Stabilization Of Laterite With Rubber Latex

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Abstract: Air pollution and the emission of greenhouse gases related to the manufacture of clinker for the manufacture of cement, leads to consider the use of a natural binder other than cement for the stabilization of laterite. This laterite-rubber is a new sustainable material for construction and building. In this work, a study on the amount of ammonia to delay the coagulation of latex for use as a stabilizer was conducted. In addition, tests of water resistance, absorption and mechanical tests were carried out on this new material to define its properties. 3% ammonia was used to delay coagulation of the latex. 0 to 30% latex content was used to stabilize laterite specimens. The tests carried out on these different test pieces gave the following results: 15% latex specimens dissolve completely in water while 20% test specimens dissolve completely in water; 25% and 30% are water resistant. The absorption rate decreases as the latex content increases in the test pieces. t goes from 14,45% for the specimens to 15% to 5.87% for the 30% test pieces. The compression test shows an increase in resistance from 0.37 MPa for latex-free specimens to 3.15 MPa for 30% latex specimens. Also, the study of the mechanical properties (rheological behavior) shows that the specimens have a plastic behavior when the latex content increases.

Key words: clinker, laterite, latex, materials

I- Introduction

The earth is used in many works, as evidenced by the achievements of our planet. After being abandoned with the advent of industrial building materials, especially concrete and steel, it is today the subject of a renewed interest in many countries. Sand and laterite are the raw materials of choice in these achievements. These achievements for the most part use a cold stabilizer or hydraulic binders. Cement, a pulverulent material based on silicates and calcium aluminate obtained by firing, has been used as a binder for the stabilization of building materials. What led [1] to use Portland cement in the valorization of laterites of Ivory Coast for the manufacture of facing briquettes. Similarly, [2] has developed and characterized cement stabilized clay blocks (CIMARG). Cement is currently inaccessible despite the drop in the price of the 50 kilogram bag. The price which was 5500 francs rose to 5000 francs. Also, the process inherent in the manufacture of cement clinker, which releases CO2, which is estimated at 5% [3], led us to think about the use of another type of binder for stabilization. Hevea latex has therefore been proposed to stabilize laterite in order to design a new type of material. Rubber latex is a raw material derived from rubber tree, a tree that grows in tropical areas. It is thus a material present in Ivory Coast where one counts there numerous plantations of rubberwood. The most commonly used species in the rubber field are PB 235, GT 1, PB 217, AVROS 2037, AF 261 [4]. Natural rubber is obtained after coagulation rubber latex and is still essential in many areas of human activities such as aeronautics, mechanics, the field medical [5]. The general objective of this work is to use rubber latex for the stabilization of laterite in order to propose it as building materials.

II-1 Presentation of the raw material

II-1.1 Laterite

The laterite used comes from the town of Cocody on a site near the University Felix Houphouet Boigny specifically GPS coordinates: 5 ° 20'144"N and 3 ° 59'04.9"W

II.1.2 rubber latex

The latex comes from a private rubber plantation located in the town of Dabou (Ivory Coast) specifically at 5 ° 20'13.8"N and 4 ° 23'55.7"W. To delay curing of the latex, ammonia is added to the latex

II-2 Characterization of the raw material

II-2.1 Characterization of laterite

The water content of laterite was determined. To do this, a representative sample of the material is taken after the laterite has been screened with a 4 mm sieve and weighed. This first mass represents the wet mass (Wh) then the sample is dried in an oven at 105 ° C for 24 hours. Let (Ws) be this new mass obtained after its passage in the oven. The amount of water present in the soil is calculated in relation to the total dry soil weight in accordance with the standard NFP 94 057. This water content (w) expressed as a percentage is calculated from the following expression:

$$\omega = \frac{\omega h - \omega s}{\omega s} \times 100 \qquad (1)$$

After the moisture content, particle size analysis of laterite was determined. It makes it possible to determine the distribution of the grains of a sample according to their sizes. Thus, for the grain distribution of the sample, a determined amount (350 g) of the sample was taken. The material is then deposited on the column of seven (7) mesh screens decreasing. After 10 minutes of vibration this sieve column, each refusal of the sieves is weighed. The sieve of laterite with a sieve of 0.063 mm diameter was subjected to sedimentometric analysis. For this analysis, the various measurements obtained make it possible to determine the diameter of the particles in order to plot the particle size curve using the formula below:

