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RESEARCH ARTICLE

EFFECT OF MOISTURE CONTENT ON THE BEHAVIOUR OF TREATED BORASSUS IN CONCRETE

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Abstract

The aim of thisscientificworkis to investigate the effect of moisture content on the behaviour of borassus in concrete. At the beginning of thisstudy, characterisation tests are carried out on the materials used. These materials include Nokoué lagoonsand, rolledgravelfrom the Mono, concrete and cut-to-length rônier. Afterformulating the concrete using the DREUX - GORISSE method, the Borassus plant reinforcementsweretreated with a hydraulicwaterproofing binder (cement glue, bitumen and Flintkote Be3) and nine (09) beamswere made, three (03) per category of waterproofingtreatment. In addition, three (03) control beams are used as comparison materials. The analysis of all the results of the four-point bending tests led us to the conclusion that Flintkote Be3 and bitumen are very effective waterproofingproducts for the treatment of the surfaces of rônier wood beforethey are introducedinto the concrete, because the smaller the variation in the moisture content of the beams (example of PARB beam: 2.36%), the greater the resistancetheydevelop to the appliedload (example of PARB beam: 19.36 ± 1.84 kN) and consequently the lower the deformability of the beams. It thenappearsthatbitumen and Flintkote Be3 canthereforeact as a productthateliminates the dimensional variations of borassus reinforcements in concrete and provides good resistance of borassus-reinforced structures.

Introduction:-

As hygroscopicityis a property of borassus wood which causes dimensionalinstabilitywhen in contact with moisture, its association with concrete should not beleft to chance withoutperfect control of itsbehaviourwhen used as a structural element in real service situations. This leads us, in view of the studiespreviouslycarried out in the field, to focus on the behaviour of the composite in relation to the impact of the moisture content on the behaviour of borassus in concrete. Moisture exchange is a very sensitive issue, as itis one of the determiningfactorsthatcanweaken the adhesion and even the strength of the Borassus-concrete composite.

In view of the enormouspotentialthat borassus represents in construction, its association in concrete as a reinforcement in the sameway as steelis of increasinginterest to research. This raises questions about itsbehaviour in concrete. Substituting borassus for steel in concrete and ensuringthat the concrete-borassus composite willwork as a

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single material over time. Borassus is a hygroscopicmaterial and isthereforesubject on the one hand to dimensionalinstabilitydepending on its state and on the other hand to slippagewithin the concrete whensubjected to stress. Theseinstabilitiescan affect adhesion, whichseemsverydetrimental. L'échange d'humidité entre les deux matériaux au cours du mûrissement du composite provoque soit une diminution dimensionnelle (retrait) ce quientraine la rupture de la surface d'adhérence, soit une augmentation de dimension (absorption) qui au-delà d'une limite acceptable peut occasionner le claquage du béton.

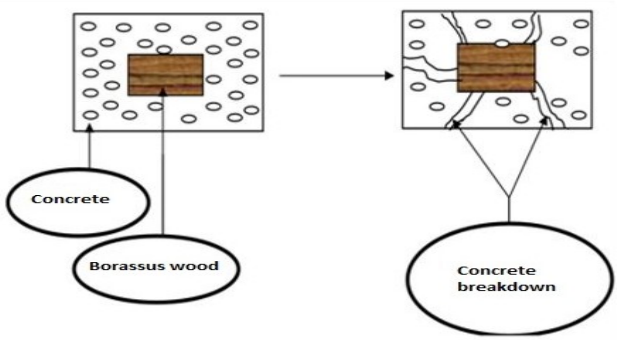


Figure 1 :-Breakdown of the Concrete-Borassus composite following the swelling of Borassus

