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INFLUENCE OF THE USE OF THE DUNG OF COW ON THE COMPRESSIVE STRENGTH OF MORTARS OF BAR GROUND

The use of the materials of proximity is imperative more and more in the traditional constructions and the house in rural areas. In numerous traditions, the dung of cow (DOC) is a basic material in the construction. However, the performances of the use of the dung of cow (DOC) in the construction are scientifically little proved. The present research project studied the influence of the use of the dung of cow on the compressive strength of mortars of bar ground for the usages of blocks in compressed ground (BCG) and/or blocks in stabilized ground (BSG). An analysis is led by comparing the compressive strength of reference mortars (simple bar ground and bar ground more 4 %, 8 % and 12 % of Portland cement) and mortars (simple bar ground and cement Portland) containing different proportions of BDV (2 %, 4 %, 6 %, 8 % and 10 %). The results mainly allowed to show that the addition of a small quantity (lower than 6 %) of DOC sawdust doesn't decrease the compressive strength of the mortar of bar ground, it tends to improve it slightly. Beyond a 6 % content, the addition of the DOC decreases systematically the compressive strength of the mortar of bar ground.

***Keywords**: Bar ground, stabilized, dung of cow, compressive strength.*

1. Introduction

The population growth has for corollary the satisfaction of fundamental needs among which is situated the accommodation. In numerous countries, the ground constitutes the main material of construction and the traditional house is essentially with the material «ground» [4, 5, 16].

The cement is generally involved to stabilize the ground and techniques of compression come in support. Besides the compression and the stabilization by the cement, several other methods and materials are used in the constructions of traditional houses [2, 3, 8]. In number of these materials is the DOC which is a basic element in the construction. The DOC is the droppings of cow, of ox or of bull, and by extension of quite different bovidaes (ruminants with hollow horns), the DOC is used in the construction for: the erection of walls, the treatment of cracks, the coating et the waterproofing of facing [7, 16]. It is mixed in certain materials of proximity (sand, ground, flaw, branches…) to serve of binder, to give a solid character and to participate in the waterproofness of the material. The DOC so serves in the mortar for the traditional constructions. A study of traditional practices allowed to understand the interactions clays / bio-polymers. The DOC, biopolymer plays a role of organic adjuvant coming from animal or vegetable when it is added to the material ground to improve its properties and the durability of the built in ground [4]. En France, the DOC was added to the plaster to improve its characteristics [7].

The use of the DOC in mortars of coating is widely spread in several countries of Africa [2, 18]. In Benin, it is used in particular in the North in Atacora and Donga regions (construction of Ta-ta Somba) but also in the South in the lakeside villages. According to the testimonies, it confers on the houses, smooth, pleasant and fresh covers.

Recent studies inform about the incorporation of the sawdust of DOC and some ash of DOC in mortars and concretes [11, 17, 18]. In this context, a more fundamental approach to the study of the influence of the DOC in mixtures of mortar of bar ground and/or of cement finds its relevance. The mechanical characterization of mixtures of mortar containing some DOC will allow to estimate the performances brought back and transcribed by the literature as well as the habits and the practices which exist even nowadays.

2. Purpose of the research

The present article aims at studying the influence of the use of the DOC on the compressive strength of mortars in bar ground with use of blocks in compressed ground (BCG) and/or blocks in stabilized ground (BSG). This analysis will be done by comparing the compressive strength of reference mortars (earth of simple bar more Portland cement) and mortars containing various proportions of the BDV (simple bar ground and bar ground plus cement Portland). The article aims exactly at estimating the influence of the content in DOC on the compressive strength of various mortars put in experiment. The analysis of the results will allow to understand the interests of the use of the DOC in the habits and the practices of traditional constructions. She will also allow to determine an optimum content of incorporation of DOC for mortars of sufficient resistances.

3. Experimental program

The experimental program contains the study of the compressive strength of twenty four (24) different mortars with bar ground containing various proportions of Portland cement and/or DOC. Four (4) reference mortars (without dung of cow) are used with contents of 0 %, 4 %, 8 % and 12 % of cement. From these reference mortars, the DOC is introduced into proportions of 0 %, 02 %, 04 %, 06 %, 08 % and 10 %.

The compressive strength of twenty four (24) mortars was measured from cubic test tubes (edge 5 cm) and cylindrical (diameter: 50 mm and height: 100 mm) made by consolidation. The properties of fresh mortars and the results of the tests of compressive strength of test tubes so made are compared and analyzed.

4. Materials and procedures

4.1. Materials

4.1.1. Bar ground

The used bar ground in the preparation of test tubes is taken in the district of Glo-Djigbé (municipality of Abomey-Calavi / Republic of Benin). The taking is made at a depth about 1 meter of the natural ground. The site is located in twenty five kilometers (25 km) of the main campus of the University of Abomey-Calavi (UAC).

In the taking, the material is a clayey soil of red color. The results of the grain size analysis are presented in the table 1 and the figure 1.

