Compressed and Stabilized Earth Blocks in Louisiana

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Introduction

Compressed and stabilized earth block (CSEB) construction systems are becoming popular due to their low cost, low carbon footprint, use of indigenous materials, and inherent simplicity compared to other construction system [1]. It is mostly used in dry and arid regions, whereas it has rarely been used in humid climate like Louisiana due to:

a) Poor resistance to weather degradation in humid climate [2],

b) Widespread perception as a substandard choice for resisting extreme wind loads [3],

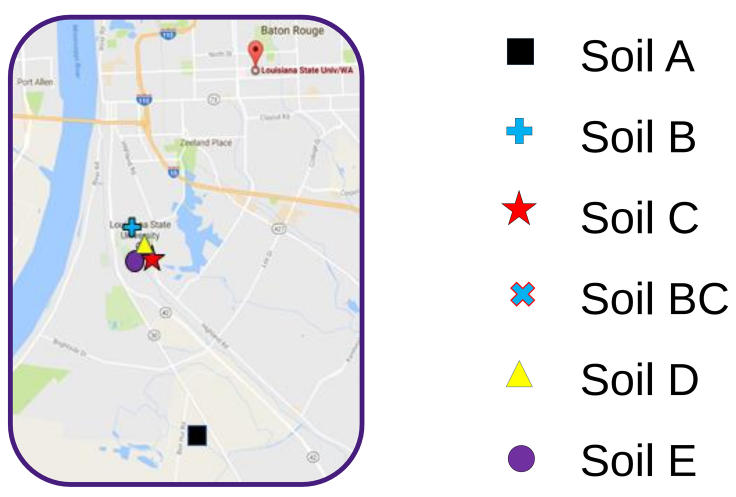
c) Limited availability of well-graded suitable soil.

The objective of this research is <u>to investigate the feasibility of CSEB systems as a hurricane-resistant, affordable, and durable housing typology in Louisiana</u>.

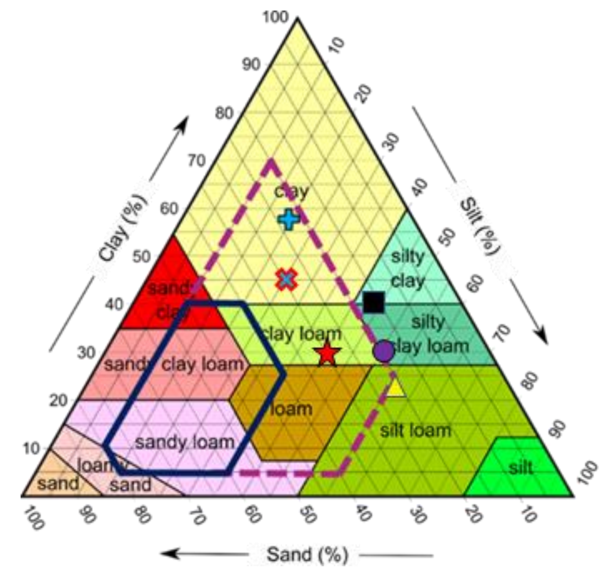
Soil Identification

- Composition of soil suitable for fabricating compressed earth blocks (CEBs) [3-5] can be represent on the USDA soil texture triangle, as shown in figure.
- Soil samples were taken from different locations in Baton Rouge and were identified on the USDA soil texture.

<u>The soil B and C lay within the sub-optimal composition region, and the soil A, D, and E lay immediately outside this region.</u>



Locations of soils Baton Rouge, LA



USDA soil texture triangle

Mechanical Properties of CSEBs

Prototype CSEBs of nominal dimension 290 x 145 x 75 mm^3 were fabricated with soil A and different amounts of Type II Portland cement (PC). <u>CSEBs with 9 wt% and 12 wt% cement content satisfy the necessary strength requirements</u> for low rise building (up to two story):

a) NMAC [6] recommends a minimum mean f_{bd} = 2.07 MPa, a minimum f_{bd} = 1.72 MPa, and a minimum mean MOR = 0.35 MPa

b) Minimum mean f_{bw} = 1.5 MPa is recommended in humid environment [3].

Mechanical properties of CSEBs for different cement content.

Cement content	MOR [MPa]		f_{bd} [MPa]		f_{bw} [MPa]	
(%)	Mean	COV	Mean	COV	Mean	COV
3	0.39	11.4	1.66	8.74	0.75	4.91
6	0.53	6.38	2.01	6.13	0.97	9.91
9	0.66	4.87	2.97	7.19	1.58	4.32
12	0.78	4.17	3.89	5.47	2.16	5.84

COV is coefficient of variation expressed in %, MOR is modulus of rupture, f_{bd} is dry compressive strength, and f_{bw} is wet compressive strength.

Durability Investigation of CSEB Wall

- A single-wythe CSEB wall of dimension 1220 x 920 mm^2 was built with CSEBs produced from reconstituted soil BC (soil B and C were mixed together in equal parts) and 6 wt% Type II Portland Cement.
- A 12-mm-thick layer of soil-cement (soil BC and 6 wt% cement) and a thin layer of cement paste paint was applied to half portion of the wall. The wall was exposed to outdoor weather conditions for six months and was visually inspected regularly.

<u>Humid weather produces very demanding conditions for CSEB Wall and the proposed dual layer plaster was effective in protecting the CSEB wall</u>.

