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# Assessment of compressed earth blocks made in Spain: International durability tests

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## HIGHLIGHTS

- We study the durability against rain of compressed earth blocks.
- We analyze the usefulness of test procedures proposed in the international normative.
- The lack of unified criteria in the tests produces differences in the results obtained.
- Spanish CEB are fit for exterior and/or interior walls depending on stabilization.
- This analysis could be a reference in the writing of future normative documents.

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## ABSTRACT

This research studies the durability against rain of the most industrialized construction material based on unbaked earth: compressed earth blocks (CEBs). The test procedures will be those ones proposed in the international normative (44 normative documents studied), analyzing the usefulness of these tests. The lack of unified criteria in the tests produces differences in the results obtained depending on the method used. Spanish stabilized CEB are fit for both interior faces and exterior walls, while non-stabilized CEB are just adequate to be used in exterior walls by applying a protection. This analysis could be a reference in the writing of future normative documents for all the world.



## 1. Introduction

### 1.1. Compressed earth blocks

Constructions based on unbaked earth date back since more than 9000 years ago [1]. Compressed earth block (CEB) has become more common in the last few years as an earth construction system [2], proving to be an industrialized material, besides its traditional value as an element of self-construction.

CEB includes all the variations of this product, whether or not the earth is stabilized [3]. Although throughout the literature different designations are used, all refer to the same products: compressed earth block [4], pressed brick [5–7], pressed block [8], compressed stabilized earth block – CSEB [9–12], soil cement solid bricks [13–24], soil–cement block [25], ground blocks cements [26], compressed earth brick [8] or stabilized soil blocks [27]. The most common format is a rectangular parallelepiped (or prismatic) formal with a length "*l*", a width "*w*" and a height "*h*", obtained from static or dynamic compression of wet earth, followed by an immediate stripping, and that may contain stabilizers or additives to achieve or develop the particular features of the products [4,26].

In Fig. 1, it compiles the sizes of the CEB accepted in the official normative of the countries that have a standard of compressed earth block. However, in the Spanish standard UNE 41410 [4], NMAC 14.7.4 [28] or the American regulation published by ASTM International [8], sizes and tolerance of the blocks are not specified, allowing some liberty in the making of these earth materials.

It can define the CEB as the product obtained by compression of wet earth, followed by a stripping, and that may contain stabilizers or additives to achieve certain properties and which dry compressive strength equals or is more than 2 MPa.

Mechanic compression improves the physical properties of these blocks. Benefits of using earth in this manner include improved strength and durability as compared with adobe [29].

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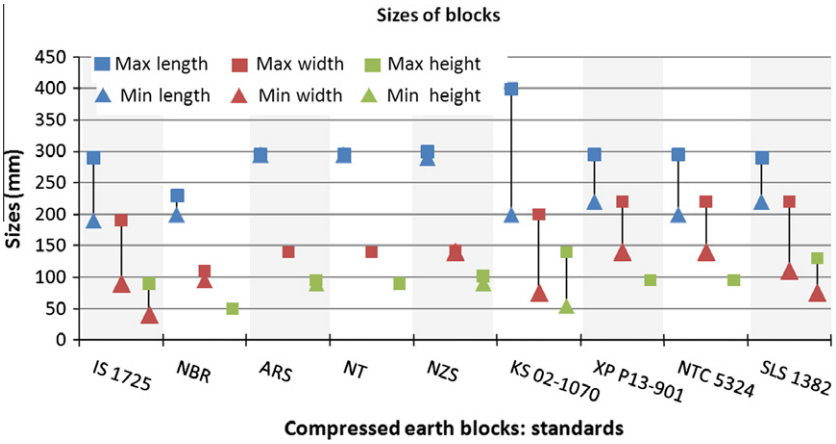


**Fig. 1.** Sizes of blocks (length, width, height) in international normative (CEB).

Besides, the advantages of these CEB are that they do not need the high temperature curing as required by fired clay bricks [30] and the optimum compression level is reached by hydraulic presses.