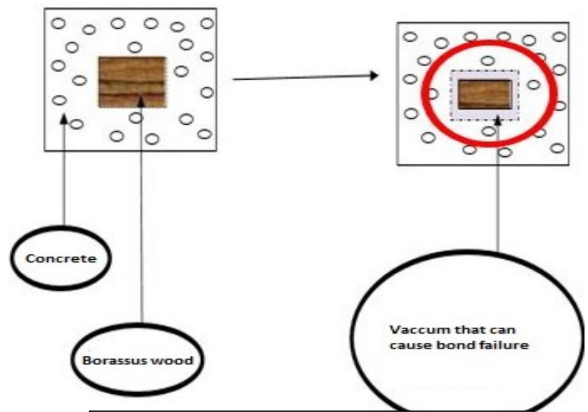
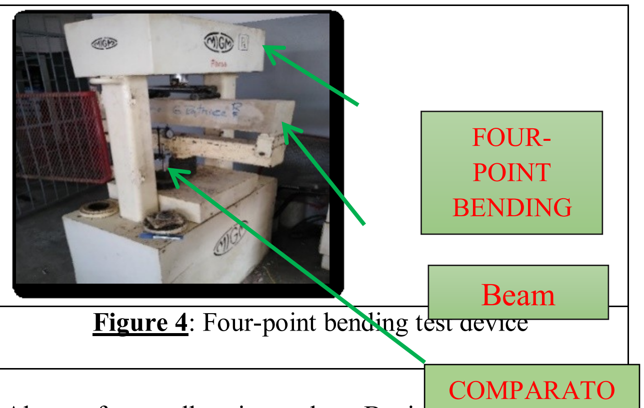


Figure 2:-Adhesion failure of the Concrete-Borassus composite following the shrinkage of Borassus

Material And Methods:-

Material:

It consistsessentially of a MIGM four-point multi-speed bendingdevice; a 10 N resolution; ahydraulicpress for compression tests.

	
Figure 3 :Compression testingdevice	**Figure 4**: Four-point bending test device

The plant material used for our tests comesfrom the Pahou-Ahozon forestgallery in southern Benin. A stand of male Borassus Aethiopum Mart wasfelled, cut and sawnintoplanks and, afterthesevarious stages, the resulting rônier plankswere dried at the ATC timbercompany in Allada to a moisture content of 12%. Finally, the plant materialwastransported to the wood workshop of the Lycée Technique Coulibaly in Cotonou whereitwasmachinedintostandardised test specimens of dimensions 20 x 20 x 85 cm^3.

Figure 5 :- Machining of slats in a reinforcement test tube

Figure 6:- Standard test tubes from 20x20x 85 cm^3

Method for the water-repellenttreatment of roofter plant reinforcements:
Three (03) waterproofingproductswere used

Flintkote Be3, whichis a cold bitumenemulsionwithoutharmfulvapours for all protection and waterproofingworks, wasapplied in twolayers of 2mm each to the walls of the rônier reinforcements and dried for 24 hours.

Oxidisedbitumenoffers good protection againstmoisture, noise, vibration and heatloss. Due to itsefficiency and usefulness in the construction field, itwasapplied hot to a thickness of 2mm on the rônier reinforcementsafter a heatingoperation. The treated reinforcement isdried for 24 hours.

Cement-glue mortarconsists of a mixture of cement, very fine sand and fixing additives. This mixture issoldready to use, either in powderform, in bags of variousquantities (from 1 to 25 kg), or in pots as a ready-to-usepaste. In our case, we used the greypowder in a 20 kg bag. To obtain the cement glue mixture, wefollowed the instructions on the packaging. Once the mixture had been obtained, weappliedit to the plant reinforcement of the rônier to a thickness of 5 mm.

Figure 7 :- Flintkote Be3 pot

Figure 8 :- BitumenBread Package

Figure 9 :-Packet of Permafix cement glue

Protocol:
When the reinforced concrete works in simple bending, the upper fibres are compressed and the lower fibres are stretched. As the concrete already has a very good compressive strength, the tensilestrengthisthentaken up by the tensionedreinforcementswhich are placed on the lower fibres. With this in mind, we have arranged the Borassus reinforcements at the level of the lower fibres in order to betterassess the tensilestrength of the Borassus-concrete composite material in the case of water repellenttreatments.