Table 1- Grain size Analysis of the bar ground used

Sieve (mm)	Tailings cumulate (%)	Undersizes (%)
2.5	0	100
1.25	3,01	96,99
0.63	23,91	76,09
0.315	53,50	46,50
0.16	66,37	33,63
0.08	70,90	29,01
Undersize material	99,76	0,24

The material has a density in the saturated state dry surface of 2,43. Its absorption is 8,2 %. The material presents a fine grain size [NFP-94-056]. It has 29 % of elements of size lower than 0,080 mm. The maximal particles diameter is lower than 2,5 mm and the coefficient of fineness of the material is 1,47. The material is a muddy or clayey fine sand. The determined Atterberg limits following the specification NF P 94 – 051 of the clayey sand are: liquidity limit (WL) is 40 %, plasticity index (WP) is 17 % and the plasticity limit (IP) is 23. It is thus about a « clayey sand (CS) » according to the classification LPC (1980).

4.1.2. Cement

The adjuvant used in the present study is a Portland cement. It is a cement produced in Benin by the company SCO-Lafarge. This cement contains 95 % of clinker and is delivered in 50 kg bag. The class of resistance of the used cement is up to standard NF EN 196-1.

4.1.3. Dung of cow

The DOC is found in abundance in the zones of concentration of breeding bovidae. The used material " DOC " in the present study is in the shape of sawdust. The DOC is taken on a site of experiment of breeding cattle belonging to the Faculty of Science of Agronomy (FSA) of the University of Abomey-Calavi (UAC). The site is located in the area Zopah in the Abomey-Calavi municipality (in 15 km of the main campus of the University of Abomey-Calavi (UAC).
The DOC is taken fresh (within 24 hours after the defecation) is returned to the Laboratory of Materials and Structures (LAMS), for a pre-sun-curing during ten (10) days then in the stove in a temperature of 60°C until constant mass. The dry material is reduced in the shape of sawdust by means of an mill of fine stitch of the Faculty of Science of Agronomy (FSA). The sawdust of dung of cow so obtained in a density of 1,09. The water content of the dung of cow in the fresh state (in the taking) is 300 %.

Figure 1- Sizing Curve of the used bar ground

4.2. Procedure

Besides the tests of characterization of materials (bar ground and sawdust of DOC), he is proceeded to the determination of the density on mortars in the fresh state and in the hardened state. The water content of fresh mortars is determined and the tests of compressive strength are made on the samples of mortars after 28 days of air drying.

4.2.1. Identification of mixtures

Mortars are identified in the following way: the letter (S) appoints the range, the first number appoints the water content in cement and the following number appoints the content in dung of cow. The ranges S-4-8 mortar of the series 4 % of cement and containing 8 % of DOC. The figure 2 presents a scheme to facilitate the identification of mortars.

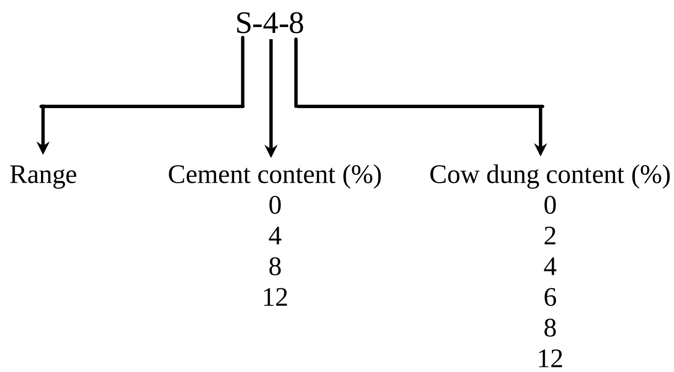


Figure 2- Identification scheme of mortars

4.2.2. Dosages of mortars

The different dosages are presented in the table 2.

Table 2- Different proportions of the used materials

Range	Identification	Content of materials (%)		
		Bar Ground	Cement	DOC
S-0 (0% de cement)	S-0-0	100	-	0
	S-0-2	98	-	2
	S-0-4	96	-	4
	S-0-6	94	-	6
	S-0-8	92	-	8
	S-0-10	90	-	10
S-4 (4 % de cement)	S-4-0	96	4	0
	S-4-2	94	4	2
	S-4-4	92	4	4
	S-4-6	90	4	6
	S-4-8	88	4	8
	S-4-10	86	4	10
S-8 (8 % de cement)	S-8-0	92	8	0
	S-8-2	90	8	2
	S-8-4	88	8	4
	S-8-6	86	8	6
	S-8-8	84	8	8
	S-8-10	82	8	10
S-12 (12 % de cement)	S-12-0	88	12	0
	S-12-2	86	12	2
	S-12-4	84	12	4
	S-12-6	80	12	6
	S-12-8	80	12	8
	S-12-10	78	12	10

The mortars S-0-0, S-4-0, S-8-0 and S-12-0 are the four (04) reference mortars. Their formulations are representative of uses and ordinary practice regarding mortar with use of blocks in compressed ground or blocks in stabilized ground [10, 12, 16]. They were also determined for purposes of comparison. The water content is determined to have the humidity necessary for the workability and for the preparation of samples. The dung of cow content varies from 0 % to 10 % to take the study into account.