$$D = \frac{K}{1000}\frac{\sqrt{L}}{\sqrt{T}} \quad (2)$$

T: time (min);
K: constant determined by the reference table;
L: distance traveled by the particle between the surface of the liquid and the level of the depression of the hydrometer;
D: particle diameter.

II-2.2 Characterization of latex

The latex used in this study is in liquid form. Exposed to the open air, it coagulates. Ammonia (NH_3) was therefore used to delay coagulation. The amount of ammonia that has been mixed with the latex to keep it fluid for use in stabilizing laterite is 3%. Thus, during this study, the influence of the ammonia concentration used on the coagulation of latex, as well as the different volumes of latex on the coagulation time were studied. To do this, latex containing ammonia was removed and placed in a jar until the coagulation of the latex. Thus, this characterization made it possible to estimate the time that the latex would have to coagulate for the different mixtures. This characterization allowed at the same time to estimate the exposure time of the specimens until the coagulation of the latex

II-3 Sampling methods

Place illustrations (figures, tables, drawings, and photographs) throughout the paper at the places where they are first discussed in the text, rather than at the end of the paper. Number illustrations sequentially (but number tables separately). Place the illustration numbers and caption under the illustration in 10 pt font. Do not allow illustrations to extend into the margins or the gap between columns (except 2-column illustrations may cross the gap). If your figure has two parts, include the labels "(a)" and "(b)". Three main steps made the samples. This is the preparation, shaping and drying. The laterite extracted from the site, passes the sieve 2 mm. Only the sieve is recovered for shaping. This phase consisted in taking 350 g of the sieve and mixing it with different volumes of latex. The whole is kneaded for 5 minutes. The mixture obtained is introduced into a mold 5 X 5 X 8 cm contained in the manual flap press. Thanks to 25 strokes of the flap of the manual press, the mixture is compacted. At the end of 25 shots, samples are obtained after demolding. The latex content used for making the samples varies from 0 to 30%. The samples obtained are dried at room temperature. The drying lasted between 6 to 7 days depending on the latex content used. It is on these different samples, that a certain number of the tests were carried out.

II-4 Characterization of samples

II-4.1 Absorption test

Water absorption is the physical property of some materials to absorb water in the liquid state [6]. The sample is dried in an oven at 60 ° C until constant mass, then weighed (Ms). Then the sample is immersed in water for 24 hours, ie (Mh) the wet mass. Absorption is given by the formula:

$$n = (VV\ VT)\ x\ 100 = (Mh - MS\ \varrho VT)\ x\ 100 \quad (3)$$

Or
n is the absorption expressed as percentage VV and VT: void volume and total volume;
Mh and Ms: mass (kg) of wet sample and mass (kg) of dried sample;
ρ: Density of water taken at 1g / cm3.

II-4.2 Test of water resistance

The water resistance makes it possible to assess the stability of the material in the water because some immersed materials degrade. The test of the water resistance of our test pieces consists of immersing them in a bucket of water for 4 days after having dried them. Once removed from the water, their behavior and surface conditions are appreciated. This observation is made again after 48 hours of drying.

II-4.3 Compression test

The compression test is a mechanical destruction test that involves subjecting a material to a certain load. This test reflects the resistance of the material to a given force but also the quality of the bonds that are created between the different constituents. The tests were carried out with a hydraulic press. The test pieces used are immersed in water for 4 days, then dried for 3 hours, they are subjected to compression. The value of the strength of each category (percentage of latex used) of test pieces obtained is an arithmetic average of five test pieces. The formula of compressive strength is given by:

$$\sigma = \frac{F}{S} \quad (4)$$

III-Results and discussion

III-1Content in water of laterite

The results of the water content of laterite are recorded in Table I. This table presents the masses and water content of three samples of the laterite used. The arithmetic mean of these grades allowed us to estimate the water content of the laterite used. This water content is equal to 12.91%.