Mechanical properties of CBEBs before construction and after demolition of the wall

Tested specimens	MOR [MPa]		MOE [MPa]		f_{bd} [MPa]		MOE [MPa]	
	Mean	COV	Mean	COV	Mean	COV	Mean	COV
CSEBs before construction	0.57	11.3	164.3	22.0	1.38	6.4	31.2	16.98
CSEBs protected	0.64	22.7	279.5	17.1	1.79	5.5	55.6	20.21
CSEBs unprotected	0.37	21.8	143.3	31.6	1.50	13.8	44.8	26.82

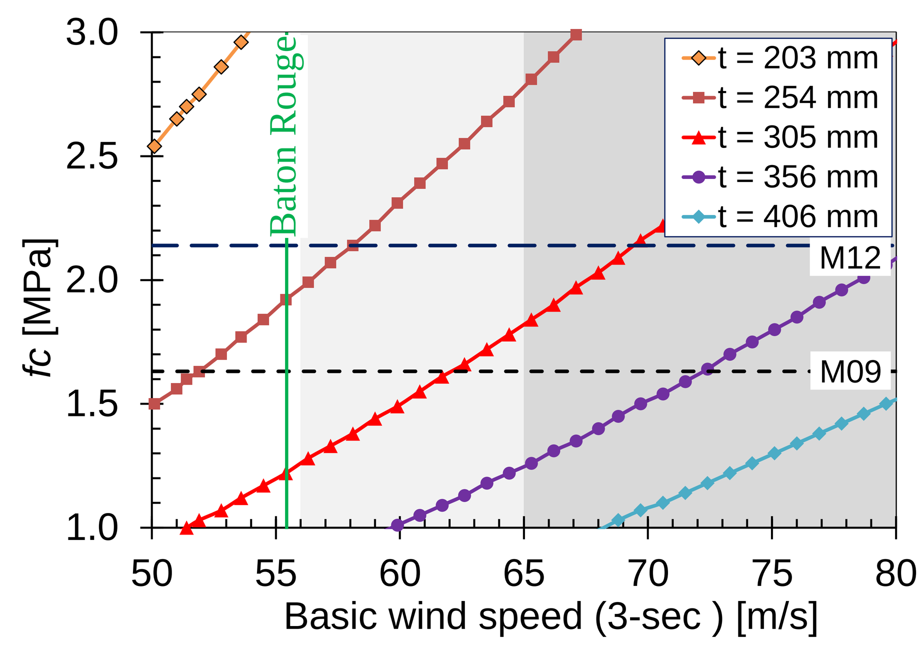
COV is coefficient of variation expressed in %, MOR is modulus of rupture, MOE is modulus of elasticity, and f_{bd} is dry compressive strength.

Wall (left to right): **immediately after construction; after three months; after six months**

Hurricane Wind Resistance of CSEB Systems

The hurricane wind resistance of CSEB systems was determined by using the parametric strength demand curves developed by Matta et al. [3] for the main wind-force resisting system of one-story single-family dwellings (with a flat roof) located in exposure zone C [7].

- The characteristic compressive strength of masonry was determined according to Eurocode 6 [8], which provides conservative strength values [9] and can be applied to the strength ranges of CSEBs considered in this study.
- M09 and M12 identify the characteristic masonry strength for CSEB masonry built using CSEB with 9 wt% and 12 wt% cement, respectively, and a mortar with compatible compressive strength.



Parametric strength demand curves

<u>For Baton Rouge, a CSEB wall made of M12 can be built using a single-wythe configuration (*t* = 254 mm), whereas M09 would require a double-wythe configuration (*t* = 305 mm).</u>

Economic Feasibility Study

A prototype CSEB house of 1000 ft^2 area and built using M12 masonry was compared with an equivalent traditionally-build wooden house. Components other than the walls (e.g., foundation, roof, and floor systems) were assumed to be equal, and thus have the same costs for the two houses.

- The CSEB walls were assumed to be built using interlocking CSEBs with thin layers of mortar slurry and grouted vertical steel reinforcement [10].
- Costs were determined using the average national costs of material and labor as reported by RS Mean [11].

<u>The cost of the CSEB walls is slightly lower than the light-frame wooden wall systems.</u>

Cost estimates of CSEB and wooden frame walls for prototype house

	CSEB	Wooden
Material	$6,954	$15,638
Labor	$19,917	$13,068
Overheads	$12,119	$14,007
Total wall cost	**$38,989**	**$42,714**
Total cost of assemblies	$45,441	$45,441
Total cost of house	**$84,430**	**$88,155**

Conclusions

a) The soil available in the East Baton Rouge area is suitable for fabricating CSEBs.

b) The CSEBs fabricated with at least 9 wt% of cement content satisfy the minimum strength requirements for building single-story dwellings.

c) A dual layer plaster consisting of a soil-cement stucco with a coat of cement paste can provide sufficient protection to exterior CSEB walls in humid climates.

d) Hurricane-resistant earthen dwellings can be built in Baton Rouge, LA, using interlocking CSEB masonry walls at a lower cost than traditional light-frame wooden systems.

<u>This feasibility study shows that earthen dwellings built with interlocking CSEB wall systems can be an attractive choice for low-cost hurricane-resistant housing.</u>

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