ABSTRACT

In the context of growing environmental concerns and rising housing demand, especially among economically weaker sections, there is a pressing need for sustainable, cost-effective construction materials and technologies. The high carbon footprint of conventional construction materials primarily results from the production of cement and structural steel, with the manufacture of each tonne typically emitting approximately one tonne of carbon dioxide. This doctoral research has investigated the potential of cow-dung-based products as a viable alternative to concrete for eco-friendly housing, focusing on their strength and thermal performance.

The doctoral research involved comprehensive scientific investigations into the use of cow-dung bricks, which exemplify carbon-neutral/negative, renewable, and thermally efficient building materials. These bricks eliminate the need for kiln firing and cement, significantly reducing carbon emissions while utilising animal and agricultural waste that would otherwise contribute to carbon emissions. Additionally, they offer promising thermal insulation properties and contribute to sustainable waste management.

To scientifically validate their use, the research involved fabricating 100 brick samples with 20 different compositions, combining varying ratios of the constituent materials: cow dung, clay, and lime. The study performed compressive strength tests in accordance with the standard protocols for burnt clay bricks. Unlike red burnt clay bricks, the cow-dung-based bricks did not exhibit brittle failure; instead, they demonstrated a distinct mechanical behaviour in their stress–strain response. Based on the test results, the study identified the five optimal compositions.

Subsequently, thermal conductivity tests were performed on these compositions, again in accordance with standard protocols. One composition (50% cow dung, 45% clay, and 5% lime) demonstrated ideal overall performance, with high compressive strength and low thermal conductivity, making it suitable for strong, thermally comfortable housing applications.

To demonstrate proof-of-concept real-world applicability, two experimental housing prototypes were constructed for a long-term thermal comfort study.: (a) Green Structure: built entirely from cow-dung bricks with the best-performing composition as mentioned above. (b) Control Structure: constructed using standard red burnt clay brick walls and reinforced concrete (RC) roof. Comprehensive monitoring of multiple parameters, including external and internal air temperatures, humidity, internal and external wall temperatures, wind speed, and other vital metrics, was conducted using both manual measurements and embedded sensors. Comparative analysis of indoor conditions over seven months, from January to July 2025, revealed that the "Green Structure" exhibited superior thermal comfort, with lower indoor temperatures and more stable relative humidity than the "Control Structure".

In a nutshell, this doctoral research underscores the potential of Panchgavya-based materials, especially cow dung, to promote sustainable, thermally efficient, and affordable housing solutions for rural and low-income populations, while also contributing to sustainability and reducing the carbon footprint. As a byproduct, the research has also led to the development and demonstration of a mechanised procedure for competitive, high-yield production of cow-dung bricks suitable for industrial adoption in real-life construction.