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Earth Wall Construction in the Context of the Eurocode

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Abstract: **Stepping into a terrain of old, unpopular or informal construction methods, like earth construction, in the 20th century may seem unguided and unregulated. Although there was no direct reference to unbaked earth construction, the performance based structure of the Eurocodes obviously accommodated informal construction methods. The paper is a study and analysis of the codes and identification of relevant areas of application of the codes in relation to the enhanced compressed earth masonry, which is a subject of an on-going research. Codes provide regulatory guide and standards as a basis for the establishment of tasks and the parameters for assessing any achievement.**

Keywords: **Earth walls, Eurocodes, Performance, Regulations.**

I. INTRODUCTION

The Eurocode replaced the British Standards in 2010 as a uniform standard for European countries. It is a world acclaimed standard, which most countries outside Europe also adopted as a model and a guide in construction, manufacturing industries, etc. The industrial revolution, which originated in Britain brought a quick awareness of need for standards, thereby placing the British Standards in the forefront in this regard.

Most local building codes made particular references to the British Standards. A typical example is the Nigerian Building Code of 2006. In recognition of the introduction of Eurocode in 2010, the Nigerian Engineers have called for a review of the Nigerian Building Code to align with the provisions of the new Eurocode. [1].

This aligns truly with Eurocode brochure, 2010, which states as follows:

> *"The Eurocodes are seen as leading the way in structural codes. Their flexibility enables adoption and use not only within Europe, but internationally. This feature has been recognized by several countries outside Europe and they are already committed to adopting Eurocodes."* [2]

Apart from industrial application, codes provide regulatory guide and standards as a basis for the establishment of tasks and the parameters for assessing any achievement. One of such tasks is the enhancement of earth construction.

In this regard, two of the seven primary objectives of the Eurocodes as stated in BSI Eurocode brochure 2010 are:

1. *"Provide common design criteria and methods of meeting necessary requirements for mechanical resistance, stability and resistance to fire, including aspects of durability and economy."*
2. *"Be a common basis for research and development, in the construction industry."* [2]

This paper is therefore aimed at identifying the 'common bases' for an on-going research in earth construction technology which is apparently an informal construction system. The paper examined the basic areas of earth construction and correlated such areas with corresponding guides and expectations in standardised Eurocodes environment.

II. A REVIEW

A. Soil Identification and Tests:

The compressed earth block technology begins with the identification of appropriate soil by particle size distribution test, moisture content, plasticity, compressibility index etc. These were addressed in the geotechnical investigations and testing areas of the Eurocodes, which were, EN ISO 14688-1:2002, [3] and EN ISO 14688-2:2004, [4]. It is important to note that most literature which treated these topics derived there resources from these standards.

B. Guide to Structural Design

The structural Eurocodes are comprehensive and detailed compilation of guides, procedures, requirements and tests, which cover all principal construction materials. The actual codes consist of ten (10) code series classified by material and special technical considerations. It ranges between Eurocode 0 or Base Eurocode, Basis of structural design to Eurocode 9, Design of aluminium structures.

The Eurocodes 6, which addressed the design of masonry structures and the EN ISO 14688-1&2, [3], [4] for soil identification and tests, are the main focus of this paper.

C. Design of Masonry Structures

This part of the Eurocodes exhaustively addressed Design consideration, selection of materials and execution of masonry. The general requirements for the selection of material for masonry works in EN 1996-2:2006, [5], clause 2.2.1 in three sub-clauses states as follows:

> *"(1)P Materials, where incorporated in the works, shall be able to resist the actions to which they are expected to be exposed, including environmental actions."*
>
> *"(2)P Only materials, products, and systems with established suitability shall be used."*
>
> *"(3) Where the selection of materials for masonry is not otherwise covered in Part 2, it should be done in accordance with local practice and experience."*
>
> [5]

D. Established Suitability

The sub-clause (2)P above gave room for establishment of suitability for informal or new materials not specified in the code. The conditions for establishment of suitability were further given in the notes as follows:

> *1. "Conformity to a European standard that is referred to by the Eurocode."*
>
> *2."Where no appropriate European standard or a deviation, suitability may be established by: (a) Technical approval, or (b) National standard, or other provisions; as long as they refer specifically to uses within the Eurocode and are accepted in the place of use of the material."*
>
> [5]

E. Recognition of local practice and experience

The sub-clause (3) above showed that Eurocodes recognized local practice and experience. Where a material for masonry is not covered in the Eurocodes, it should be done in accordance with local practice and experience.

