

CHARACTERIZATION OF TRADITIONAL RAW MATERIALS USED IN HOUSING CONSTRUCTION IN HUAMBO REGION – ANGOLA

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1- INTRODUCTION

The sustainability of buildings associated to the use of raw earth has motivated the studies and the development of techniques and methods in the context of this type of construction. In the region of Huambo, Angola, these construction techniques are widely used, especially for low-income families who represent the majority of the population. Much of the buildings in Huambo province are built with adobe (Fig.1). Due to the climate in this region, subtropical, hot and humid, with altitudes above 1000 meters and extensive river system, these buildings are particularly vulnerable to the action of water and develop, in many situations, early degradation. The Huambo Province is located in central Angola, has an area of about 36,000 km² and approximately 2 million inhabitants (Fig. 2).



Figure 1 – Earth Construction in Huambo Region - Angola.

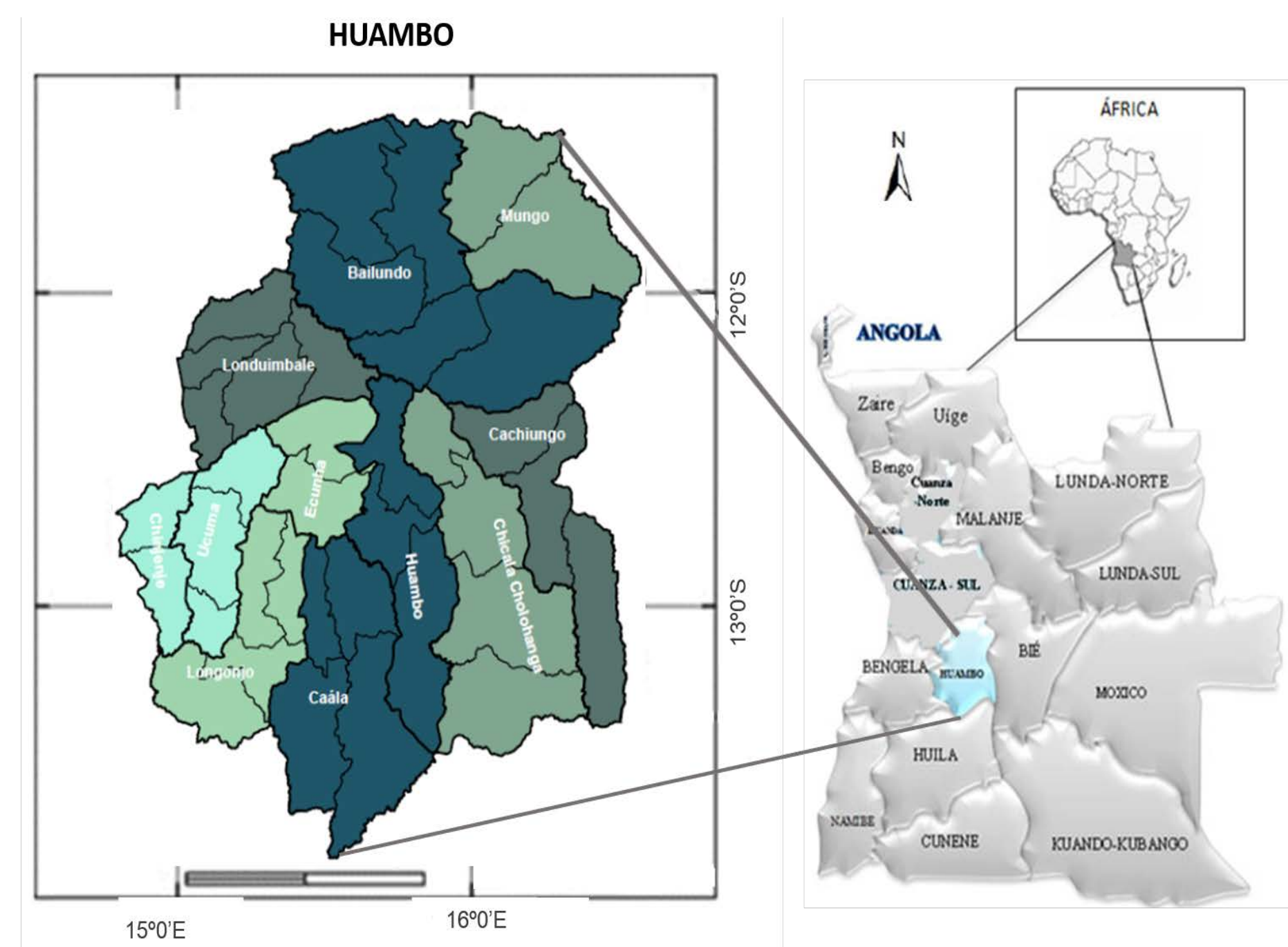


Figure 2 – Study area in Province of Huambo, Central Plateau of Angola.