4.2.3. Production of mortars and preparation of test tubes

All the mixtures are manually made. For every mixture, six (06) kg of mortar were produced. The quantity of added water is the one which assures the necessary workability for the preparation of test tubes. It is quantified by deduction from the data of the wet density and the dry density. The mortars are produced in three stages. Mixing until homogenization of the cement and the bar ground; then addition of the DOC and mixing (for mortars containing some cement), and finally, addition of mixing water and mixing until the obtaining of a homogeneous mixture.

Two types of test tubes were produced: the first type has cubic shape with 50 mm of edge and the second is cylindrical 50 mm in diameter and 100 mm in height [NF EN 13286-41] (figure 3). The cubic molds are filled in two (02) layers pounded by 25 knocks each with a tamping iron (metallic rod of diameter 15 mm with round ends). The cylindrical molds are filled in three (03) layers pounded by 25 knocks each. The samples are turned out after 24 hours and preserved in laboratory at room temperature during twenty eight (28) days.

(a) (b)

Figure 3 – Test tubes made for the tests of compressive strength: (a) - cubic, (b) - cylindric

4.2.4. Determination of the density and the water content The density of the fresh mortar is determined in using a waterproof normalized container up to standard NFP94-053. The test tubes having served for determining the density of the fresh mortar are dried in the stove until constant mass and are used to determine the density of the dry mortar. The water content of mortars is determined according to the standard NFP94-050.

4.2.5. Characterization of the mechanical resistance. The used test for the mechanical characterization is the test of compressive strength. The tests are realized after 28 days. To minimize the effects of imperfections bound to the consolidation, the selected test tubes for the tests are the ones presenting the lowest spacing of masses thus having equivalent levels of consolidation. The test of compressive strength in the present study is made according to the standard NF EN 13286-41. The used equipment is a normalized mechanical press of Laboratory of Materials and Structure (Figure 4).

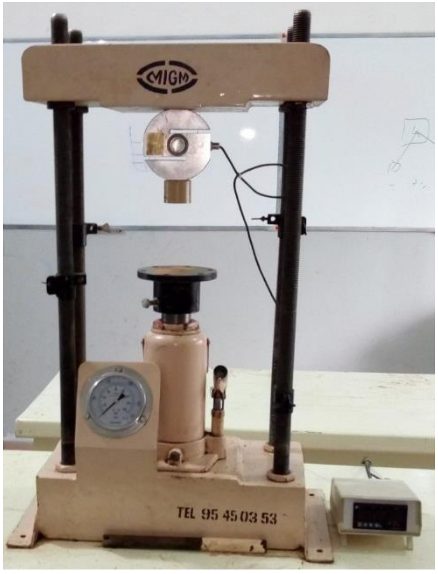


Figure 4 – Photo of the used mechanical press

5. Results

The table 3 presents the composition of mortars as well as the densities at the fresh state and at the dry state. The used bar ground of is in the saturated state surface dry (SS).

The highest water content is obtained with the mortar S-12-10 (12 % of cement and 10 % of DOC) whereas the lowest water content is obtained with the mortar S-0-0 (exempt of cement and of DOC). In a global way, the highest water contents are obtained for the strong dung of cow contents (8 % and 10 %).

The highest density is obtained with the mortar S-0-0 whereas the lowest density is obtained with the mortar S-0-10 (90 % of bar ground and 10 % of dung of cow). The highest densities are obtained for the low DOC contents (0 % and 2 %) and the lowest densities are obtained on mortars containing some strong DOC content (8 % and 10 %).

The table 4 presents the average values and the standard deviations of the compressive strength in twenty eight (28) days of all the test tubes (cubes and cylinders). The data analysis of this table shows that the average variability of the compressive strength of samples is of ± 0,19MPa for all the results. The average variability corresponds to the average of the individual spacing.

Table 3- Composition and characteristics of mixtures of mortars (kg / m^3)

Range	Identification	Composition of mortars				Density	
		Bar ground	Cement	BDV	Water	Fresh	Hardened
S-0 (0% de cement)	S-0-0	1745	-	-	144	1889	1745
	S-0-2	1702	-	35	146	1883	1737
	S-0-4	1631	-	68	155	1854	1699
	S-0-6	1447	-	92	196	1735	1539
	S-0-8	1231	-	107	232	1570	1338
	S-0-10	1099	-	122	265	1486	1221
S-4 (4% de cement)	S-4-0	1502	63	-	150	1715	1565
	S-4-2	1481	63	32	161	1737	1576
	S-4-4	1396	62	62	176	1727	1551
	S-4-6	1265	58	86	213	1631	1438
	S-4-8	1183	55	110	259	1634	1375
	S-4-10	1088	52	130	300	1595	1295
S-8 (8% de cement)	S-8-0	1402	122	-	181	1705	1524
	S-8-2	1372	122	30	189	1713	1524
	S-8-4	1355	123	62	199	1739	1540
	S-8-6	1237	115	86	233	1671	1438
	S-8-8	1149	109	109	280	1648	1368
	S-8-10	1073	105	131	323	1631	1308
S-12 (12% de cement)	S-12-0	1354	185	-	206	1745	1539
	S-12-2	1318	184	123	213	1745	1532
	S-12-4	1242	177	118	231	1709	1478
	S-12-6	1150	168	112	269	1672	1403
	S-12-8	1063	159	106	327	1656	1329
	S-12-10	1012	156	104	370	1667	1297