This clause has given a lot of flexibility to the use of new, informal or unpopular materials in the Eurocode.

A typical local practice in this context may be the traditional earth block construction practice with reference to the National Building Code of another country like Nigeria and the Compressed Earth Block Code for Africa by CDI and CRA Terre [6].

F. Masonry Construction Materials in Eurocode 6

The code EN 1996-2:2006, [5], clause 2.2.2(1) made specific references and provisions for the following construction material for masonry units:

1. Clay Masonry units (fired clay). (EN 771-1), [7]
2. Calcium silicate masonry units. (EN 771-2), [8]
3. Aggregate concrete masonry units. (EN 771-3), [9]
4. Autoclaved aerated concrete masonry units. (EN 771-4), [10]
5. Manufactured stone masonry units. (EN 771-5), [11]
6. Natural stone masonry units. (EN 771-6), [12]

Other materials:

While specific references and provisions were made to the above material, the Code accommodated other materials in EN 1996-2:2006, [5], clause 2.2.2(2). It states:

> *"For products not in accordance with EN 771 (e.g. reclaimed products) the design specification should state the required performance characteristics and the means of their verification including the requirements for sampling and frequency of testing."* [5]

The compressed earth block like the reclaimed products is here accommodated with the condition that the following design specifications would have to be stated:

1. Required performance characteristics.
2. Means of their verification (tests) to include the requirement for sampling.
3. Frequency of testing.

G. Recognition of local practice and experience

The required performance characteristics common to all materials for masonry units in the codes are: Dimensions, Flatness of bed faces, Plane parallelism of bed faces, Configuration and appearance, Density, Mechanical strength, Water absorption by capillarity, Moisture movement, Reaction to fire, Thermal properties, etc.

Table 1 shows these properties, the clause number in EN 771-3:2011, [9], and the appropriate location of Test method in the Eurocode.

Table 1: Common properties applicable to Masonry units and their test methods, (Eurocode EN 771-3:2011), [9].

Property	**Clause number in EN 771-3:2011 and others.**	**Test Method**
Dimensions	5.2.1 and 5.2.2.1	EN 772-16
Flatness of bed faces	5.2.2.2	EN 772-20
Plane parallelism of bed faces	5.2.2.3	EN 772-16
Configuration and appearance	5.3	EN 772-16, EN 772-2, EN 772-20
Density	5.4	EN 773-13
Mechanical Strength	5.5	EN 772-1, EN 772-6
Water absorption by capillarity	5.8	EN 772-11
Moisture movement	5.9	EN 772-14
Reaction to fire	5.11	EN 13501-1
Thermal properties	5.6	EN 1745
Water vapour permeability	5.10	EN ISO 12572 or EN 1745
Shear bond strength	5.12	EN 1052-3
Mortar/Rendering and Plastering mortar	EN 1996-2 clause 2.2.3 EN 998-1, EN 998-2	EN 1015-1 to 21
Ancillary components	EN 845-1 to 3	EN 846
Geotechnics investigations Soil Classification and Properties.	EN ISO 14688-1:2002 EN ISO 14688-2:2004	

(Extracted from Eurocode EN 771-3:2011), [9].

The amount of the above tests required in determining performance is dependent on the use, the nature of material, the micro conditions of exposure of completed masonry and the regulatory requirements in area of application. The detailed classification of micro conditions of exposure of completed masonry is well presented in Annex A of EN 1996-2:2006, [5].

III. CONCLUSION

This paper which is a prelude to an on-going research, sets out to evaluate the relevance of old, unpopular or informal construction materials and methods in the framework of a leading contemporary standards – the Eurocodes. The findings were that the Eurocodes having a performance based approach to standardization is extensive in coverage yet resounding in outcome. The codes recognised local practise and experience, and are adequately accommodating. The enhanced compressed earth block is adequately accommodated in the Eurocodes, it only has to clearly define its roles and reveal its innate properties in a test of performance. These thus set the background upon which further research can be developed.

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