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Process of Evolving Earthen Building Codes: Insights for Nigerian Building Industry

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Abstract - Purpose: In spite of its availability, sustainability, cost effectiveness, thermal efficiency, and ability to provide healthy indoor air quality, earth as a building material is still not widely desirable for construction. One of the drawbacks has been the lack of standardized building codes that regulate the use of earthen materials and construction methods. Despite studies on other qualities of earthen building material, little is discussed on evolving earthen building codes, particularly for Nigerian construction industry.

Study Approach: This paper uses systematic literature review and content analysis of secondary data as methodology to access the process and procedures of evolving earthen building codes in selected countries. The aim is to identify crucial elements that can be replicated in the Nigerian construction industry, with a view to facilitating the discourse on use of earthen building materials.

Findings: Four major elements identified in the earthen code development process in all the selected countries comprised the aim of providing earthen building codes; the key drivers of the process; the involvement of diverse stakeholders and professionals; and practical steps engaged towards drafting and approving the codes.

Originality/Value: The Nigerian situation is discussed to suggest the makeup for these four elements. Given the large land mass of Nigeria, and the wide variation of soil type from one region to another, it is recommended that the elements for each region be drafted to suit peculiar characteristics of the region. Future research would look into technical peculiarities of each region.

Keywords: Building Codes, Earthen Building Material, Earthen Construction, Housing, Nigeria.

1. INTRODUCTION

Earth stood as the predominant material for constructing houses throughout the millennia. However, earthen building material though easily available, sustainable, cost effective, thermally efficient, and provide healthy indoor air quality, is still not as widely desirable for construction when compared to other construction materials commonly found in the present-day market. Rapid industrialisation and the introduction of new building materials such as concrete, steel, glass and reinforced concrete, presented new challenges in building safety, durability and quality of structures erected. These necessitated the systematic approach to standardised building codes. The codes were generally accepted for adoption and use with these new materials worldwide (Roos, 2019). These codes became a model that provided a uniform set of guidelines that could be evolved, adopted and enforced (Dey, 2024). Such standardisation with codes for conventional building materials of concrete, steel, masonry blocks, made it easy for mass production, quality control, and dependability. The preference for the advantages such technological advancement in the new building materials afforded, caused the gradual replacement of local traditional building materials like Earth.

Furthermore, consideration on choice of materials for construction are seen to be foremostly hinged on standards and technical characteristics, before cost consideration or local availability. This was made evident in a study by Nina, Eires and Oliveira (2023), where participants were asked about factors that motivated their choice of particular building materials and construction techniques. The factors of ‘technique of construction’, ‘construction solutions’, ‘durability’ and ‘maintenance cost’ were identified as highly relevant far beyond other factors. Economic factor came in second place; while cost of material, low pollution generation or recyclability were considered far less relevant. These findings make it evident that construction techniques and construction solutions of building materials are judged to be very crucial components in any building project in ensuring safety, durability and quality of the structure, both during construction and at occupancy. To ensure that these characteristics are maintained, the standards of building materials and construction methods are usually regulated through codes. Building codes are rules set out by government and relevant regulatory bodies, to be a model that provides a uniform set of guidelines. Building codes ensure that constructions are carried out safely, and meet the minimum requirement for structural stability, fire safety, and accessibility (Idoko, 2023). Codes are also established to ensure that builders are responsible for the safety of their structures, and that they are held accountable for any

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failures. Building codes are thus based on sound engineering principles, designed to reduce the risks of catastrophises such as building collapse or fires (Madee, 2023).

Even though earth is one of the oldest in most countries, it lacks the backing of necessary regulatory standardisation to safeguard its use for construction. The inability or difficulty in obtaining building permits has been identified as one of the barriers to implementing Earthen construction (Ben-Alon, Dwaikat and King, 2020). In an attempt to draw attention of the construction industry towards the use of earthen building materials and construction techniques, previous studies have tended to highlight the benefits of earth-based materials (Nwaki and Eze, 2022); to review the economic and environmental advantages of Earthen materials for housing (Adegun and Adeyemi, 2017); and to promote Earthen material as a tool towards effective low-income housing (Kayode & Olusegun, 2013), among others. Many other researches have carried out technical and laboratory tested studies to ascertain the quality, standards and suitability of earthen material for construction (Nina, Eires, Oliveira, 2023). In spite of these, the rate of adoption of earthen materials for construction is still quite low, and sometimes non-existent in modern cities. Pele-Peltier (2022) opined that the lack of standardised codes on earth construction is holding back the renewal of the use of this material in modern constructions. It would appear therefore, that the gap between the benefits/suitability of earthen materials for construction, and the actual adoption of this material lies in the absence of guiding codes and regulation. This study, therefore, seeks to bridge this gap by highlighting fundamental elements in the process and procedures of evolving sustainable and applicable codes for earthen building materials, with the view to suggesting initial process towards the development of building codes for earthen materials and construction in the Nigerian building industry.