Table 4- Compressive strengths of mortars after 28 days

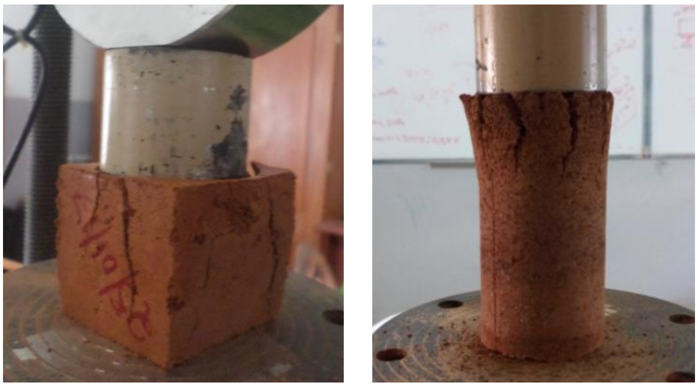
Range	Identification	Compressive strength (MPa)			
		Cubes		Cylinders	
		Strengths	Standard deviation	Strengths	Standard deviation
0% of cement	S-0-0	1,30	0,17	0,97	0,22
	S-0-2	1,56	0,05	0,95	0,34
	S-0-4	1,59	0,08	0,96	0,18
	S-0-6	1,12	0,12	0,76	0,32
	S-0-8	0,86	0,02	0,61	0,14
	S-0-10	0,80	0,08	0,56	0,26
4% of cement	S-4-0	1,80	0,20	1,25	0,20
	S-4-2	1,96	0,13	1,32	0,27
	S-4-4	2,10	0,15	1,29	0,15
	S-4-6	1,71	0,15	1,12	0,23
	S-4-8	1,25	0,10	0,84	0,18
	S-4-10	1,04	0,09	0,63	0,38
8% of cement	S-8-0	3,20	0,20	2,12	0,19
	S-8-2	3,32	0,10	2,18	0,32
	S-8-4	3,51	0,17	2,24	0,26
	S-8-6	2,64	0,14	1,84	0,24
	S-8-8	2,32	0,18	1,32	0,15
	S-8-10	1,89	0,27	0,89	0,35
12% of cement	S-12-0	3,90	0,14	2,62	0,17
	S-12-2	3,96	0,17	2,58	0,25
	S-12-4	3,98	0,12	2,66	0,15
	S-12-6	3,18	0,14	2,28	0,31
	S-12-8	2,50	0,18	1,83	0,15
	S-12-10	2,15	0,21	1,48	0,21

The medium strength of all the test tubes for all types of mortar is 1,85 MPa with a medium relative variability of ± 10% (0,19/1,85). The most important gaps between the test tubes are obtained with mortars S-4-10 (0,38), S-8-10 (0,35), S-0-6 (0,31) and S-12-6 (0,31). The average of the gaps for the cubic test tubes is 0,14 whereas the one of the cylindrical test tubes is 0,23. The strengths of the cylindrical test tubes present a dispersion relatively higher than the one of the cubic test tubes.

In most of the cases, the observed fracture on cylindrical test tubes took place on the first half of the test tube. The observed fracture on the cubic test tubes is on all the test tube (figure 5). La geometry and the mode of manufacturing of the BTC lead an anisotropy which results in a difference of compressive strength when the geometry and/or the mode of making test tubes change [10].

5.1. The compressive strengths of cubic samples

The histograms of the figure 6 show the evolution of the compressive strength in 28 days of the different test tubes by ranges (0 %, 4 %, 8 % and 12 % of cement). On the cubic test tubes, the highest compressive strength is obtained on the mortar S-12-4 containing 84 % of bar ground, 12 % cement and 4 % of DOC. The lowest is obtained on the mortar S-0-10 containing 90 % of bar ground, 0 % cement and 10 % of DOC. We note globally that the highest values are obtained with mortars having a stronger content in cement (12 %) with contents in DOC varying between 0 % and 4 %.



(a) (b)

