

Mechanical characterization of compressed earthen blocks stabilized with cement, pozzolan, and lime

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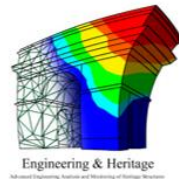
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The proposals for the construction of sustainable and eco-friendly housing require an exhaustive study of its mechanical properties and structural system. In the present study there were evaluated the mechanical properties of Compressed Earth Blocks (CEB) stabilized with chemical stabilizers materials like cement, pozzolan or lime.

Soil



Original soil sieved by the mesh #4 and then was added well graded sand in 15% by weight.

Chemical stabilizers



Portland cement
type I (Ce)



Hidraulic Lime (Ca)

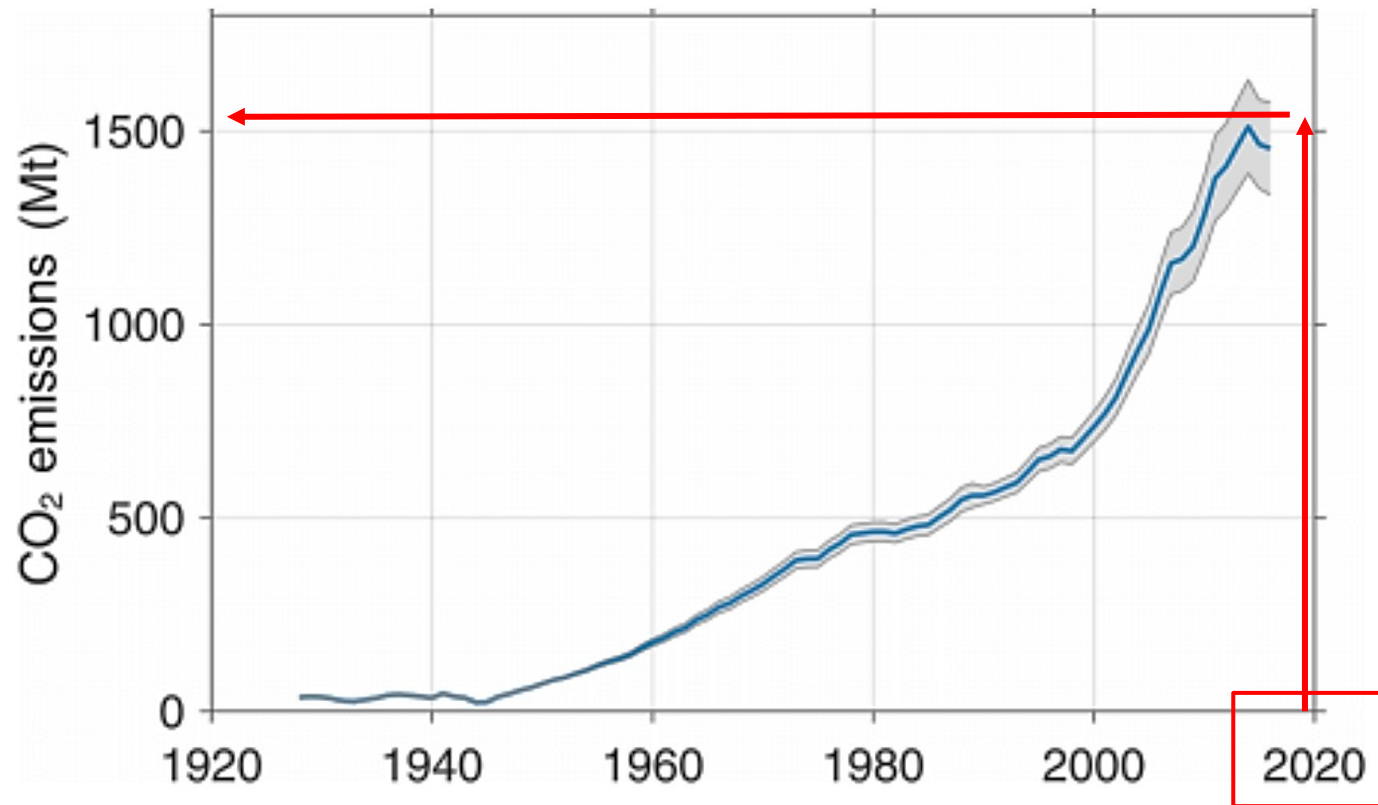
Composition: 11.2 μm
grain size and a specific
weight of 2.78 gr/cm³



Pozzolan (Pz)

Composition: crushed
limestone and 3% to
15% of Ca(OH)₂

Cement production is one of the industries responsible for the production of million tons (Mt) of CO₂ per year.



