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Construction regulations with earth in the world

The earth building normative documents in the world

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SUMMARY

The earth has been used as material for construction for centuries. However, the regulations in this regard are very dispersed, and in most developed countries numerous technical and legal problems arise to carry out a construction with this material. This article studies the regulatory landscape for constructions with raw earth at an international level, analyzing fifty-five standards and regulations from countries spread over five continents, which represent the state of the art in the standardization of raw earth as a construction material.

It is a referenced study on the current standards and regulations developed by the national standardization bodies or authorities corresponding. The regulations and the agencies that issue them are presented, analyzing the structure and content of each one. The most relevant aspects are studied and analyzed, such as stabilization, soil selection, product requirements and existing tests, comparing the different regulations. This work can be very useful for the development of future standards and as a reference for architects and engineers who work with earth.

SUMMARY

For centuries, earth has been used as a construction material. Nevertheless, the normative in this matter is very scattered, and in the most developed coun tries, carrying out a construction with this material implies a variety of technical and legal problems.
This article analyzes, in an international level, the normative panorama about constructions with earth, analyzing fifty five standards and regulations of countries all around the five continents; these represent the state of art that normalizes the earth as a construction material. It is a study indexed on the actual procedures and regulations developed by the national organisms of normalization or correspondent authorities. The standards and the organisms that produce them appear, analyzing the structure and the content of each one. We have studied and analyzed the most relevant aspects, such as stabilization, soil selections, the requisites of the products and the existent test, comparing the diverse normative. The knowledge from this study could be very useful for the development of future standards and as a reference for architects and engineers that work with earth.

113-110

Key words: norms, construction with earth, blocks of compressed earth, adobe, tapial.

Keywords: *standards, earth building, compressed earth blocks, adobe, rammed earth.*

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1. INTRODUCTION

Earth is increasingly valued as a construction material. Given the growing interest in this ancient material, and in the absence of a legal framework, many countries try to standardize its use to solve the current problems derived from the absence of regulations that allow the use of construction techniques with raw earth.

There are numerous works that focus on the study of standards and regulations in the field of construction, such as the studies carried out by Soronis (1), Cañas (2), Hooton (3) or Mahlia (4). In the field of application of building with earth, many countries have been working on standardization in recent years, Colombia (2005) and Spain (2008) stand out, with the publication of new standards; Chile, Ecuador, Mexico and Nicaragua, developing future standards; o Peru improving existing documents (5).

This growing activity makes it convenient to analyze the state of the art of standardization for construction with raw earth.
For this, we have carried out a search in a variety of sources, international standardization organizations, databases, organizations and construction networks with earth, in addition to basing ourselves on lists of regulations already published (2).

Following the classification made by Cañas 2007 (2), the study has focused on the standards issued by the national standardization bodies and the regulations issued by the authorities, according to the European Standard EN 45020: 2007, which in turn adopts ISO/IEC Guide 2:2004 (6). However, although it is not the object of study in this work, it is important to point out the existence of documents that, without having the character of norms or regulations, are important in certain countries, such as the normative documents of Germany or Australia.

2. RULES AND REGULATIONS

In the process of searching and studying international standards and regulations in the framework of construction with raw earth, 55 documents have been located. Table 1 details the standards or regulations found, where it is indicated: Country, the reference of the Standard or Regulation; the issuing body (ORG); the bibliography reference, which is reflected by the number that appears in the bibliography epigraph of this article (REF); if the document only deals with stabilized earth (EST), and if it contemplates any of the three main techniques on which our study focuses: adobe, mud wall or compressed block (Technique). In Table 2 they are ordered by date of publication of the current regulations of each country.

The set of documents found is very varied. For better handling and understanding, some regulations from the same country have been grouped together. These are the cases of the Brazilian standards for BTC (7-19), the New Zealand ones (32-34), the Peruvian NTP of stabilized adobe (36-38), the collection of the African regional standardization organization ARS 670-683 (39 - 52) and the Tunisian standards (56.57).

From all of them, a set of standards and regulations have been selected that are representative of the international standards for building with raw earth and are valid for detailing the current status (see table 3). In this selection, the Nigerian standard NIS 369 (31) has been discarded due to the difficulty in accessing and obtaining the document; Turkish standards TS 537, TS 2514 and TS 2515 (58-60) for not being written in Spanish, English or French; and the Italian laws (28,29) considering their scarce applicability with a technical-constructive nature.

