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Utilization of Kiln Room Waste as Raw Material for the Production of Refractory Kiln Props

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Otimeyin Pius[1], Osariyekemwen Daniel N[1]

[1]Fine and Applied Arts Department, Faculty of Environmental Sciences University of Benin, Benin City, Edo State, Nigeria.

Correspondence: Otimeyin Pius, otimeyinpius@gmail.com

Abstract

This study investigated the recycling of ceramic kiln room waste as broken refractory bats, bricks and props for the production of refractory kiln props used as kiln bat footings in ceramic firing operations. Waste refractory materials were processed and blended with kaolin, ball clay, and silica to develop a refractory body suitable for kiln-prop production. Test props were formed, dried, and fired to approximately 1200°C. The results showed that the recycled composite body produced kiln props with satisfactory strength, moderate shrinkage, and resistance to warping and cracking during firing. The study demonstrates that ceramic waste from the kiln room can be effectively reused in the manufacture of kiln props, thereby reducing waste generation and dependence on imported refractory products.

Keywords: Ceramic Waste, Kiln Props, Refractory Materials, Recycling, Kiln Furniture.

Introduction

Kiln props are essential refractory supports used with kiln shelves during the firing of ceramic wares serving as refractory support bases for ceramic bats during firing. It is evident that kiln furniture is incomplete without props, as they provide the structural footing for stacking wares. Their availability is critical for efficient kiln loading and the prevention of shelf deformation. In many ceramic studios, including university training facilities, inadequate access to quality kiln furniture often limits production efficiency. The lack of suitable refractory props in the Ceramics Unit of the Department of Fine and Applied Arts, University of Benin, has created a major challenge for the firing of ceramic wares. Kilns are the most critical equipment for producing finished ceramic products, and they require proper arrangement of refractory slabs (bats) and supports (props), collectively referred to as kiln furniture, to hold wares during firing.

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This study explores the production of kiln props from recycled ceramic body waste generated within the ceramic kiln room. Firing transforms clay into durable ceramic products through exposure to elevated temperatures. Because kiln furniture is repeatedly subjected to thermal stress, it must possess high refractoriness, dimensional stability, and resistance to warping. (Alexander Asanja Jock et al. 2013). Recycling ceramic waste from the kiln room into refractory products offers both economic and environmental benefits.

Literature Review

A kiln is a thermally insulated chamber built with refractory bricks capable of withstanding, storing, and conserving heat. It consists of a refractory chamber supplied with flames from one or more fireboxes, with a chimney to draw out heat and smoke. The chamber is fitted with shelves for loading ceramic wares, bats, and props (Otimeyin 2016).

Kiln Props

Kiln props are fabricated from highly refractory clay bodies. They are commercially available as solid or tubular fireclay props in various sizes and shapes. High-temperature insulating bricks can also be cut to size for use as posts. However, conventional practice often leads to the misuse or underutilization of ceramic body waste, largely due to limited awareness, poor guidance, inadequate time, and lack of practical demonstration.

High-temperature props must resist deformation or sagging (warpage) under heat. Therefore, this study seeks to address two key gaps: first, to expose students in the department who have limited knowledge of hollow kiln props, and second, to develop and produce hollow kiln props from kiln-room ceramic waste that can withstand very high firing temperatures (Semir, 2025).

Refractory MaterialsA ceramic body must possess specific properties to be functional. In the plastic state, it should have good workability so it can be shaped easily. During drying, it must dry at a reasonable rate without cracking. During firing, it should develop into a strong, dense structure with minimal shrinkage.

Improving one of these properties often requires a compromise in another. As in most practical applications, balance is essential to achieve the best overall result. Similarly, achieving low shrinkage usually involves sacrificing some degree of workability. Ceramic bodies are usually composed of clays, fluxes, and fillers. Clays provide plasticity, fluxes encourage vitrification, and fillers such as grog and silica improve dimensional stability and reduce shrinkage. Grog, which consists of crushed fired ceramic material obtained from refractory furniture items as bats and props on which these wares are placed, is particularly important in refractory bodies because it enhances thermal shock resistance and minimizes deformation during firing. (Otimeyin, 2021)

Clay Body

Shaibu (2005), stipulates that a clay body is a mixture of clay, quartz, and other earthy minerals blended to achieve specific ceramic properties. Some clays are usable in their natural state without additives and are called natural clay bodies which in the words of Molokwu etal., (2014) are more reliable and durable using local materials that are easily obtainable. Pre-scientific potters relied on such clays, sometimes adjusting them with non-plastics like sand, flint, kaolin, or fireclay to reduce shrinkage and modify workability.

Otimeyin (2021), states that clay bodies are prepared mixtures of clays and related materials formulated for specific purposes. They are not found in nature but are created through human technology by blending clays with minerals such as feldspar, grog, and flint to achieve desired workability and results.

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A common question is why several clays are combined with non-plastic materials instead of using a single "ideal" clay. A well-formulated body therefore blends several clays, each contributing a specific property, with the addition of flint to reduce shrinkage and feldspar to act as a flux. This combination provides a balanced compromise. Improvement of any one of these properties may mean sacrificing something of the others. As with almost everything in life, we must compromise to obtain the best overall results. Another advantage is stability: if one raw material deviates slightly from specification, the overall effect on the body remains minimal. Thus, a ceramic body can be defined as a carefully proportioned blend of ceramic raw materials used by potters to form ware.