Table I: *Mass and moisture content of each sample*

Wet mass of the M1 sample (g)	Mass after drying M2 (g)	Water content (%)
340.5	300	13.5
340.5	299.7	13.61
340.5	305	11.63

III-2 Granulometric analysis

The results of particle size analysis obtained made it possible to construct the granulometric curve presented in figure.1. This graph shows the cumulative percentage of grains passing from sieving and grains from sedimentometry as a function of their diameter (Φ). This graph shows four types of laterite particles. Clay particles of diameter (Φ ≤ 2 µm) whose content is estimated at 10%, then silt (2 µm ≤ Φ 63 µm) with a content of 20%; sand (63 µm ≤ Φ 2 mm) represents the largest particles with a content of 68% and for gravel (Φ ≥ 2 mm) with a particle content of 2%.

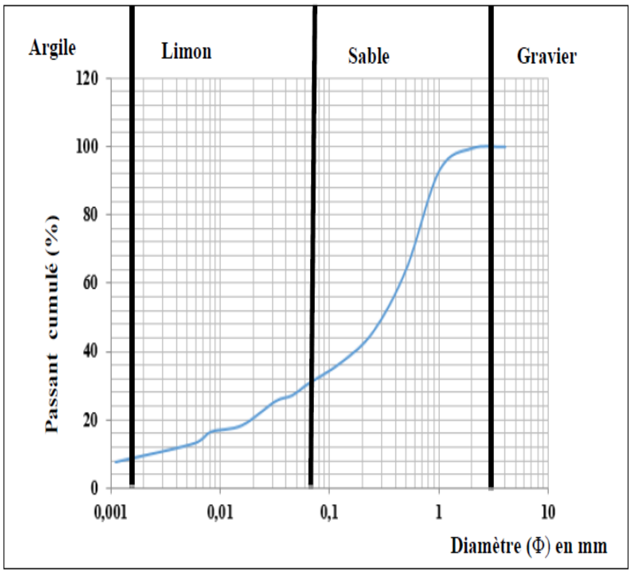
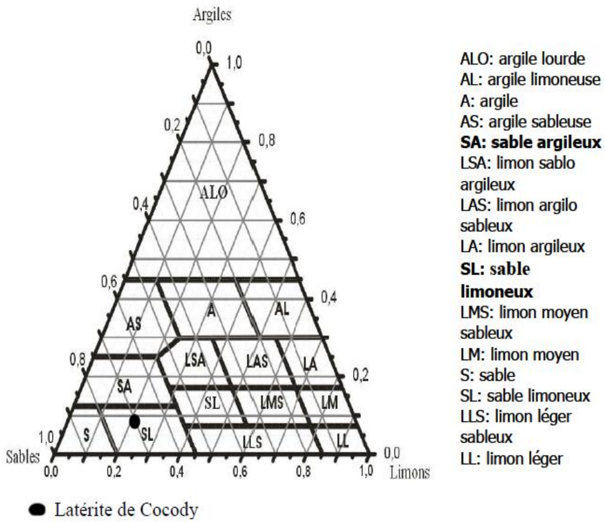


Figure 1: *Particle size analysis curve of laterite*

The projection of the results of the granulometric analysis (percentages of sands, silt and clay) in the triangular soil textural classification diagram, allows us to affirm that the laterite used is silty sand (Figure 2).



III-3 Characterization of Rubber Latex

III-3.1Influence of ammonia concentration on coagulation of latex

Figure 3 below shows the state of the latex stabilized with 3% ammonia at the time of its use and its state three days later.