This selection is structured into fifteen groups of norms and regulations, (counting in the same group all the norms or regulations of a country except in the case of Peru and the US because they have been developed by different entities). All have been issued by national bodies except a New Mexico state standard, the African Regional Body International Standards Group (ARSO), which includes several countries in Africa, and the standard published by the ASTM International Organization. Figure 1 shows the standards and regulations by year of approval in chronological order.

Group 1: Brazil
Brazil has issued thirteen standards (7-19), developed by the Brazilian Association of Technical Standards (ABNT) from 1986 to 1996, on soil-cement and its construction applications in the form of soil-cement blocks and monolithic walls. .

Group 2: Colombia
In 2005, the Colombian standard NTC 5324 (20) was issued, edited by ICONTEC, being a translation of the French experimental standard XP P13-901,2001(24) of AFNOR on BTC.

Group 3-4: USA
The New Mexico regulation (21) is issued by the CID (Construction Industries Division) in 2004, based on two currently repealed codes

Recently, the international organization "American Society for Testing and Materials" has developed the technical standard ASTM E2392 M-10 (22) approved in January 2010 and published in March of that year.

Group 5: Spain At the end of 2008, the first Spanish standard (23) for construction on earth was developed, and the first current non-experimental European standard for compressed earth blocks, issued by the AEN/ CTN 41 SC 10 "Building cation with raw earth" from AENOR.

Group 6: France
The XP P13-901:2001 (24) experimental standard is a provisional document accessible to the public, developed by the national organization AFNOR in order to obtain the necessary experience in its application, on which to base a future standard.

Group 7: India
The regulatory body in India since 1987 is the BIS (Bureau of Indian Standards) whose predecessor was the ISI (Indian Standards Institution) which published the revised IS 2110 (25) standards in May 2007, the IS 1725 standard (26) and the IS 13827 standard (27).

Group 8: Kenya
KS 02-1070 (30) issued by the KBS (Ken ya Bureau of Standards) is a revision of the 1993 standard.

Group 9: New Zealand
In 1996, the three standards issued by the national organization SNZ (New Zealand Standards) (32-34)

Group 10-11: Peru
The Peruvian standard NTE E 080 (35) of 2000 comes from a previous version of 1977 of the ININVI (National Institute for Housing Research and Standardization) which was ab absorbed by the public body SENCICO (National Service for Standardization, Training and Research for the Construction Industry). Currently the Peruvian standard is undergoing a second revision and expansion. The NTP standards (36-38), issued by the Peruvian Standardization System INDECOPI.

Group 12: Regional Africa In 1998, 14 standards on BTC were issued (39-52) by the African Regional Organization for Standardization (ARSO) published in a technological series of the CDI/CRATerre (60).

Group 13: Sri Lanka
The Sri Lanka Standards Institute (SLSI) develops at the end of 2009 three standards on stabilized compressed earth blocks (53-55).

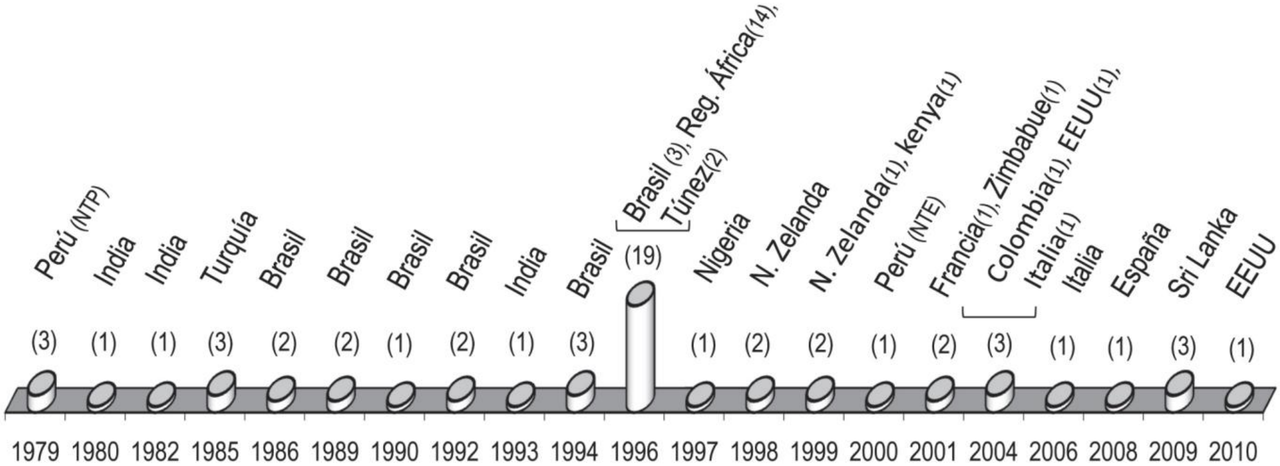
Group 14: Tunisia
Two NT standards (56,57) published in 1996 by the Tunisian standardization body, INNORPI.