2 - OBJECTIVES

This work aims to evaluate, by conducting *in-situ* tests, physical and mechanical properties of soils and adobe blocks typically used in the construction of those buildings.

ACKNOWLEDGEMENTS

To FCT for funding the research grant with reference SFRH/BSAB/113791/2015 and the Project with reference: UID/GEO/04025/2013

3 - METHODS

The methodology is based on field campaigns (Fig. 3) where *in situ* expeditious tests were performed in soils (smell test, bite, color, touch, brightness, sedimentation, ball, hardness, etc.) and tests on adobes blocks manufactured with traditional procedures (Fig. 4) particularly in terms of durability and erodibility (erosion test at Geelong method: evaluation test of wet / dry cycle, applying the New Zealand standards 4297:1998; 4298:1998 and 4299:1998).



Figura 3 – Sampling sites on Huambo Province: (1) Napika; (2) Calenga; (3) Londumbale; (4) Lepi; (5) Ussoque; (6) Alto Hama; (7) Catolo; (8) Ngolo; (9) Chianga; (10) Tchicala-Cholohanga; (11) Longongo; (12) Ukuma; (13) Chingenje; (14) Lomanda; (15) Ndondo; (16) Lunge and (17) Mungo.

4 - MATERIALS



Figure 4 – Manufacture of adobes in Huambo Province - Angola.

5 - "IN SITU" TESTS IN SOILS AND ADOBES



Figure 5 – Sedimentation test.

Table 1 – Average percentage of the sand, silt and clay particles, resultant of sedimentation test by the "bottle test" in the soils of some localities of Huambo Province - Angola.

Particles (%)	Napika	Calenga	Londumbale	Lepi	Ussoque	Alto Hama	Catolo	Ngolo	Chianga	Tchicala	Longongo	Ukuma	Chingenje	Lomanda	Ndondo	Lunge	Mungo
Sand	18,6	20,3	19,7	25,3	25,6	23,3	9,4	15,3	16,4	23,9	21,1	29,4	18,3	25,0	18,6	16,1	20,8
Silt	22,1	3,2	5,4	1,4	5,4	5,0	6,1	5,0	12,2	5,3	4,7	28,9	8,3	4,7	10,0	4,2	2,5
Clay	59,3	76,5	55,6	73,3	69,1	71,7	84,4	79,7	71,4	70,8	74,2	41,7	73,3	70,3	71,4	79,7	76,7

Table 2 – Characteristics observed *in situ* in each type of soil used in the manufacture of adobes.

Locality	Color	Smell	Touch	Remarks
Napika		clay smell	little roughness when rubbed between fingers	more clay and less sand
Calenga		clay smell	some roughness when rubbed between fingers	lot of clay: small amount of sand
Londumbale		musty smell	little roughness when rubbed between fingers	lot of clay: organic matter
Lepi		strong smell of clay	without roughness when rubbed between fingers	lot of clay: small amount of sand: shrinkage cracks
Ussoque		clay and musty smell	little roughness when rubbed between fingers	lot of clay: sand: organic matter
Alto Hama		clay/musty smell	little roughness when rubbed between fingers	lot of clay: sand: organic matter
Catolo		little odour	with roughness	very granular soil (grains around 1 mm) with little clay
Ngolo		do not smell musty	little roughness when rubbed between fingers	lot of clay: very little amount of sand
Chianga		slight musty smell	little roughness when rubbed between fingers	granular soil with grains around 2 mm
Tchicala		clay smell	very rough when rubbed between fingers	very granular soil with grains around 2 mm
Longongo		slight clay and musty smell	little roughness when rubbed between fingers	more clay than sand: little organic matter
Ukuma		clay smell	with roughness	clay and sand
Chingenje		slight clay and musty smell	little roughness when rubbed between fingers	more clay than sand: little organic matter
Lomanda		slight musty smell	very rough when rubbed between fingers	very granular soil with grains around 2 mm
Ndondo		slight musty smell	very rough when rubbed between fingers	very granular soil with grains around 2 mm
Lunge		slight musty smell	little roughness when rubbed between fingers	more clay than sand: little organic matter
Mungo		strong smell of clay	without roughness when rubbed between fingers	lot of clay and very little sand