2. METHODOLOGY

The paper examined the process of development of four existing codes of earthen building materials for Australia, New Mexico, New Zealand and Peru. This study used a systematic literature review and content analysis of secondary data. The data were taken from relevant published journals, books and conference papers. Building code development process of the four countries were analysed to understand pathways, trends, professional and organisational participation, steps and sequences of operation, and other systemic involvements.

3. LITERATURE REVIEW

3.1 Background of Earthen Building Code Development

Early 'rules' for using earth as building material were the painted documents of mud block buildings in ancient Egypt in 1500 BC (Thompson, Augarde and Osorio, 2022). These paintings depicted the process of building with mud blocks, detailing the block sizes, the block bonds in the wall construction, and the use of a plumb as an expression describing the technical standards and quality control (Fathy, 1973). Since then, earthen buildings have traditionally been designed and constructed based on local knowledge, which are often passed down orally from generation to generation (Fabbri, Morel, Aubert, Bui, Gallipoli, Ventura, Reddy, Hamard, Pele-Peltier and Abhilash, 2021). Earth building materials were produced in situ, and quality tests were carried out according to quick and simple field tests by hand (Saliba, Al-Shaar, and Delage, 2025). It was soon realised that the tests were not exactly reproducible. This brought about the need to formulate guidelines governing the utilisation of earthen materials in construction, in order to address the technical requirements and considerations.

The first contemporary technical standard, "The Lehmbau Regeln", dedicated to earthen building materials and construction in Europe was the German Earth Building Code (Schroeder, 2018). It summarised the technical knowledge of earthen construction available at the time to help regulate the use of earth for construction in Germany. The Lehmbau Regeln was developed through the collaboration of specialist organisations within the trained project group made up of representatives of ARGEBAU, and the German Institute of Building Technology (DIBT). According to Reddy, Maniatidis and Walker (2022), Lehmbau Regeln summarised the entire technical knowledge of earthen construction available at the time, to help regulate the use of earth for construction in Germany. Since then, several earthen building codes, guidelines, and standards have been developed in other countries, based on research and fieldwork (Schroeder, 2012).

Apart from the Lehmbau Regeln, some other developed earthen standards are the Australian Earth Building Handbook, New Mexico Earthen Building Materials Code; Peruvian Building Code for Earthen Buildings; and New Zealand Earthen Building Standard. Reddy *et. al.* (2022) stated, however, that although there are about 70 standards on earthen building materials and construction currently in the world, there is a lack of coherence among the standards, and there are no globally acceptable terminologies and processes of evolving code amongst the countries. In this regard, Pacheo-Torgal and Jalali (2012) explained these localised

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differences in building codes for earthen materials and construction as being due to differences in the process of evolving it, the differing associations involved in developing it, and the need to meet the need of varying earth structure of each region. In the same vain, Bolger (2000) noted that earthen building codes should be made country-specific, to suit the environment where it will be applied. It should be noted, however, that while building code development process is slightly different within each organisation, the process is intended to comply with several key criteria (Whole Building Guide (WBG), 2025). Such criteria include a balance of all relevant stakeholders – prominent technical professionals, construction practitioners, enforcement authorities, and product manufacturers (Vaughan and Turner, 2013). In addition, the code development process is expected to be transparent, facilitate trust, and ensure diverse engagement and inclusivity (Moullier and Krimgold, 2015). The study looked into the earthen code development process of four countries: Australia, New Zealand, New Mexico and Peru.

3.2 Australia Earthen Building Standard

In Australia, codification of earthen construction practices began with the publication of "Bulletin 5: Earth Wall Construction" in 1952, which, although not a formal standard, served as the primary reference for decades (Strazzeri, 2022). Later developments included handbooks supported by 'Standards Australia' (the leading standards development body in Australia), and Committees such as BD-083 – a committee set up for earth building codes (MIEAust, 2001). The codes aimed to provide reliable design and construction practices for lightly loaded Earthen structures suited to local climates. Key drivers towards evolving the code included regional adaptation, affordability, and increasing interest in sustainable architecture. The code development process was consensus-based, involved practitioners, researchers, and industry professionals. Agencies such as Engineers Australia were key participants, supported by architects and members of the Earth Building Association of Australia (EBAA). Building contractors, educators, and researchers also contributed to the development of the Code. The development steps encompassed drafting by experts, technical review, public consultation, and eventual publication by Standards Australia. Updates on the codes occurred on an as-needed basis, typically when requested by practitioners or prompted by new research findings (Hall and Djerbib, 2004).