Kiln Furniture

Kiln parts are the structural components of the kiln itself. Kiln furniture refers to refractory fittings and accessories placed inside the kiln to support and space ware during firing. These accessories ensure efficient heat circulation and a successful firing. Kiln furniture, including shelves and props, is manufactured from refractory materials capable of withstanding repeated exposure to high temperatures. Refractory bats and props as expressed by Idowu, (2026) are very expensive in Nigeria, as a result of high cost of importation, and in most cases, they are not available. Hollow or tubular kiln props are commonly preferred because they promote uniform heat distribution and reduce thermal stress.

Standard kiln furniture includes refractory shelves/bats and props/posts. Furniture for high-temperature firing is typically made from high-alumina refractory capable of withstanding temperatures up to 1300°C in slightly reducing atmospheres (Ibude etal, 2012). Kiln props are supports made from highly refractory clay bodies. Fireclay posts are available in various sizes. Tubular props with a central opening are common, as the opening promotes even thermal expansion. Solid cast posts are also available, and high-temperature insulating bricks can be cut to size for use as posts.

Materials and Methods

Waste refractory materials consisting of broken kiln bats, bricks, and discarded props were collected from the ceramic studio. Additional materials included kaolin, ball clay, and silica (flint). The waste materials were crushed, ground, and sieved to obtain grog.

Selection and Preparation of Raw Materials

Appropriate raw materials were identified through prospecting around the ceramics kiln room. Waste refractory materials, primarily broken bats, bricks, and props, were collected for recycling. Local kaolin and ball clay were sourced from Auchi, Edo State, Nigeria. Flint was also included in the batch formulation. The production of hollow refractory props began with the systematic collection of materials, tools, and equipment, followed by the practical implementation of the experimental procedure. Kaolin is characterized by low plasticity, coarse particle size, and a whitish color. It is relatively free from organic and inorganic impurities. In this study, kaolin served both as a binder and a refractory component in the prop composition.

Flint remains a form of microcrystalline Silica occurring naturally as hard nodules which functions primarily as a filler in ceramic bodies. Fillers reduce warpage and distortion during high-temperature firing by minimizing shrinkage and controlling thermal expansion. Ball Clay was the secondary, sedimentary clay formed from the weathering of feldspathic rocks that possesses fine particle size and high organic/inorganic content, which contribute to plasticity. Ball clay was added to improve the workability of the body.

Grog are previously fired fragments of broken bats, bricks, and props crushed, ground, and sieved into powder and incorporated into the body composition to reduce shrinkage and warpage, increase

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refractoriness, and open the body structure for uniform drying. Silica was ground to a fine particle size and used as a major constituent of the clay body to enhance structural stability and refractoriness. The composition was retained because test specimens withstood the target firing temperature without deformation, confirming its refractory performance. All raw materials were weighed, blended, and processed according to the designed composition for the fabrication of hollow refractory kiln props.

Body Preparation and Composition Design

To develop a suitable refractory body for prop production, a triaxial blend of three primary components was initially tested to identify a composition capable of withstanding firing temperature and mechanical load stress. The raw materials were measured by weight percentage, with the total batch composition summing to 100%. Based on preliminary tests, the optimized body composition was adopted as follows:

The final body composition consisted of:

Materials	Percentage Composition	50kg Batch Composition
Ball clay	30%	15kg
Grog	38%	19kg
Silica/Flint	10%	5kg
Kaolin	22%	11kg

After weighing, the materials were thoroughly mixed, plasticized, and wedged to achieve homogeneity. Test pieces were thrown on the wheel, dried, and fired. The composition passed the firing and load-bearing test, confirming its suitability for refractory prop production.

Throwing of the Props

According to Otimeyin (2021), wheel throwing involves shaping a prepared clay mass on a rotating wheel head through manual manipulation. The materials were thoroughly mixed and prepared into a workable plastic body, wedged into a spherical form. Then the kiln props were formed on a potter's wheel beginning by centering on the wheel head. Water was applied to the hands to lubricate and prevent adhesion of the clay body. Centering was achieved by applying downward pressure with both hands, followed by opening the centered mass using the thumbs to create the hollow form. The props were thrown to the required height and wall thickness. They were thereafter air-dried to the bone-dry stage, and fired to approximately 1200°C. Observations focused on shrinkage, cracking, warping, and load-bearing performance after firing.

Results and Discussion

The recycled ceramic body successfully produced kiln props capable of withstanding firing temperatures of approximately 1200°C. The props exhibited acceptable dimensional stability, moderate shrinkage, and no significant warping or cracking during firing. The inclusion of grog derived from ceramic waste contributed significantly to the refractory characteristics of the body. The fired props demonstrated adequate mechanical strength and were suitable for repeated use during kiln operations. These findings support the use of recycled ceramic waste as a valuable raw material for refractory applications.

Conclusion

The study established that ceramic body waste can be effectively recycled and incorporated into refractory body formulations for kiln-prop production. The resulting props possessed the thermal and structural properties required for ceramic firing operations. Recycling waste ceramic materials not only reduces

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environmental waste but also provides a cost-effective alternative source of kiln furniture for ceramic studios and industries.

Recommendations

Ceramic educators, researchers, and industrial practitioners should further investigate the use of recycled kiln room waste in refractory product development. Additional studies should evaluate long-term durability, thermal shock resistance, and performance at higher firing temperatures. Wider adoption of locally produced kiln props could reduce dependence on imported refractory products and promote sustainable ceramic production.



Plate 1: Materials used for the production of kiln props



Plate 2: The thrown props of the wheel



Plate 3: The props are kept to dry



Plate 4: Props in use after first firing

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