Group 15: Zimbabwe
The Zimbabwe standard (61) was issued in 2001 by the National Standards Agency (SAZ) and is based on a publication by Keable 1996 (62).

3. ANALYSIS OF THE STRUCTURE AND CONTENT OF THE REGULATION INTERNATIONAL

A large part of the documents analyzed (79%) focus their content on the study of a single construction technique, be it adobe, BTC or mud. The remaining papers examine various techniques. In this way, the SAZS 724 (61) and IS 2110 (25) standards are exclusive for tapial. Containing provisions only for adobe is the Peruvian NTE E 080 (35) and, for adobe is-

1. Regulations in force by year of approval



(Nº): number of regulations in force between parentheses.

Table 1

List of standards and regulations found

País	Norma/Reglamento	ORG	REF	EST	Adobe	BTC	Tapial	Notas
	NBR 8491, 1986.		7					BTC estabilizado con cemento especifica, métodos de ensayo.
	NBR 8492, 1986.		8					
	NBR 10832, 1989		9					Procedimiento fabricación BTC con prensa manual/hidráulica
	NBR 10833, 1989		10			x		
	NBR 10834, 1994.		11					Especificaciones y métodos de ensayo de bloques de suelo- cemento
	NBR 10835, 1994		12					
Brasil	NBR 10836, 1994	ABNT	13	x				
	NBR 12023, 1992		14					Métodos de ensayo para suelo-cemento
	NBR 12024, 1992		15					
	NBR 12025, 1990		16					
	NBR 13554, 1996		17					
	NBR 13555,1996		18					
	NBR 13553, 1996		19				x	Tapia con cemento
Colombia	NTC 5324,2004	ICONTEC	20	x		x		Estabilizado con cemento
EEUU	NMAC, 14.7.4, 2004	CID	21		x	x	x	Reglam. Estatal de Nuevo México.
	ASTM E2392 M-10	ASTM	22		x		x	
España	UNE 41410:2008	AENOR	23			x		Primera norma Europea
Francia	XP P13-901,2001	AFNOR	24			x		Norma experimental
	IS 2110 : 1980	BIS	25	x			x	Paredes de suelo-cemento
India	IS 1725 : 1982.	BIS	26	x		x		
	IS 13827 : 1993	BIS	27		x		x	Directrices resistencia a terremotos
Italia	Ley nº 378, 2004		28		x	x	x	Leyes para la conservación del patrimonio de tierra
	L.R. 2/06 2 2006		29					
Kenya	KS 02-1070: 1999.	KEBS	30	x		x		
Nigeria	NIS 369:1997.	SON	31	x		x		
	NZS 4297, 1998.		32					
Nueva Zelanda	NZS 4298, 1998.	SNZ	33		x	x	x	
	NZS 4299, 1999.		34					
	NTE E 0.80, 2000	SENCICO	35		x			
Perú	NTP 331.201, 1979		36					
	NTP 331.202, 1979.	INDECOPI	37	x	x			
	NTP 331.203, 1979.		38					
	ARS 670, 1996		39					
	ARS 671, 1996		40					
	ARS 672, 1996		41					
	ARS 673, 1996		42					
	ARS 674, 1996		43					
	ARS 675, 1996		44					
Regional África	ARS 676, 1996		45					
	ARS 677, 1996	ARSO	46			x		
	ARS 678, 1996		47					
	ARS 679, 1996		48					
	ARS 680, 1996		49					
	ARS 681, 1996		50					
	ARS 682, 1996		51					
	ARS 683, 1996		52					
Sri Lanka	SLS 1382-1:2009	SLSI	53	x		x		Bloques de suelo comprimido estabilizados
	SLS 1382-2:2009		54					
	SLS 1382-3:2009		55					
Túnez	NT 21.33:1996	INNORPI	56			x		En francés
	NT 21.35:1996		57					En francés
	TS 537, 1985.		58	x				
Turquía	TS 2514, 1985.	TSE	59		x			En turco
	TS 2515, 1985.		60					
Zimbabue	SAZS 724, 2001.	SAZ	61				x	