### 1.2. Standards for compressed earth block

The number of normative documents on compressed earth block (CEB) that were identified and used in this article are forty four. The totality of international norms in reference to the CEB are:

The norm IS 1725 [25] from India, twelve norms NBR [13–24] from Brazil, fourteen norms ARS [31–44] from African Regions, two norms NT [45,46] from Tunisia, three norms NZS [5–7] from New Zealand, one norm KS 02-1070 [27] from Kenya, one norm XP P13-901 [47] from France, one norm NTC 5324 [26] from Colombia, one norm UNE 41410 [4] from Spain, one norm ASTM E2392M-10 [8] from the American Society for Testing and Materials, and lastly, one norm NMAC 147.4 [28] from New Mexico. In addition to these, three normative documents of great international prestige are EBAA 2001 [48], HB 195 [49] and Bulletin 5 [9].

In this normative about compressed earth blocks, the application field in 85% of the analyzed standards and regulations contemplates the stabilization of the blocks. In the rest of the documents it contemplates blocks with or without stabilizers always that mechanical specifications referred in the document are accomplished. This is the case of the first European normative [4], which limits the amount of stabilizers and additives to 15%.

A compressed earth block is considered valid if the proposed mechanical specifications are complied, needing a minimum value of compression (dry and wet values). The amount of moisture of the block influences the values of compression [50], so that a dry value is obtained when the CEB is tested when the weight is constant after two consecutive loads; or a wet value if the test is performed on the block previously submerged in water. In most of the international standards, it considers CEB those blocks that have a compression value in dry that is equal to or more than 2 MPa; case of the Brazilian standards [13], Colombian standard [26], Indian standard [25] or the experimental French standard [47].

### 1.3. Typologies of CEB: standards

The typologies of compressed earth blocks, which are defined in the standards and regulations, are classified according to different properties:

**Table 1**
Drip and spray erosion test, international normative.

| Technical documents | Reference | Drip erosion | Spray erosion | Technical |
|---|---|---|---|---|
| IS 1725 | [25] | | X | b |
| NZS | [5–7] | X | X | a, b, c |
| SAZS 724 | [65] | X | X | c |
| SLS 1382 | [10–12] | | X | b |
| UNE 41410 | [4] | X | | b |
| ASTM E2395M-10 | [8] | X | X | a, b, c |
| EBAA 2001 | [48] | X | X | a, b, c |
| HB 195 | [49] | X | X | a, b, c |
| Bulletin 5 | [9] | | X | a, b, c |

(a) Adobe; (b) compressed earth block; (c) rammed earth.

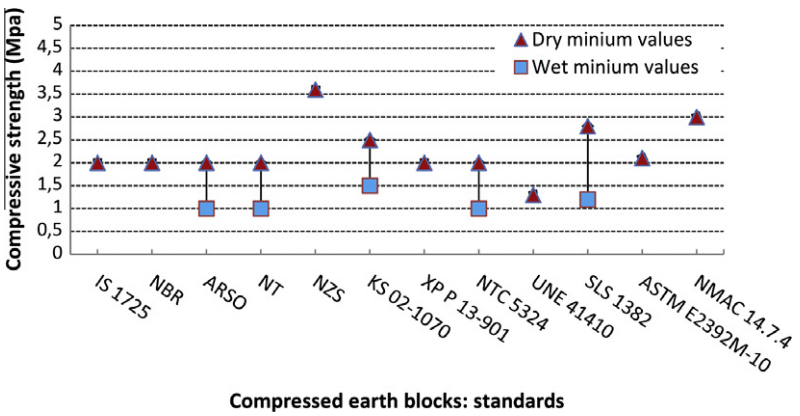


**Fig. 2.** Minimum values of dry and wet compressive strength in all international standards (CEB).