6 - RESULTS

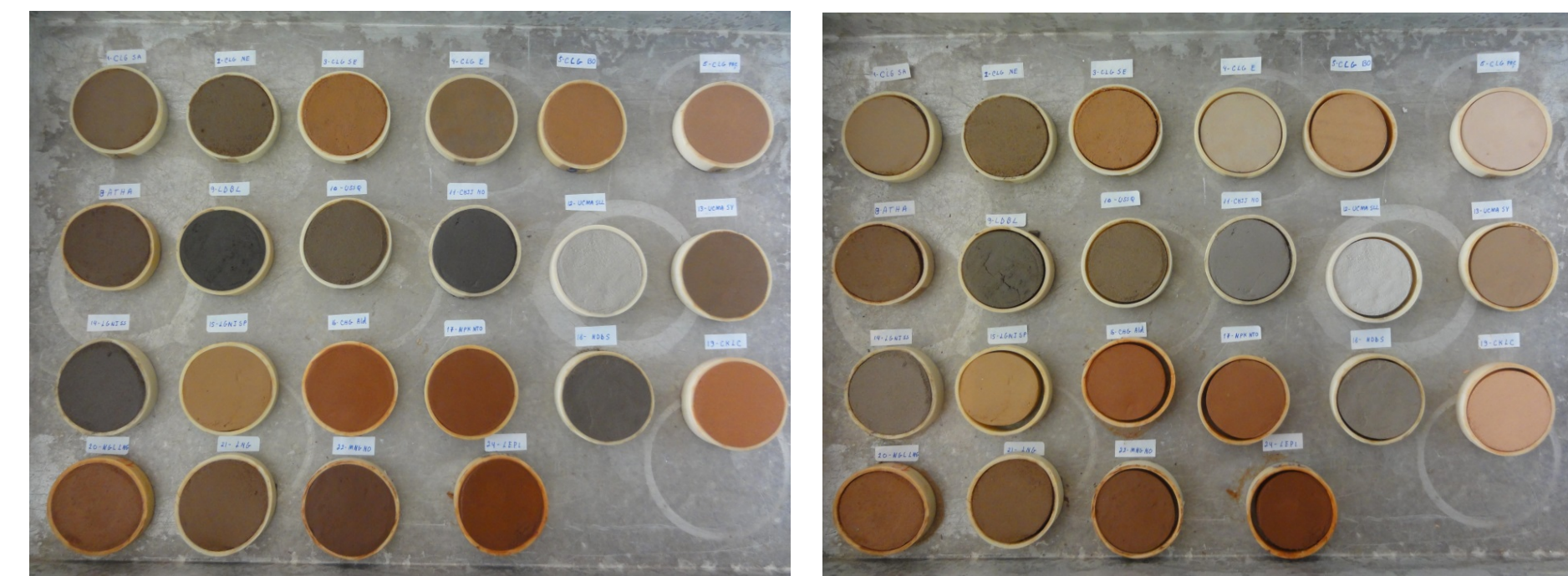


Table 3 – Shrinkage test values.

Soil	Shrinkage [mm]	Shrinkage [%]
Local		
Calenga SA	2,50	5,00
Calenga NE	1,38	2,72
Calenga SE	2,00	4,00
Calenga E	1,87	3,74
Calenga BO	3,86	7,72
Calenga PRC	1,53	3,06
Alto Hama	1,43	2,86
Londumbale	1,77	3,54
Ussoque	1,72	3,44
Chingenje	0,91	1,82
Ukuma SLL	3,18	6,36
Ukuma SV	1,52	3,04
Longongo SS	0,66	1,32
Longongo SP	3,66	7,32
Chianga	3,68	7,36
Napika	3,10	6,20
Ndondo	3,11	6,22
Tchicala	2,41	4,82
Ngolo	1,71	3,42
Lunge	1,51	3,02
Mungo	2,62	5,24
Lepi	3,96	7,92

Figure 7 – Shrinkage test on rings (5 cm diameter; 1 cm height): a) moist soil; b) after 48 hours of air drying.

Table 4 – Erodibility test results (average values) of adobes using the method of Geelong.

Adobe	Groove depth [mm]	Depth of water [cm]
Local		
Napika	0,20	1,30
Calenga	1,20	4,00
Londumbale	4,17	2,67
Lepi	2,75	1,20
Ussoque	3,50	3,95
Alto Hama	4,80	4,80
Catolo	3,00	3,50
Ngolo	8,92	8,83
Chianga	2,00	2,50
Tchicala	6,67	15,00
Longongo	5,00	2,40
Ukuma	3,25	12,23
Chingenje	2,67	2,87
Lomanda	2,00	2,50
Ndondo	0,50	1,00
Lunge	5,29	4,40
Mungo	4,00	4,00

7- CONCLUSIONS

- ❑ The majority of materials are clayed soils with sand and varying amounts of organic matter (Tables 1 and 2).
- ❑ The tested soils showed significant shrinkage values, mostly above 3% (Table 3).
- ❑ According to the test results Geelong (Table 4), the tested adobes have acceptable characteristics (less than 15 mm groove depth) for earth construction, in accordance with New Zealand Standard NZS 4298 (1998).
- ❑ These results will contribute to the characterization of the geomaterials and methods used in construction with earth in Huambo Province, contributing to the improvement of these sustainable solutions, with a strong presence in this region. The results of this study will also contribute to the proposal of constructive solutions with improved performance characteristics, comfort, safety and durability.

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