Annual CO₂ emissions from cement production (Andrew M.: “Global CO₂ emissions from cement production, 1928–2018” Andrew, 2018).

This research **proposes the use of less polluting materials such as hydraulic lime and pozzolan** to stabilize the CEB's. A mechanical characterization of different dosages was carried out to evaluate the resistance obtained after chemical stabilization.

N°	Dosage Type	Dosage by weight (%)				w (%)	w/c
		BS (%)	Ce (%)	Ca (%)	Pz (%)		
1	BS	100	-	-	-	12 - 14%	-
2	BS + Ce10%	90	10	-	-	9 - 10%	0.9 - 1.0
3	BS + Ce 9.0% + Ca 1.0%	90	9	1	-	8 - 9%	0.9 - 1.0
4	BS + Ce 7.5% + Ca 2.5%	90	7.5	2.5	-	9 - 10%	1.2 - 1.3
5	BS + Ce 5.0% + Ca 5.0%	90	5	5	-	8 - 9%	1.6 - 1.8
6	BS + Ce 9% + Pz 1%	90	9	-	1	9 - 10%	1.0 - 1.1
7	BS + Ce 8% + Pz 2%	90	8	-	2	9 - 10%	1.1 - 1.3
8	BS + Ce 7% + Pz 3%	90	7	-	3	9 - 10%	1.3 - 1.4

The water content values for the dosages were obtained after analyzing the workability of the mixtures

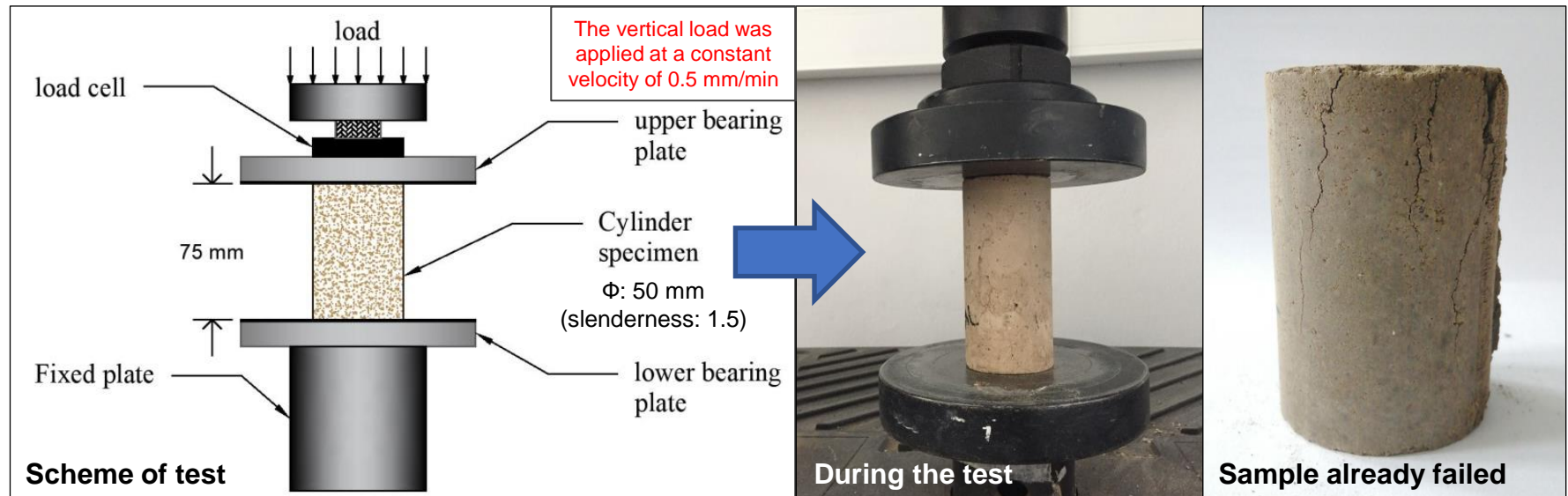
The amount of stabilizer used does not exceed 10% of the total weight