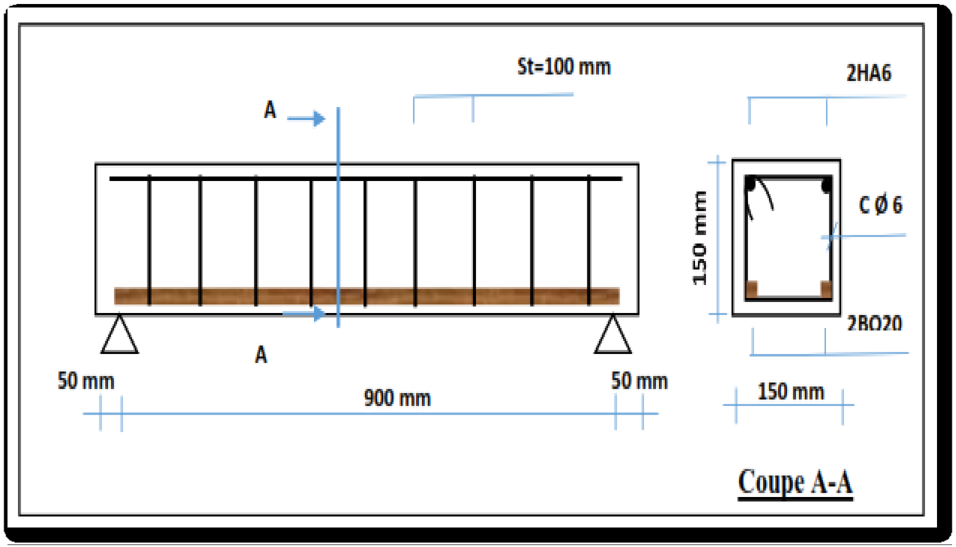


Figure 10 :-Longitudinal and cross section of a test beam.

		
Figure 11 :- Borassus plant frame treated with Bitumen.	**Figure 12** :-Borassus plant frame treated with Flintkote Be3	**Figure 13:-**Borassus plant reinforcement treated with cementmortar glue

Assessment of moisture content:
The samples of the plant reinforcementsextractedfrom the concrete wereimmediatelyweighed on the digital display scale with an accuracy of 0.01g to prevent the evaporation of moisturefrom the wood (Wetweightscale setting: Mh). To finally know the exact amount of water contained in thesereinforcements by weightloss, theyweresteamed at a temperature of 105°C+or- 5 and dried at a constant water content. This last drying operationenabled us to find the dry mass of the samples of the rônier reinforcement (dry mass balance: Ms).

Figure 14 :-Extraction of the treatedBorassus frames

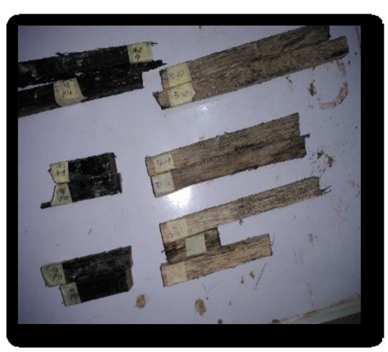
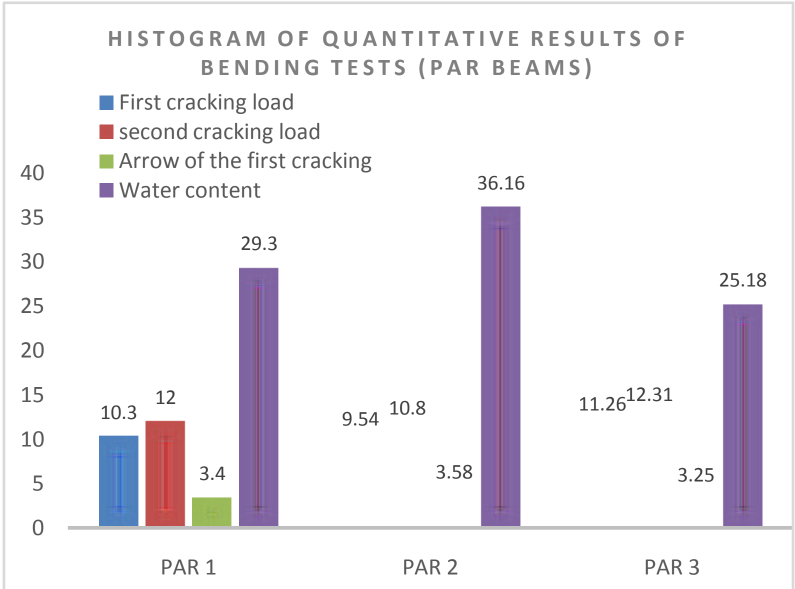