Figure 5- Fracture system of test tubes:
(a) - cubic, (b) - cylindric

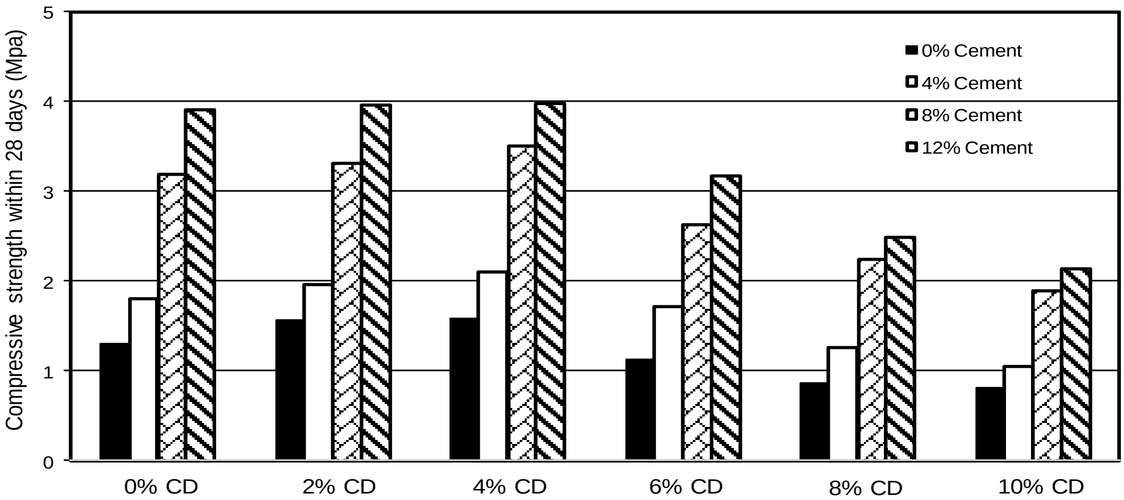


Figure 6- Compressive strength of bar ground mortars (cubic samples)

5.2. Compressive strengths of cylindrical samples

The figure 7 shows the evolution of the compressive strength of different cylindrical test tubes by series (0 %, 4 %, 8 % and 12 % of cement) stronger .The strongest and lowest values are respectively obtained on mortars S-12-4 and S-0-10. The tendency of the obtained results on the cylindrical test tubes is thus similar to the one obtained on the cubic test tubes.

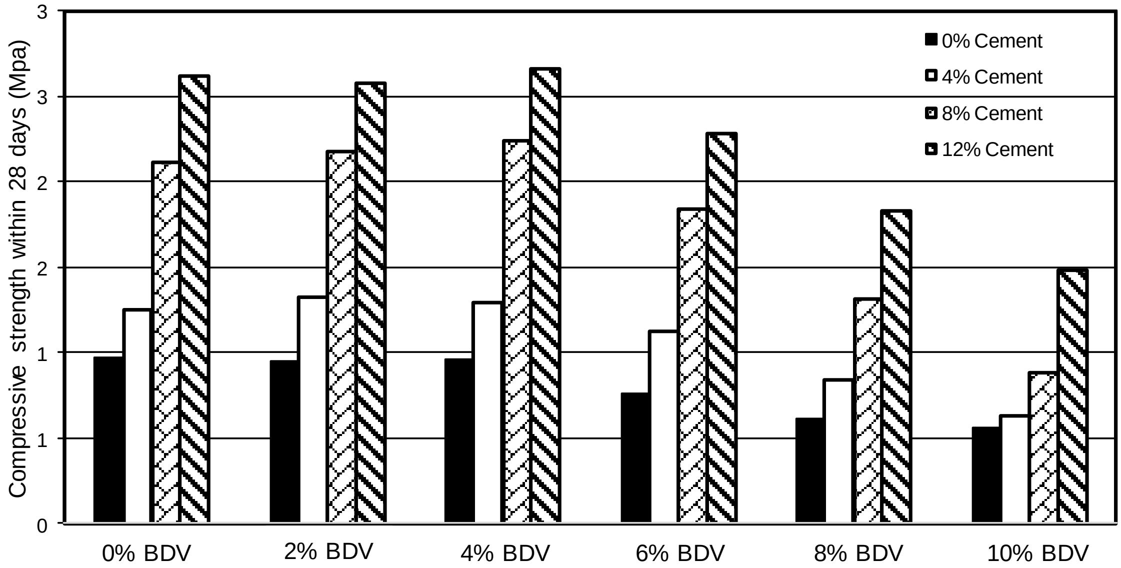


Figure 7- Compressive strength of bar ground mortars (cylindrical test tubes)

6. Analysis and discussion

6.1. Influence of the cement content on the strength of reference mortars

The figure 8 shows the influence of the cement content on the compressive strength of reference mortars. The compressive strength increases with the cement content. This behavior is typical for mortars of bar ground and up to the practice [1, 2, 12, 16]. It gives some explanation by the presence and the increase of silicates of hydrated calcium (C-S-H) consequent in the hydration of the present grains of cement in used mortars of bar ground [2, 14].

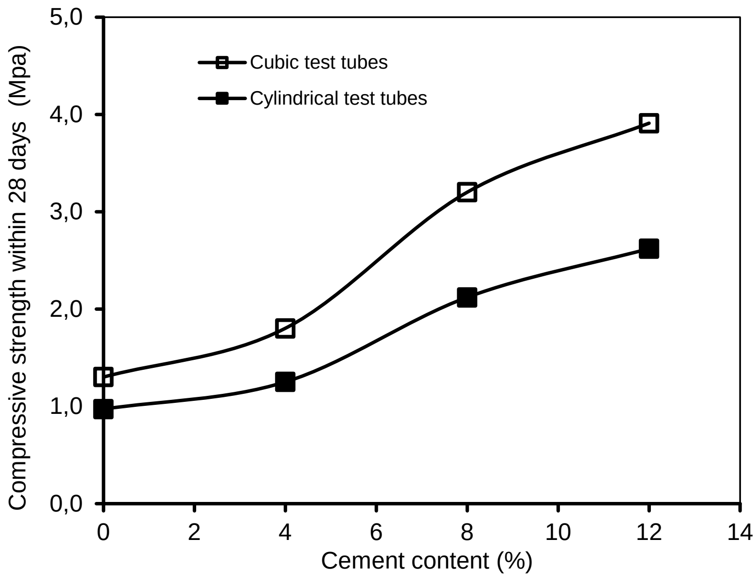


Figure 8- Influence of the cement content on the compressive strength of bar ground mortars