Percentage of materials used for each proposed dosage

Water/cement range for each dosage

The experimental campaign was made taking in consideration two mechanical test: **uniaxial compressive test** and **split test**. In addition, for the eight dosages proposed, those with the best mechanical properties were determined.

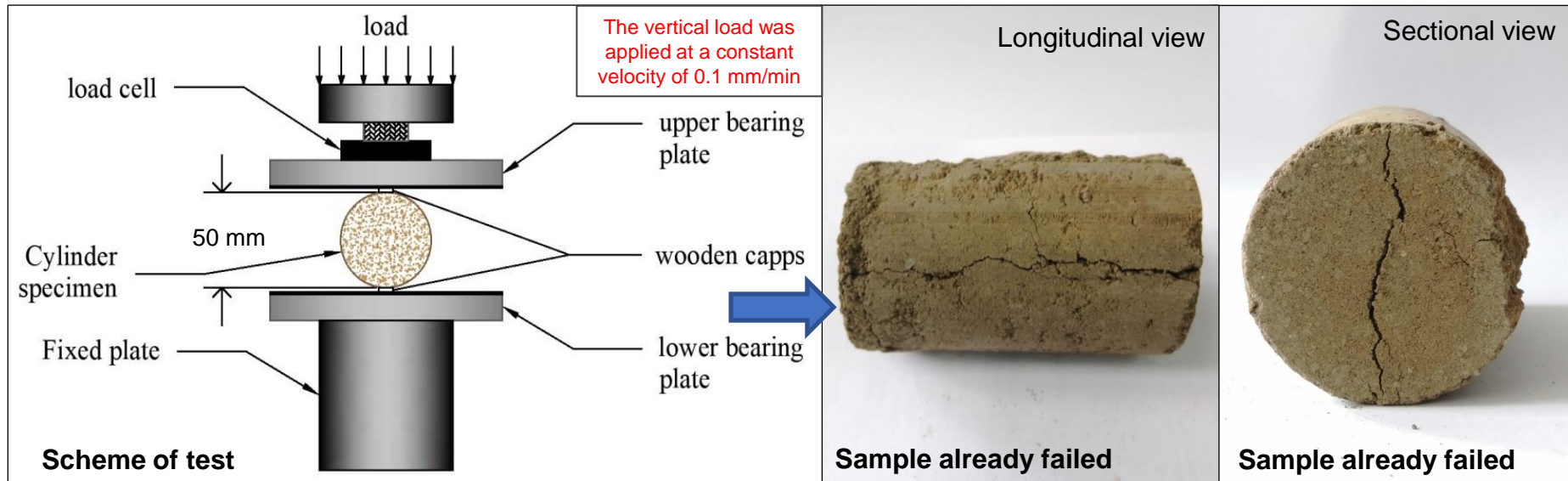
UNIAXIAL COMPRESSIVE TEST: Specimen type → CYLINDERS



Specimens were tested at the ages of 7, 14, 21 and 28 days (considering 5 specimens per age), for each dosage.

The experimental campaign was made taking in consideration two mechanical test: **uniaxial compressive test** and **split test**. Furthermore, different dosages were considered to check which one provides the best requirement.

SPLIT TEST: Specimen type → CYLINDERS



Specimens were tested at the age of *28 days* (considering 5 specimens for each dosage).

The results of the **uniaxial compression tests** showed that stabilization always provides an increment of the compressive strength, no matter the curing age.