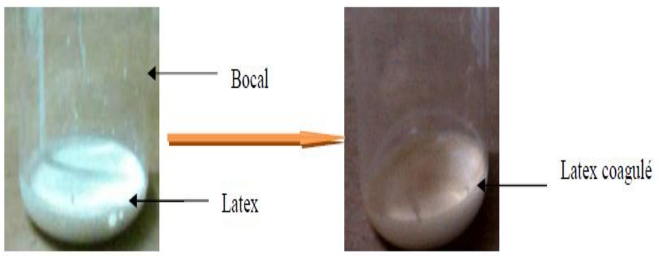


Figure 3: *State of the latex before and after three days*

The result obtained shows that the amount of latex that was collected did not coagulate the first hours but three days later. This result makes it possible to affirm that the use of the concentration (3%) of ammonia does not deteriorate the coagulation of the latex but delays it. Indeed, ammonia being a basic solution, it fluidizes the latex while neutralizing the natural acidification and slows down most of the enzymatic processes that occur in a neutral or acidic medium. These results are consistent with those of [6].

III-3.2 Influence of different volumes on coagulation time

Coagulation is a characteristic of latex which contributes to the improvement of the resistance. The latex used as binder must therefore coagulate to have resistant test pieces. The table below gives the values of the coagulation time obtained.

Table II: *Coagulation time of the different volumes of latex with 3% ammonia*

Volume in ml of latex with ammonia removed	Coagulation time (days)
17.5	6
35	8
52.5	11
70	13
87.5	15
105	17

The table shows the coagulation time of different volumes of latex with the same concentration of ammonia. According to this table, the coagulation time varies with the volume of latex removed. This table shows that the lower the amount of latex stabilized with ammonia, the faster coagulation occurs. This finding could be explained by the contact of the stabilized latex with the air. In fact, exposed to the air, ammonia evaporates and this evaporation induces enzymatic reactions that lead to coagulation [8]. Thus, the higher the volume of the latex, the more ammonia will take time to evaporate.

III-4 Characterization of the specimens

III-4.1Determination of the latex content for the manufacture of test specimens

Specimens stabilized with rubber latex in varying proportions were made. Observations were made on the specimens to assess their condition physical. In order to better perceive the physical state of its test pieces, images of the state of these test pieces at different levels were taken (FIG. 4).

a) 0% test tube b) Non-wet surface with 5% latex

c) test tube 10% latex d) 15% latex test tube

e) test tube with 20% latex f) test tube with 25% latex

g) test tube with 30% latex h) hrubbery sample with 35% latex

Figure 4: *Aspect of specimens at different percentages of latex*

Samples made with addition of 5% and 10% latex content do not yield consolidated specimens (Figure 4b and Figure 4c) because the binder is insufficient to consolidate the samples. The test pieces made with the 0% latex content (were made possible by the addition of 10 ml of water to the sample (FIG. 4 a). The test pieces made with the content of 15% to 30% are well consolidated (Figure d, e, f and g). These specimens have a good surface quality and this quality is more improved with the contents of 20%, 25% and 30%. These results could be explained by the amount of binder used. Indeed, when the amount of binder is sufficient, the surface of the laterite is moistened and the grains are close to each other. These grades are higher than the levels used by [6] because the specific surface of the laterite being larger requires much more binder. Beyond 30%, the test pieces are unrealizable because of the rubbery surface appearance so difficult to knead (Figure 4 h). In view of these results, the stabilization of laterite with rubber latex can be done from the minimum content of 15% latex. The specimens that have been developed will be subjected to the water resistance test, the absorption test and the compression test, respectively

III-4.2 Water resistance test

The use of a material is partly related to its weather resistance. The test pieces after a four-day stay (96 hours) were observed and the results are reported in Table III.

Table III: *Condition of the test specimens after stay in the water*

Mass ratio (Latex / Laterite)	Water resistance
0 %	Total dissolution
15 %	No apparent damage
20 %	Stable
25 %	Stable
30 %	Stable

The total dissolution of the latex-free test pieces is explained by the rupture of the bonds between the laterite particles caused by the water. The water of the 15% test pieces is colored because the particles not coated with the rubber latex are in contact with the water. The test pieces are stable in water from 20% in that the amount of latex is sufficient to maintain the particles of laterites bound while significantly reducing the pores. The results show that good resistance of the test pieces to water is obtained at 20% latex content. These resistances are better for contents equal to 25% and 30%.