Abreviaturas: ORG (Organismo); REF (Referencia, ver en bibliografía el número); EST (Estabilización, si solo contempla el uso de tierra estabilizada)

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Table 2

Table of current regulations

Año	País	Norma	REF
1979	Perú	NTP 331.201,331.202,331.203	36-38
1980	India	IS 2110	25
1982	India	IS 1725	26
1985	Turquía	TS 537, TS 2514, TS 2515	58-60
1986	Brasil	NBR 8491, 8492	7-8
1989	Brasil	NBR 10832,10833	9-10
1990	Brasil	NBR 12025	16
1992	Brasil	NBR 12023,12024	14-15
1993	India	IS 13827 : 1993	27
1994	Brasil	NBR 10834,10835,10836	11-13
1996	Brasil	NBR 13554,13555,13553	17-19
	Regional África	ARS 670-683	39-52
	Túnez	NT 21.33, 21.35	56-57
1997	Nigeria	NIS 369	31
1998	Nueva Zelanda	NZS 4297, 4298	32-33
1999	Nueva Zelanda	NZS 4299	34
	Kenya	KS 02-1070	30
2000	Perú	NTE E 0.80	35
2001	Francia	XP P13-901	24
	Zimbabue	SAZS 724	61
2004	Colombia	NTC 5324	20
	EEUU	NMAC, 14.7.4	21
	Italia	Ley nº 378, 2004	28
2006	Italia	L.R. 2/06	29
2008	España	UNE 41410	23
2009	Sri Lanka	SLS 1382-1, 1382-2, 1382-3,	53-55
2010	EEUU	ASTM E2392 M-10	61

stabilized with asphalt, NTP 331.201, NTP 331.202 and NTP 331.203 (36-38). Regulating only the compressed earth block are the French XP P13-901 (24), the Colombian NTC 5324 (20), the Kenyan KS 02-1070 (30), the African regional collection ARS 670 to ARS 683. (39-52), the NT 21.33 and NT 21.35 (56.57) and the Spanish standard UNE 41410 (23).

The Brazilian one is exclusively made of compressed earth blocks, except for the NBR 13553 (19) standard, which includes a monolithic wall. Indian standards IS 2110 and IS 1725 (25,26) regulate rammed earth (soil-cement walls) and BTC respectively. NMAC 14.7.4 (21) deals primarily with the three main techniques, although it also includes lumps and clods. The most complete of the thirteen is the New Zealand one, a collection made up of NZS 4297, NZS 4298, NZS 4299 (32-34), which includes adobe, compressed earth block and mud wall, as well as poured earth. For information only, it also offers recommendations for cob and adobe in-situ. As can be seen, only two deal with the three main techniques at the same time, NMAC 14.7.4 (21) and the NZS (32-34). It is noteworthy that of the fifteen group of standards, eleven dedicate part or all of their norm to the compressed ground block.

In terms of content, we can say that the largest and most complete document is the New Zealand trio (32-34), since it ranges from material and construction requirements to issues of structural design and durability of earthen buildings, and both for adobe as for compressed earth block or tapial. The content of this group of standards is somewhat smaller in terms of unit manufacturing, topic