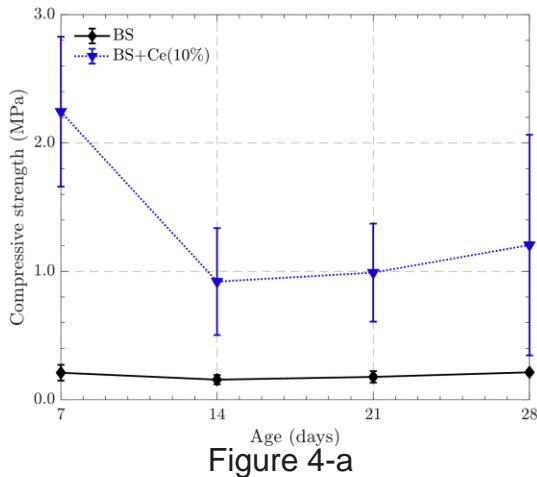


Figure 4-a

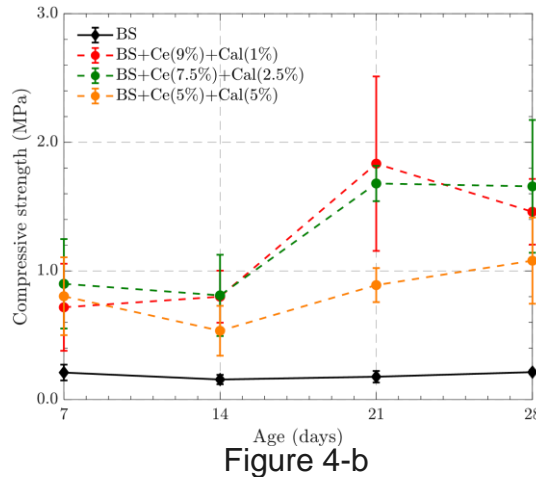


Figure 4-b

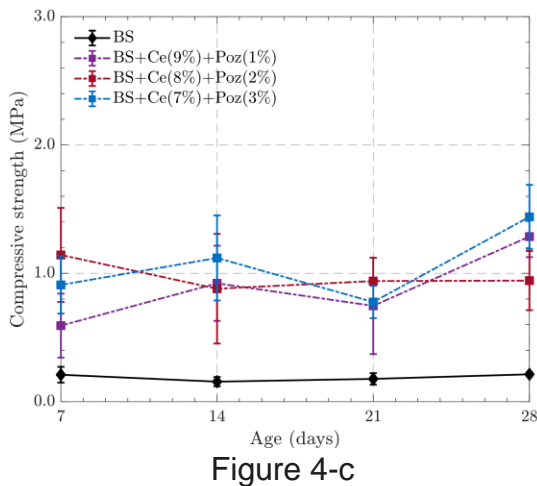


Figure 4-c

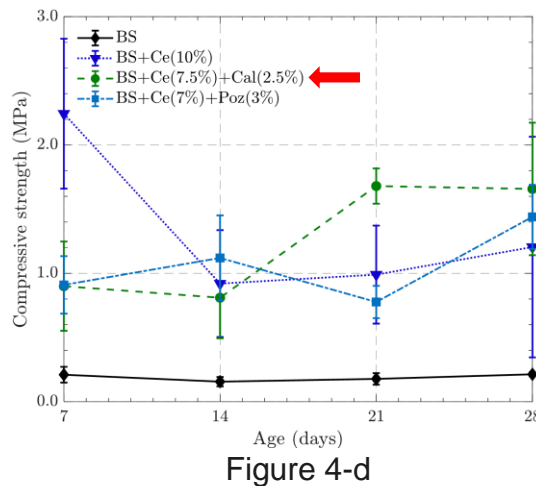
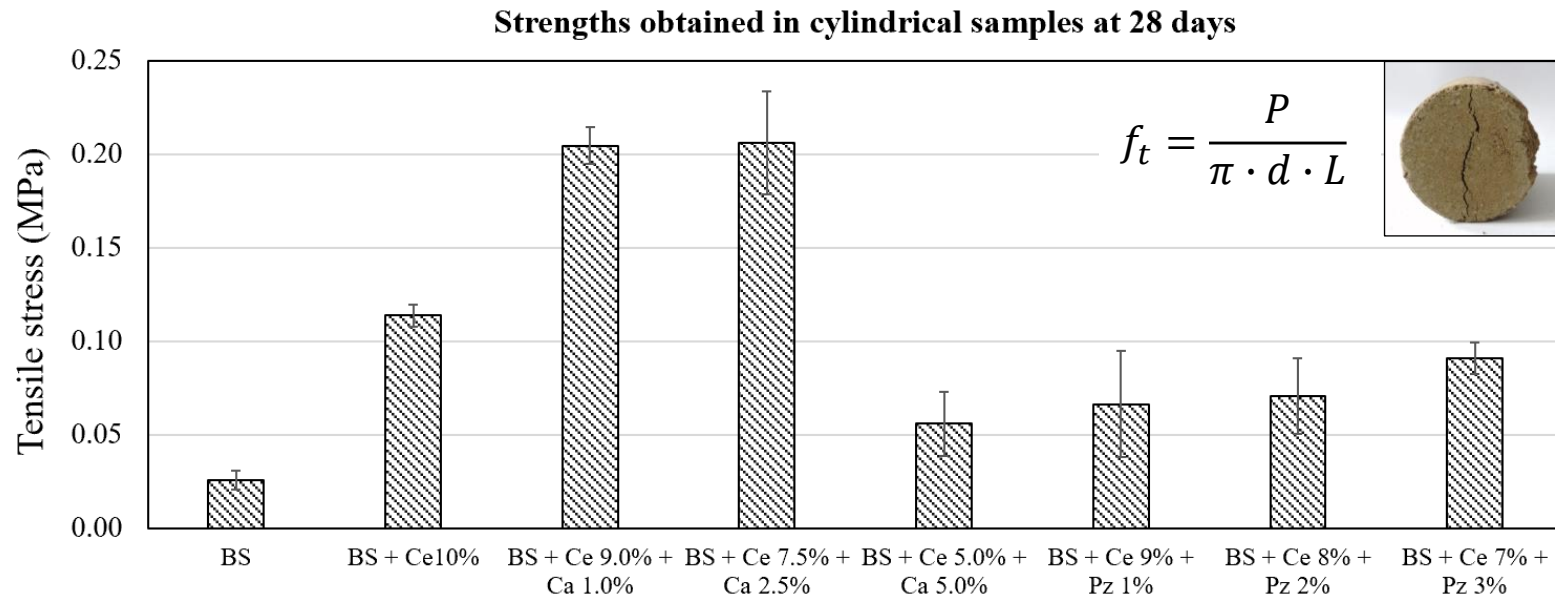


Figure 4-d

$$f_c = \frac{P}{A}$$

- Cement stabilization (Ce) gives the greater values of compressive strength, and **also the mayor standard deviation** (Figure 4-a).
- Dosage with cement and lime present good results in terms of compressive strength with **low variability** (Figure 4-b).
- Pozzolan stabilization is the one that provides **the lower enhancement on strength** (Figure 4-c).
- The summary of the best results is presented in **Figure 4-d** where the dosage N°4 (BS + Ce7.5 + Ca2.5) present the better results.

The results of the **split tests** showed that the addition of stabilizers always provides an increment of the mechanical properties of the specimen. All specimens were tested at the age of 28 days.



- Pozzolan stabilization provides the **higher variability**, on its results and moreover the *lower increment of strength*.
- Lime stabilization (dosages N°3 and N°4) presents the **higher increment on indirect tensile strength** and an acceptable variation: 4.1% and 13.2%, respectively.
- Therefore, dosage with cement and lime remains as the **better stabilizer in this experimental campaign**.

Conclusions



- Several dosages were made in order to find out which one provides the best mechanical results of compressed earth blocks.
- The mechanical characterization was performed on cylindrical samples both in the compression test and in the split test, because as there were so many tests this would increase the use of materials. With the results obtained, it is expected to manufacture CEB units and to verify these results.
- Even though, all the stabilizers add a significant enhancement of strength on the specimens, the results show that the stabilization with cement and lime provides high values of strength with the lowest variability. Furthermore, this stabilization also presents a good curing behavior since from 7 to 28 days the compressive strength grows up from 0.9 MPa to 1.6 MPa on average.
- In conclusion, the dosage which provides the greater results is dosage N°4

Thank very much for your attention.

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