III-4.3 Absorption test

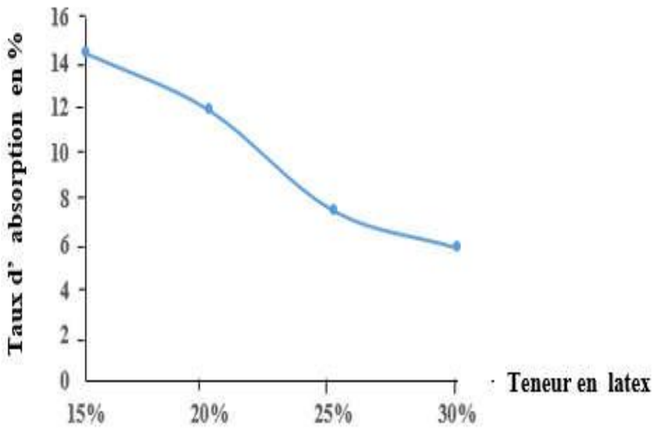


Figure 5: *Water Absorption Curve vs. Latex Content*

The curve shows the absorption rate as a function of the latex content. The absorption rate decreases as the amount of latex increases in the test pieces. The absorption rate is 14.45% for a latex content equal to 15%. This absorption rate increases to 5.87% for a content equal to 30%. The decrease in the absorption rate could be related to the coagulation of the latex. Indeed, the coagulation of the latex between the laterite particles contributes to the closure of the pores accessible to water, which considerably reduces the entry of water into the material. These results are in line with [6] work on flexible briquettes. The samples thus produced with a latex content equal to 30% absorb little water

III-4.4Compression test

The results of the dry compression test are in the form of a histogram shown in FIG.6

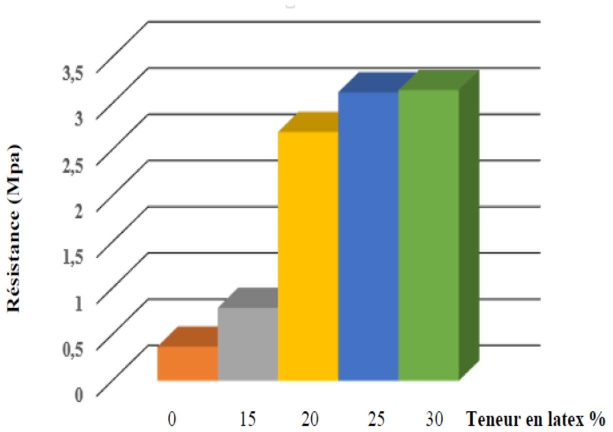


***Figure 6:** Variation of resistance versus latex content*

On this curve, an increase in the resistance as a function of the latex content in the test pieces is noted. Resistance values increase from 0.37 MPa for latex-free test specimens to 3.15 MPa when the latex content is 30%. The strengths of the specimens increase thanks to the latex. Indeed, the latex used as a binder reinforces the bonds and closes the pores between the particles. The work of [9] and [10] on the use of Néré extract and shea in stabilization respectively gave similar results. The comparison of the compressive strength of his work with that of latex shows that latex improves the strength of the materials. The maximum strengths of the shea and néré-based test pieces are 2.05 MPa and 1.8 MPa, while the maximum resistances of the latex-based test pieces are 3.15 MPa.

Conclusion

Hevea rubber, a 15%, 20%, 25% and 30% natural binder, stabilized silty sand laterite for the fabrication of materials. Physical and mechanical tests have made it possible to better appreciate the qualities of the specimens made and these tests have revealed that:

- the absorption rate of the test specimens decreases when the quantity of latex increases;
- Test specimens with a latex content of less than 15% dissolve completely while those containing more than 15% latex resist and this resistance is very high for 25% and 30% test specimens;
- The compressive strength increases as the amount of latex increases in the test pieces that could be made.
- All these results show that it would be interesting to have better performance test pieces to use contents between 25 and 30% of latex.

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