6.2. Influence of the dung of cow content on the water content of fresh mortars

The figure 9 shows the influence of the dung of cow content on the water content of mortars. For the four (04) series of mortar (0 %, 4 %, 8 % and 12 % of cement), the lowest water contents are obtained on mortars without dung of cow and the highest water contents are obtained with mortars containing 10 % of dung of cow. The water content of mortars thus increases with the dung of cow content. This behavior results from the absorbent character of the sawdust of dung of cow obtained by drying (section 4.1.3). Let us remind that the dung of fresh cow has a strong water content (300 %).

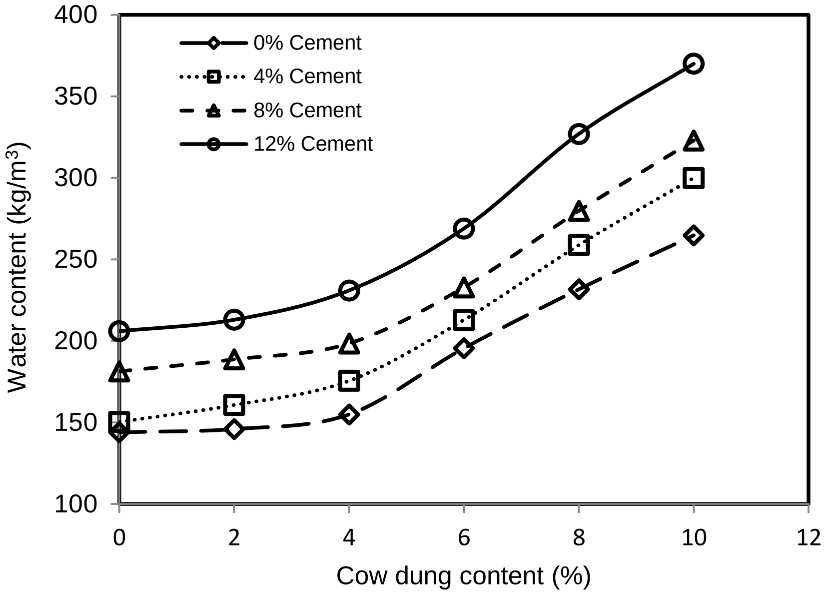


Figure 9- Influence of the cow dung content on the water content of mortars

6.3. Influence of the content in dung of cow on the resistance in compression of mortars

The figure 10 shows the influence of the dung of cow content on the compressive strength of the test tubes of mortar without cement. The cubic and cylindrical test tubes showed the similar tendencies. The lowest compressive strength are obtained on test tubes containing 10 % of dung of cow and the highest values are obtained on test tubes containing between 0 % and 4 % of dung of cow. The compressive strength of the cubic test tubes increased with the incorporation of the dung of cow in a proportion from 0 % to 4 %, beyond 4 %, it systematically decreased. As for the cylindrical test tubes, the compressive strength did not decrease with the incorporation of the dung of cow in a proportion from 0 % to 4 %, beyond 4 %, it systematically decreased.

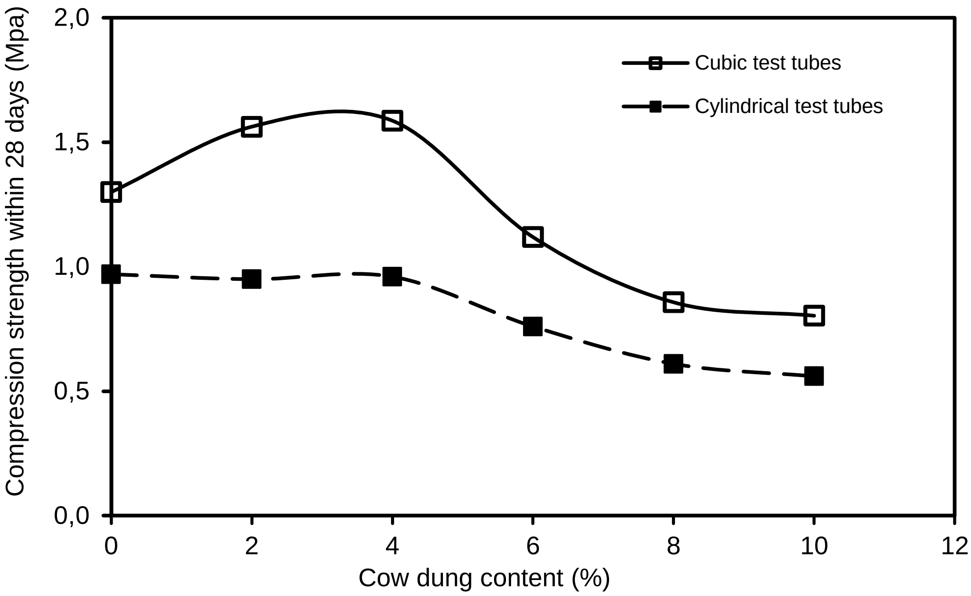


Figure 10- Influence of the cow dung content on the compressive strength of mortars