Table 3
Selected rules and regulations and content

País/Grupo	Norma/Reglamento	REF.	EST.	Técnica	Campo de aplicación	Selección suelos	Requisitos productos	Ensayos	Fabricación	Construcción	Diseño
Brasil 1	NBR 8491, 1986.	7	x	Bloque comprimido macizo	Condiciones exigibles para recibir los bloques	x	x				
	NBR 8492, 1986.	8			Ensayos de resistencia a compresión y absorción de agua para bloques			x			
	NBR 10832, 1989	9			Procedimiento de fabricación con prensa manual/hidráulica	x			x		
	NBR 10833, 1989	10		Bloque comprimido macizo y perforado		x			x		
	NBR 10834, 1994.	11		Bloque comprimido perforado sin función estructural.	Condiciones de recepción	x	x				
	NBR 10835, 1994	12			Forma y dimensiones de los bloques		x				
	NBR 10836, 1994	13			Ensayos de resistencia a compresión y absorción de agua			x			
	NBR 12023, 1992	14		Bloques suelo-cemento	Procedimientos de ensayos			x			
	NBR 12024, 1992	15						x			
	NBR 12025, 1990	16						x			
	NBR 13554, 1996	17						x			
	NBR 13555,1996	18						x			
	NBR 13553, 1996	19		Pared monolítica sin función estructural	Condiciones exigibles para los materiales para paredes monolíticas sin función estructural.	x	x				
Colombia 2	NTC 5324,2004	20	x	Bloques macizos de suelo-cemento para muros y divisiones.	Caracterización y métodos de ensayo de los bloques macizos suelo-cemento.	x	x	x			
EEUU 3	NMAC, 14.7.4, 2004	21		Adobe, Bloques de tierra comprimida y tapial	Reglamento de construcción	x	x	x		x	
4	ASTM E2392 M-10	22		Adobe, tapial	Guía para construcción de sistemas con tierra	x		x	x	x	
España 5	UNE 41410:2008	23		Bloques de tierra comprimida	Definiciones, especificaciones y métodos de ensayo	x	x	x			
Francia 6	XP P13-901,2001	24		Bloques de tierra comprimida	Terminología, dimensiones y métodos de ensayo	x	x	x			
India 7	IS 2110 : 1980	25	x	Pared in-situ de suelo-cemento	Especificaciones técnicas para paredes no mayores de 3,2 m de altura y anchura >300mm muros de carga o >200mm particiones.	x	x			x	
	IS 1725 : 1982.	26	x	Bloques de tierra comprimidos estabilizados.	Requisitos y pruebas para bloques de tierra de uso en construcción en general. Procedimientos de ensayos.	x	x	x			
	IS 13827 : 1993	27		Adobe y tapial	Directrices para la mejora de la resistencia sísmica de edificios de tierra		x			x	
Kenya 8	KS 02-1070:1,1999.	30	x	Bloques de suelo estabilizados con cemento o cal	Requisitos para la construcción con este bloque	x	x	x			
Nueva Zelanda 9	NZS 4297, 1998.	32		Adobe, bloque comprimido, tierra vertida, tapial	Diseño estructural y de durabilidad de los edificaciones de tierra					x	x
	NZS 4298, 1998.	33			Caracterización de materiales y especificaciones de construcción para el uso de tierra cruda. Procedimientos de ensayos	x	x	x	x	x	
	NZS 4299, 1999.	34		Adobe, bloque comprimido, tapial	Requisitos de diseño y construcción para adobe, bloques comprimido o tapial que no necesitan diseño específico.					x	x
Perú 10	NTE E 0.80, 2000	35		Adobe	Requisitos para la construcción de adobe simple y adobe estabilizado	x	x	x	x	x	x
11	NTP 331.201, 1979	36	x	Adobe estabilizado con asfalto	Definiciones, condiciones generales y requisitos		x	x	x		
	NTP 331.202, 1979.	37			Procedimientos de ensayo	x					
	NTP 331.203, 1979.	38			Muestreo y recepción.		x				

Table 3

Selected rules and regulations and content

País/Grupo	Norma/Reglamento	REF.	EST.	Técnica	Campo de aplicación	Selección suelos	Requisitos productos	Ensayos	Fabricación	Construcción	Diseño
Regional África 12	ARS 670, 1996	39		Bloques de tierra comprimida	Terminología BTC.	x					
	ARS 671, 1996	40			Clasificar los BTC						
	ARS 672, 1996	41			Clasificación de morteros de tierra.						
	ARS 673, 1996	42			Definir formas de albañilería						
	ARS 674, 1996	43			Requisitos de BTC ordinarios	x	x				
	ARS 675, 1996	44			Requisitos aplicables a BTC vistos	x	x				
	ARS 676, 1996	45			Requisitos de morteros ordinarios		x				
	ARS 677, 1996	46			Requisitos de morteros vistos		x	x			
	ARS 678, 1996	47			Requisitos para albañilería revestida					x	x
	ARS 679, 1996	48			Requisitos para albañilería vista					x	x
	ARS 680, 1996	49			Estado del arte fabricación BTC	x			x		
	ARS 681, 1996	50			Estado del arte para morteros tierra.	x			x		
	ARS 682, 1996	51			Estado del arte para construcción					x	
	ARS 683, 1996	52			Pruebas requeridas	x	x				
Sri Lanka 13	SLS 1382-1:2009	53	x	Bloques de tierra comprimida	Requerimientos	x	x				
	SLS 1382-2:2009	54		Bloques de tierra comprimida	Métodos de ensayo			x			
	SLS 1382-3:2009	55		Bloques de tierra comprimida	Guía sobre producción, diseño y construcción				x	x	x
Túnez 14	NT 21.33:1996	56		Bloques de tierra comprimida	Especificaciones para BTC ordinarios, características geométricas, fisico-quimicas...		x	x			
	NT 21.35:1996	57			Definición y clasificación de BTC		x				
Zimbabue 15	SAZS 724, 2001.	61		Tapial	Guías para el diseño, construcción y ensayos para estructuras de tapial.	x	x	x		x	x