3.3 New Zealand Earthen Standards

New Zealand presents one of the most comprehensive frameworks for earthen construction (Hall, 2020). The Earth Building Association of New Zealand (EBANZ) played a central role in initiating and funding the development of earth standards, in collaboration with Standards New Zealand. In 1998, the New Zealand Earth Building Standards were published, and these have recently been reviewed and updated (Hall, 2020). In developing the New Zealand Earthen Standards, a joint technical committee was set up comprising engineers, architects, researchers, and builders (Morris, 2006). The committee worked on earlier guideline documents prepared by Earth Building Association of New Zealand. There also was considerable input from Australian earth building practitioners. The standards were developed over a period of 7 years. Three national standards: NZS 4297 (Engineering Design), NZS 4298 (Materials and Construction), and NZS 4299 (Non-Specific Design -earth building not requiring specific engineering design) (Walker and Morris, 2021). Initially supported by both New Zealand and Australian practitioners, the project later became independently managed by New Zealand due to differences in regulatory environments. Key drivers towards developing the code included the need for seismic resilience, sustainable building materials, and support for self-builders. The steps entailed drafting by technical committees, reviews, field testing, national consultation, and formal approval as compliance tools under the New Zealand Building Act.

The New Zealand earth building standards underwent a significant revision in 2020, broadening their scope to incorporate emerging construction techniques and material innovations, thereby reinforcing national efforts toward sustainable and resilient building practices (Walker and Morris, 2021). The most recent updates in 2024 led to the publication of NZS 4297:2024, NZS 4298:2024, and NZS 4299:2024, which collectively establish a comprehensive regulatory framework for the design and construction of unfired Earthen structures. NZS 4297:2024 focuses on engineering design and structural durability, covering materials such as adobe, pressed earth bricks, poured earth, and rammed earth that utilize clay-based binders, with or without chemical stabilization. NZS 4298:2024 stipulates the essential material properties and workmanship standards, providing standardized testing methods and performance benchmarks. NZS 4299:2024 sets out prescriptive construction requirements for buildings that do not necessitate specific structural engineering design, incorporating tested construction details aimed at ensuring durability and weather resistance. The development of these codes was overseen by Standards New Zealand through the Technical Committee P4297-99 Earth Buildings, whose members were appointed by the Standards Executive under the Standards and Accreditation Act 2015. The development process actively involved stakeholders such as architects, engineers, conservationists, builders, and representatives from local communities.

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3.4 New Mexico Earthen Building Code

The development of New Mexico codes for earthen construction was influenced by both formal national standards and adaptations of international frameworks (New Mexico Regulation and Licensing Department, 2021). The 2021 New Mexico Earthen Building Materials Code (14.7.4 NMAC), although originating in the United States, served as a reference in Mexican contexts, particularly in rural and indigenous communities where adobe and other traditional materials are prevalent (Construction Industry Division (CID), 2021). The process was decentralized and jurisdiction-specific. The engineers often played a key role through alternative compliance pathways, such as the Alternative Materials, Methods, and Requests (AMMR) process under Section 104.11 of the International Building Code (IBC) (International Code Council (ICC), 2021). The development of these codes was driven by seismic resilience, cultural preservation, and environmental sustainability. Steps adopted included adapting international standards (such as the IBC, International Residential Code (IRC), and ASTM guides), reviewing and amending them locally, consulting stakeholders, and securing municipal or state-level approval. Relevant agencies included the Construction Industries Division (CID), while professional bodies consisted of engineers and architects, with involvement from indigenous communities, natural building advocates, and historic preservation professionals. Updates were made in line with IBC/IRC cycles, typically every three years, with the most recent enforcement that began in December 2023 (ICC, 2023; CID, 2023).

3.5 Peruvian Earthen Building Code

In Peru, the National Building Regulations included specific provisions for earthen materials like adobe and rammed earth, with a primary emphasis on mitigating earthquake risk in rural areas (MINVU, 2018). The main drivers, therefore, included seismic safety, cultural heritage, and the promotion of environmentally appropriate technologies. The development process was centralized and led by the Ministry of Housing, Construction, and Sanitation, supported by technical input from seismic experts and architectural professionals. The code development process began with drafting by the Ministry, followed by review through technical committees, public consultation, and implementation via national and local mechanisms. Professional bodies such as the Peruvian Association of Architects and engineering colleges were involved, alongside seismologists and community-based stakeholders. Code updates were conducted as necessary, often in response to emerging scientific and environmental considerations (Torrealva et al., 2020).

3.6 Stakeholders in the Nigerian Building Industry

Nigeria's building industry projects are primarily governed by the National Building Code (NBC) and various official standards published as The Nigerian Industrial Standards (NIS), which are developed and set by the Standards Organization of Nigeria (SON) (Ogunbiyi, 2014).