As thus a result the compressive strength did not decrease with the incorporation of the DOC in a proportion from 0 % to 4 % whatever the type of test tube, beyond 4 %, it systematically decreased. So the dung of cow content influences the compressive strength of mortars. In the mortars of bar ground the DOC appears as a vegetable fiber [13]. The interaction of this fiber with the bar ground favors the compaction and the decrease of the voids inside mortars when it is in small quantity, what improves the resistance of the mortar [6, 9]. For considerable proportions, this fiber increases in volume with the presence of the mixing water, what increases considerably the volume of void once the mortar is hardened. The strong presence of void in this type of mortar explains the systematic decrease of the strength of mortars containing more than 4 % of dung of cow and is justified by the substantial decrease of the density of these mortars.

The figure 11 superposes the effect of the cement and the dung of cow on the compressive strength of mortars. The analysis is led as well on test tubes cubic as cylindrical. We notice on this figure that the results obtained from the cubic test tubes indicate that the incorporation of the DOC in a proportion of 4 % produces an increase of strength close to the one due to the effect produced by 4 % of cement. Beyond, the compressive strength increases with the cement content and decreases with the DOC content. The tendency is also similar for the results obtained from the cylindrical test tubes with however, an effect relatively lower.

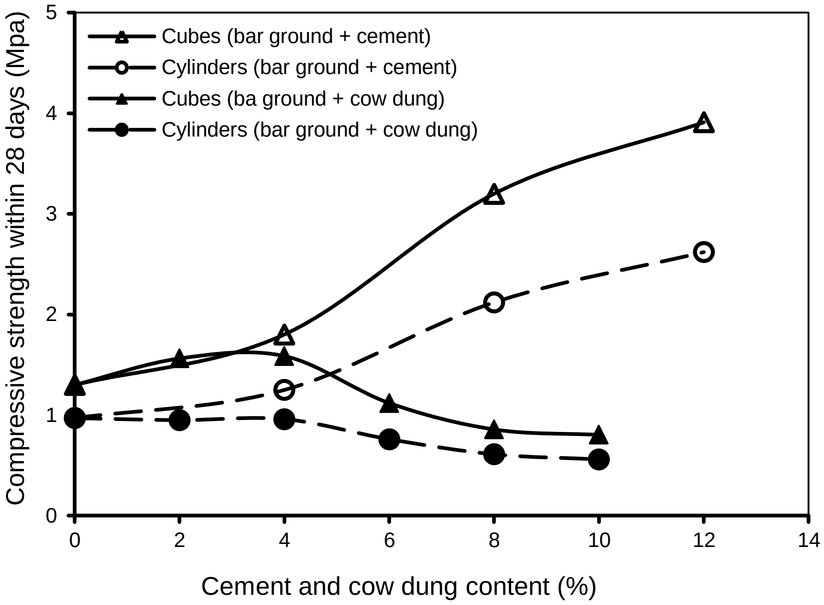


Figure 11- Compared effect of the influence of the cowpat content and of the cement content on the compressive strength of mortars

The figures 12 and 13 show the influence of the dung of cow content on the compressive strength of four ranges of mortar (0 %, 4 %, 8 % and 12 % of cement). The cubic test tubes gave strengths clearly superior to those of the cylindrical test tubes.

The test tubes of mortar of bar ground containing less than 6 % of dung of cow and stabilized in 8 % and 12 % of cement present superior strengths in 3,5MPa for the cubic test tubes and in 2,5MPa. These values of compressive strengths are sufficient for the traditional houses having a light roof with distributed load [5, 15, 16]. The loads of such a structure can be thus well supported by a wall in bar ground building block stabilized in 8 % and 12 % of cement and containing some dung of cow in a proportion not exceeding 4 %.