which is found in the Brazilians (9-10) and the ARS 680 (49) for the compressed earth block. Construction and performance provisions appear in detail only in New Mexico NMAC 14.7.4 (21), Zimbabwe SAZS 724 (61), Peru NTE E 0.80 (35), New York NZS 4298 (33) Ze land and Africa ARS 682 (51).

The ones that dedicate more content to structural design are again the New Zealanders (32,33), using limit state design principles in their formulation.
Limitations of slenderness of walls and indications on their bracing are indicated in the New Mexico regulation, NMAC 14.7.4 (21); in Zimbabwe, SAZS 724 (61) and in Peru's NTE E 0.80 (35).
What is found in all of them are requirements that must be demanded of the products, through minimum results that must be obtained from a series of tests.

This series of tests in all cases are explained in the standards themselves or referenced to other documents that contain their procedures. Only in the case of NMAC 14.7.4 (21) no reference is found.

All the standards basically consider the use of earthen walls as resistant walls, which could also be used as non-resistant. SW

Unfortunately, the Brazilian standards (11-13,19) place limitations on the use of hollow blocks and monolithic walls without structural function.

Regarding the field of application of these earth techniques, some standards limit the height for load-bearing walls to a maximum of two floors (21) or not exceeding 6.5 m in height from the top of the foundation to the top. of the earthen wall (30). On some occasions, categories of buildings are established as in the NZS standards (32-34), normal category one or two heights whose requirement are some minimum properties of use, surface, height of walls, thicknesses, load, etc. and one.

And a special category that exceeds all the characteristics of the normal category

Regarding areas susceptible to seismicity, the Peruvian standard NTE E 0.80 (35) limits the number of heights, also finding some indications for seismic-resistant design in New Zealand (32-34).

4. RELEVANT ASPECTS OF THE REGULATORY

4.1. Stabilization

In the set of selected standards, it is recommended to add some stabilizing agent (cement, lime...) to improve the characteristics.

mechanical characteristics, durability and stability of the soil, although it is not always essential, since many soils can achieve satisfactory behavior without the need for any stabilizer. The most common stabilizers are cement (21,35,39,61), non-hydraulic and hydrated lime (33,61), or asphalt emulsions for adobe (35).

Some of the standards have exclusively stabilized soil as their object of standardization, in the case of Brazilian standards (7-19), Colombian standards (20), India (26), Kenya (30) or the three Sri Lankan standards for blocks. compressed earth; for adobe the NTP standards of Peru (36-38) and for tapial the Brazilian standard (19) together with the IS 2110 standard (25).

Another approach regarding the use of stabilizers is to set a stabilizer content limit, as is the case of the New Zealand standards (32-34) and the Spanish standard (23). In the case of the Spanish standard, the total content of stabilizers (cement, lime, plaster and others) must be less than or equal to 15% of the dry mass of the block. Except for the US standard (21) which establishes exceeding a water absorption value in the case of adobe, and for mud containing a minimum of 6% by weight of Portland cement, passing the wet compressive strength tests, no another document defines stabilized earth.

4.2. soil selection

In all the standards there are references to the selection of soils, even though the approaches in each of the documents are different and sometimes even scarce (26,30). The most usual are recommendations of results based on certain tests that in many cases are imprecise, not quantifiable or based on preliminary tests.

The most cited group of properties are texture and plasticity (23,24,35,39,40,61) although there are also indications on organic content and salt content, especially if that soil is going to be stabilized. Plasticity and texture diagrams are frequent in the French (24), Colombian (20) or Spanish (23) standards, while in the Brazilian standards (7-19) liquid limit values (ÿ45%) are recommended. and plastic index (ÿ18%) or the values of the different fractions of the soil in other standards such as Peru (35) or Zimba bue (61). Other properties related to the chemical composition of the soil or pH are non-existent.