The scope specified by the NBC (2006) to cover all spheres of construction begins its relationship with the professionals on the Building Code Advisory Committee (BCAC). The effective development of earthen building codes in Nigeria requires the active involvement and representation of diverse stakeholders, including all seven professionals (architects, engineers, builders, quantity surveyors, surveyors, town planners and estate valuers) in construction. (Ogunbiyi, 2014). Subsection 3.1.1 of the NBC (2006) further states that the composition of members of the committee at various levels should include all professionals in the construction industry with not less than ten years post-registration experience.

Enforcement officials such as building control officers and planning inspectors, alongside product manufacturers of earthen materials and their representative bodies, within statutory technical committees to ensure inclusive decision-making (NCABS, 2016). Key regulatory agencies such as the Federal Ministry of Works and Housing, the SON, the Nigerian Building and Road Research Institute (NBRRI), and local planning authorities are central to policy formulation, enforcement, and oversight (Idoko, 2023; Ogunbiyi, 2014).

4.0 DISCUSSION AND RECOMMENDATION

The study on the development process of earthen building code in the four countries: Australia, New Zealand, New Mexico and Peru, revealed the presence of four major elements. The four elements identified from all the selected countries were (i) the Aim of providing earthen building codes, (ii) Key drivers that portrayed the peculiar need of the region, (iii) Stakeholders/ Practitioners involvement in the process, and (iv) practical Steps taken to draw up the earthen building codes. The diverse nature of the regulatory environments of the four countries made for different aims, varying key drivers determining the basis of the code, varying levels of input by the professionals and stakeholders, as well as different steps in the process of code development. The Aim stated the objective of the earthen building codes. The objective ranged from providing for light loads that would suit the local climate as targeted in the Australian code process, to the development of regulatory framework for engineering design and material structures

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as was the case in New Zealand. In addition, key drivers of the building codes were dependent on peculiar needs of each country. In Australia, key drivers that defined their earthen codes development were concerned with regional adaptation, affordability, and increasing interest in sustainable architecture, where as in Peru, the key drivers were high considerations of mitigating earthquake risks. Thus, their key considerations included seismic safety and the promotion of environmentally appropriate technologies.

Studying the pattern of stakeholders' involvement, the process in Peru was centralised, led by the government parastatal, supported by seismic and involving other technical experts professional and stakeholders through a technical committee. Done differently, the earthen building code development process in New Mexico was decentralised. The process was led mostly by stakeholders and professionals, consulting with stakeholders, before securing approval from the State. For practical steps taken to develop the codes, in Australia and New Zealand, professionals and practitioners led the process and acquired State approval. It is observed that the process in the countries studied, involved having public consultations to derive inputs from the end users. In all, the earthen building development process in the four countries is seen to share technical similarities, while they vary in procedure and details of execution from one country to the other.

This paper suggests that in evolving building codes for earthen materials and construction in Nigeria, the identified four elements of the earthen building process should be adapted and built upon. To facilitate the process, as was observed in the countries studied, it is recommended that the Government Ministry which has oversight of the building and construction industry, would lead the earthen building code development process. However, technical committee will be set up comprising the stakeholders and the professionals, who would carry out the activities of facilitating the development of the earthen codes. The aim of providing earthen building code would be clearly stated to align with the need and purpose of such code for Nigeria. Given the large land mass of Nigeria, and the wide variation of soil type from one region to another, the aim for each region would be drafted to suit peculiar characteristics of the regions. The varied soil conditions suggest, and this paper, therefore, recommends that technical committees be set up for each region. In the same vein, key drivers that define the peculiar geological and geophysical earthen nature of the various regions of the country will be researched and established. The key drivers that would determine the basis of the code for the predominantly sandy dry North, would vary from those of the loamy wet South. The technical committees would comprise representatives of existing building materials and research establishments and agencies such as NIBRRI, SON, as well as related professionals of the building industry. The technical committees would further drive the process by laying down steps to be followed towards developing earthen building codes, such as defining construction parameters, applicable technologies, terminologies and classifications, material specifications, initial drafting of Standards and codes, code adoption and validation, and issuing of final approvals.

5.0 CONCLUSION

This paper focused on identifying elements involved in evolving building codes for earthen building materials and construction methods. The study was based on findings from select countries of the world that have evolved earthen building codes. Based on the assessment of the procedures of code evolvement in four countries of the world, this paper has indicated four necessary elements for evolving building codes for earthen materials and construction. The adaptation of the four elements have been analysed and suggestions made for the Nigeria building and construction industry. Processes were suggested that could help in organising the building research agencies, relevant professional bodies, associations and organizations in commencing the process prior to drafting, reviewing and publication of the code for the Nigerian industry. It is hoped that the process would awaken stakeholders, professionals, manufacturers, producers, policy makers and government to this vital need that would promote affordable and safe housing provisions.

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