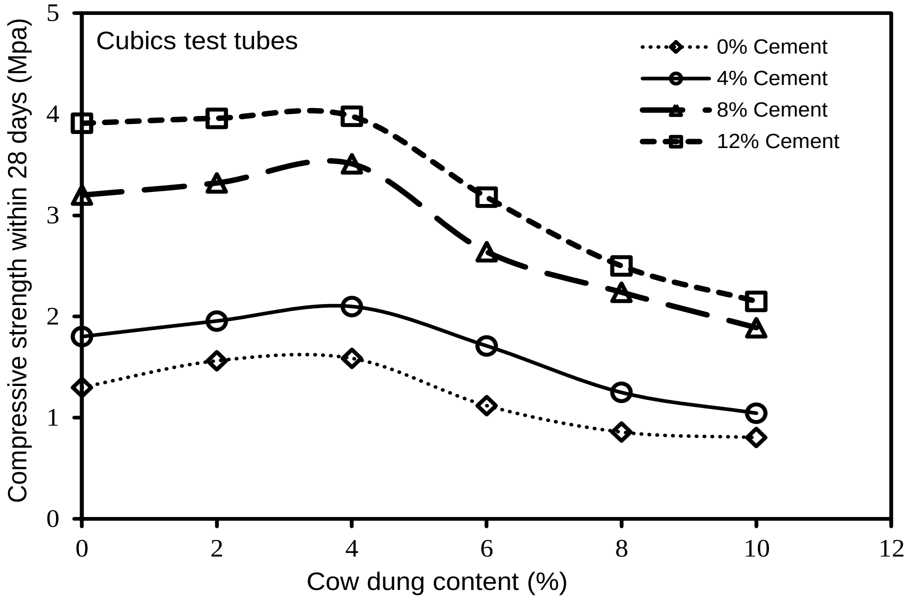


Figure 12- Influence of the cow dung content on the compressive strength of mortars (cubic test tubes)

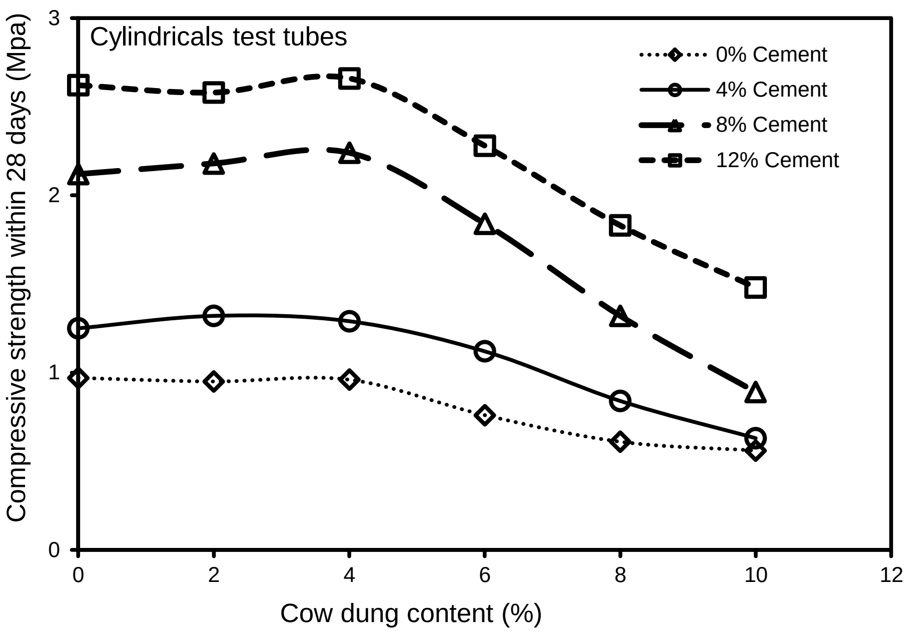


Figure 13- Influence of the cow dung content on the compressive strength of mortars (cylindrical test tubes)

7. Conclusion

The obtained results within the framework of the present study allow to highlight a certain number of main effects of use of the dung of cow in mortars of bar ground.

In a mortar of bar ground compressed and/or stabilized, the bonding of grains is assured by the compressive stresses of the material and the hydration of the cement in presence in the mixture. When it is in small proportion, the presence of the dung of cow facilitates it and improves the effects of compression and of stabilization. This phenomenon explains the increase of the compressive strength noticed when the addition of the dung of cow in a proportion included between 0 to 4 %. The addition of a proportion of dung of cow beyond decreases systematically the compressive strength.

We can conclude that in a mortar of bar ground:

1) The addition of a small quantity of sawdust of dung of cow (included between 0 and 4 %) improves the compressive strength of the mortar;

2) A strong sawdust of dung of cow content (superior to 4 %) decreases systematically the compressive strength of the mortar;

3) The addition of the sawdust of dung of cow increases the water content and decreases the density of the mortar;

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ВЛИЯНИЕ ПРИМЕНЕНИЯ КОРОВЬЕГО НАВОЗА НА ПРОЧНОСТЬ ГРУНТОВЫХ ОБРАЗЦОВ ПРИ СЖАТИИ

Использование местных строительных материалов является неотъемлемой частью практически всех традиционных построек и жилых домов в сельской местности. В значительном числе африканских стран коровий навоз (НК) традиционно является одним из основных материалов в строительстве. Однако научное обоснование использования коровьего навоза (НК) в строительстве практически отсутствует. В данной статье изучено влияние использования коровьего навоза на прочность при сжатии образцов, изготовленных из грунта, смешанного с НК, предназначенных для изготовления блоков из прессованного грунта (БПГ) и/или блоков из стабилизированного грунта (БСГ). Анализ проводится путем сравнения прочности на сжатие эталонных образцов (смесь земли с навозом и смесь земли с навозом с добавлением 4 %, 8% и 12% портландцемента). Результаты испытаний продемонстрировали, что добавление небольшого количества сухого молотого коровьего навоза (менее 6 %) не снижает прочность на сжатие образцов и даже имеет тенденцию к его незначительному упрочнению. При увеличении содержания коровьего навоза свыше 6% прочность образцов снижается.

Ключевые слова: *образцы из грунта, стабилизированные образцы, навоз коровы, прочность на сжатие.*

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