Another approach is to value the soil according to the construction product that will constitute the walls (21,32-34). This is done because there is no direct relationship between the behavior of the product and the characteristics of the soil used. It is verified through the built elements indicating tests to be carried out and results required according to the technique used (32-34) or by checking the blocks directly (21).

4.3. Product requirements

Next, we will deal with the aspect related to the required properties for the adobe and BTC pieces and also for the case of the wall in which the resulting product of the construction is the wall itself.
The specifications refer to the classification of products, dimensional, geometric, appearance, physical-chemical or mechanical-hygrometric physical characteristics through required (36) or recommended values. These product standards that specify the requirements that must be met to establish its suitability for use are very common in the land regulatory framework (7,11,12,19, 20, 23, 24, 26, 30, 33, 35 , 56,57, 61).

In the standards, the required or recommended values are obtained through tests, whose procedure is specified therein, becoming test standards.
This is so because they are not previously standardized or assume variations of the existing ones. These are the cases NBR 8492 (8), NMAC 14.7.4 (21), XP P13-901 (24), IS 1725 (26), KS 02-1070 (30) NZS 4298 (33) or NTP 331.202 (37).

The standards analyzed referring to BTC are found with a broader classification, greater geometric or appearance characteristics than those referring to adobe pieces. A very usual classification for the types of BTC is according to mechanical restrictions (26), based on the comprehension values, in the case of the Colombian (20), Spanish (23) or ARSO standards (39-52).).
They are usually solid blocks but cracks and perforations are allowed (7-19,39-52), there being limitations to these perforations (33) or being a necessary condition (26).

The reception of compressed blocks and adobe, including the applicable requirements, the sampling to be carried out and the acceptability conditions are included in NTP 331.203, (38), XP P13-901 (24), IS 1975 (26) and ARS 680 (39). Also in the case of the Spanish standard (23) it is required to guarantee all the aforementioned pre-registrations, carrying out the corresponding verifications according to the standard.

4.4. essays

Much of the information collected in standards or building regulations with earth refers to test procedures. There are publications referring exclusively to trials (8, 13,37,39-52); Other standards introduce tests in annexes, such as IS 1725 (26), KS 02-1070 (30), NZS 4298 (33), SAZS 724 (61); while other documents accompany it to product standards, in the case of the Peruvian (35), French (24) and Spanish (23) standards.

The regulations for building with earth are quite autonomous and test procedures typical of construction techniques with earth are often described, such as erosion tests (33-61). There are also many references to national standards from other fields of knowledge, especially with regard to soil preparation and classification. Among these references, texture and plasticity stand out, as in the Brazilian standards (7-19), SAZS 724 (61), NZS 4298 (33), XP P13-901 (24), and the Spanish standard (23); determination of the organic matter content (23,30) or the determination of the optimum moisture content of a soil. For the absorption of water in BTC, many national standards referring to brick are cited (23,24,26).

Some of the most cited tests in the raw earth regulations are erodibility, wetting/drying cycles and compressive strength. The water fall or pressure spray tests are quite homogeneous in any of the versions carried out (23,26,33,61), while the wetting and drying cycle test procedures are very different in terms of cycles or drying times.

Compression resistance tests are considered indicators of the quality of earth elements, but very few comparable proposals are found. If we focus on the comprehension test of the BTC pieces, we find two alternatives: test the split and stacked block, in the case of Brazilian standards (7-19) and French standards (24); or rehearse the piece as complete as in the case of the Spanish standard (23), since with the presence of the mortar a new parameter is added in addition to the one of the piece.

There are also tests related to shear stress by diagonal compression (35) or tensile strength tests with modulus of rupture or tensile strength by flexion of individual elements (21, 30, 32-35).

5. CONCLUSIONS

At present, standards with specific purposes are avoided: specifications, manufacturing processes or test methods, tending towards a joint publication for various purposes, as shown in the Spanish or French standard. Most standards are product standards, extending their field of application to test procedures.

In most cases, these types of documents refer to one or two techniques. Standards and regulations that cover earthen construction in its entirety are rarely used.

