources such as sand and gravel extraction.
	- Molding and curing of the bricks with the resulting mixture.	- Contribution to the circular economy by reusing materials.
Recycled Plastics	- Shredding and cleaning of recycled plastics.	- Reduction of the use of virgin plastics and mitigation of plastic pollution.
	- Mixing of recycled plastics with other materials such as binders and fillers.	- Lighter bricks and thermal insulation in some cases.
	- Molding and curing of the bricks with the resulting mixture.	- Contribution to plastic waste management.
Recycled Glass	- Shredding and cleaning of recycled glass.	- Reduction of the use of natural resources such as silica sand.
	- Mixture of recycled glass with other materials such as cement and water.	- Bricks with a unique and attractive appearance.
	- Molding and curing of the bricks with the resulting mixture.	- Contribution to the reduction of glass waste.
Recycled Tires	- Shredding of recycled tires to obtain rubber particles.	- Reduction of the accumulation of used tires in landfills.
	- Mixing rubber particles with other materials such as binders and fillers.	- Flexible and vibration-resistant bricks in some cases.
	- Molding and curing of the bricks with the resulting mixture.	- Contribution to the reuse of discarded tires.

5. DISCUSSION

Clay with minerals illite, clinochlore minor (ferroan), cookeite, and kaolinite allows bricks to be manufactured with illite as the primary mineral clay, a large proportion of quartz as a stabilizer, and only traces of ore that could have a detrimental effect [27]. The study by Wang [18] indicates that recycling and large reserves of gold tailings lead to several social and environmental problems. Compressive strength, water absorption, bulk density, and ignition loss exhibit different correlations with clay content, formation moisture, and sintering parameters. The use of brick tailings removes silica-rich mining waste prone to dust dispersion. Lou [28] indicates that iron ore tailings and coal gangue dust are the primary sources of industrial solid waste, the disposal of which has become severe and urgent with the increasing demand for environmental harmony. Many iron tailings and coal dust ore develop sintered bricks with shale sludge as a binder.

Bin Dai [22] mentions that protecting natural resources and ecology will avoid and gradually eliminate traditional methods of obtaining clay and natural stone by extracting cultivated land and preparing building materials using a high-temperature process. A high use of solid waste, low energy consumption, low environmental pollution, and considerable savings characterize the preparation of baking and decorative bricks. Researchers [29] state that magnesium raw materials used in the production of building materials, such as cement, ceramics, and bricks, have justified the use of the waste recycling method based on roasting the benefit of mineral tailings, with the number of process options, depending on temperature regimes and exposure time. Wang [18] reduced negative impacts on the environment by reusing abandoned shale tailings, the possibility of manufacturing bricks without burning using raw materials, including tailings shale, fly ash, and cement, and bricks were produced through mixing, molding, and curing.

CONCLUSIONS

Using alternative materials and innovative processes in manufacturing bricks and concrete has opened the door to sustainable and cost-effective solutions in the construction field. On the one hand, the bricks of Compressed Earth with Alkaline Binder Stabilizer Based on Calcined Clay, where the incorporation of 20% alkaline binder stabilizer based on calcined clay has been shown to significantly improve the development of building bricks, especially in areas exposed to severe climatic conditions. These bricks are ideal for both load-bearing applications and masonry units.

Another alternative is lime factories in Light Compounds, where adding lime fibers to the brick mixture results in lighter compounds with notable advantages. These bricks exhibit lower thermal conductivity, which makes them ideal for improving energy efficiency in buildings. In addition, they have a higher resistance to both compression and bending, which increases their durability and versatility in construction applications.

In addition, the Slate Tailings, Fly Ash, and Cement Tailings, where the production of bricks from slate tailings, fly ash, and cement is a sustainable approach that contributes to reducing waste from the mining industry. These bricks exhibit an impressive compressive strength of 26 MPa and a water absorption rate of 14.32%. In addition, its incorporation into construction projects can be a cost-effective and environmentally friendly alternative to conventional bricks.

On the other hand, plastic waste tiles, which include adding plastic waste to the brick mix, can result in a surprisingly high compressive strength, reaching up to 37.5 MPa. These bricks are resistant and show excellent resistance to water absorption, making them lightweight and cost-effective compared to conventional alternatives.

In addition, the Porous Ecological Concrete Center highlights the importance of maintaining a cement paste fluidity of 200~235 mm. As the aggregate-cement ratio increases, porosity reaches 38.93%, contributing to its drainage capacity, and water absorption remains at a low level of 11.39%. The compressive strength, although moderate at 1.14 MPa, is adequate for specific applications and reflects the porous nature of concrete.

Another approach is Recycled Concrete aggregates, which meet standard requirements with a nominal maximum size of 3/8 and 1/4 inch and can provide compressive strength values of up to 8 MPa. Including these aggregates not only contributes to waste management but also improves the workability of the mixture. In addition, using ficus-indica extract as a natural additive can significantly improve the workability and rheology of concrete.

These approaches in brick and concrete manufacturing show the potential for innovation and sustainability in the construction industry, offering solutions beyond conventional materials and promoting energy efficiency, waste management, and economic viability in construction projects.

Recommendations

These recommendations promote more sustainable and affordable construction, taking advantage of local resources and reducing dependence on conventional materials. Integrating mining waste effectively into the construction industry can benefit communities near mining areas economically and environmentally.

Harnessing Mine Tailings in the Manufacture of Sustainable Materials:

Explore the manufacture of bricks, mortars, and binders using mining tailings as raw material. Apply special treatments to this waste to obtain aggregates, cement, blocks, and bricks for sustainable housing construction.

Integration of tailings materials in masonry units implies incorporating these new materials in masonry or masonry units, especially taking advantage of mortars with tailings content for settlement between bricks. This allows the creation of solid and efficient structures in the use of resources.

Development of low-cost housing without structural supports, so it is necessary to focus on constructing affordable housing that dispenses with complex structural supports. These homes can directly benefit communities near mining areas, reducing the consumption of non-renewable natural resources. The use of materials from the environment and recycling brings significant environmental benefits.

Research and characterization of inert minerals involve accurately identifying them in mining tailings and conducting a detailed analysis of their mineralogical composition. This will make it possible to understand how they influence the properties of ecological bricks and optimize their use in sustainable construction applications.

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