Of the standards analyzed, those referring to compressed earth blocks stand out, for which there is an abundance of regulations, especially with regard to the specification of the block, geometric, dimensional, appearance, physical-chemical characteristics, etc.

The New Zealand set of standards presents a model comparable to the current approach given to other construction materials, characterized by the good definition of the subject techniques, by the abundant development of all phases of the process for the three techniques and for the detailed description of the proposed test procedures.

It is necessary to standardize the tests applied to constructions with earth, both for pieces and for monolithic walls, in order to carry out an adequate comparative analysis between the different existing construction techniques.

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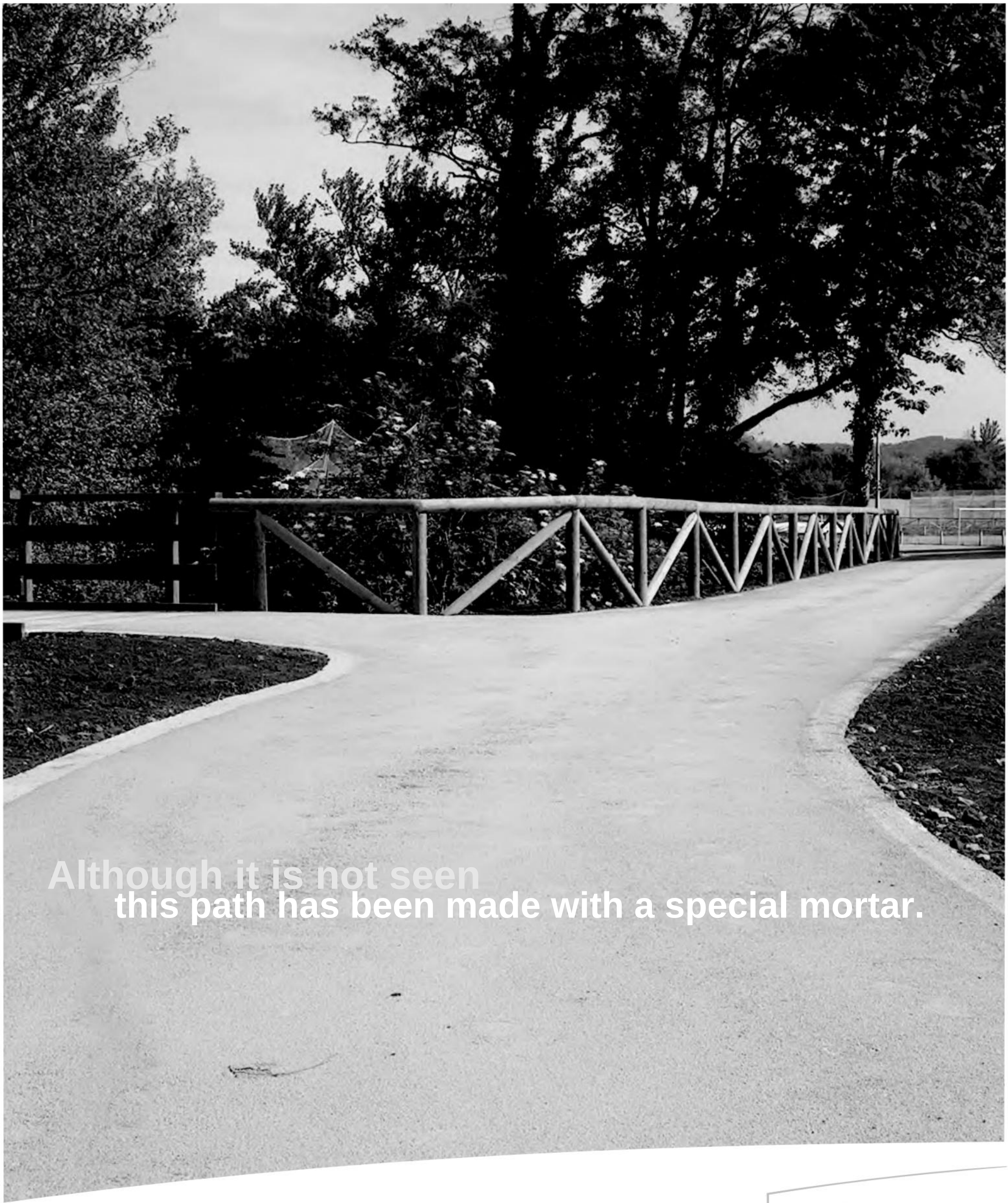

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