Figure 15:- Sample of Borassus wood extractedfrom concrete for steaming

Figure 16:- Steamed Borassus wood sample

Results And Discussion:-

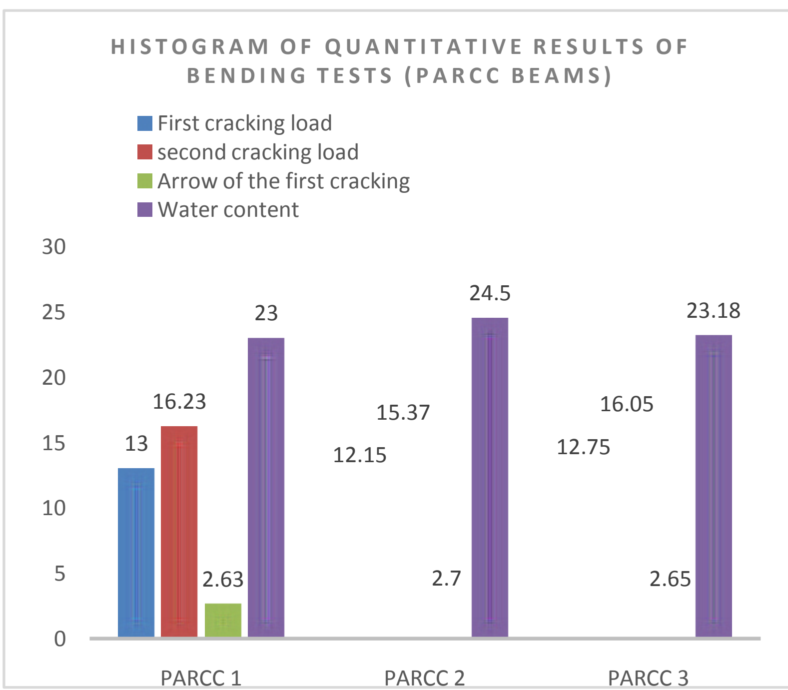
Untreated Borassus Reinforced Beams,PAR:



Based on the results of the four-point bending test of the three (03) beams reinforced with rônier wood without water-repellenttreatment, we note that rônier wood is a living materialthatreacts to water and to variations in the humiditylevel of itsenvironment.

According to the histogram opposite, thisability of these plant reinforcements to absorb a certain amount of water depending on the humidityis a major determiningcharacteristic of the resistance of the rônier wood to stress because, according to the analysis of the histogram, the higher the water content in the extracted rônier reinforcement aftercrushing (W= 30. 21 ± 5.54 %), the greater the deflectionresultingfrom the deformation of the beams (fr = 3.41 ± 0.15 mm) and the lower the first cracking load (10.37 ± 0.86 kN) and the breakingload (11.70 ± 0.80 kN).

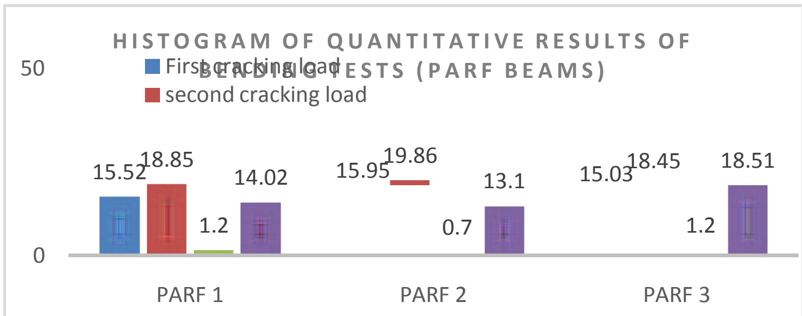
Reinforced Beams of Borassus treated with cement-glue,PARCC:



Based on the histogram of quantitative resultsfrom the bending tests of PARCC beams and compared to the data from tests on specimens of beams reinforced with rônier reinforcement withoutanypriortreatment (PAR beam), itfollowsthatcement glue is an elementthatsubstantiallyimproves the strength of the concrete-rônier reinforcement composite material.

This isexplained by the factthat the first cracking load (11.63 ± 1.30 kN) and the breakingload (15.88 ± 0.45 kN) of the PARCC beams are higherthanthose of the PAR beams by 1.26 kN and 4.18 kN respectively. With a water content of 23.56 ± 0.82% after the drying process in an oven at a temperature of 105°C, the cementitiousadhesivedid not revealitself as a productthatwould waterproof the walls of the rônier reinforcements in contact with the concrete for 28 days.

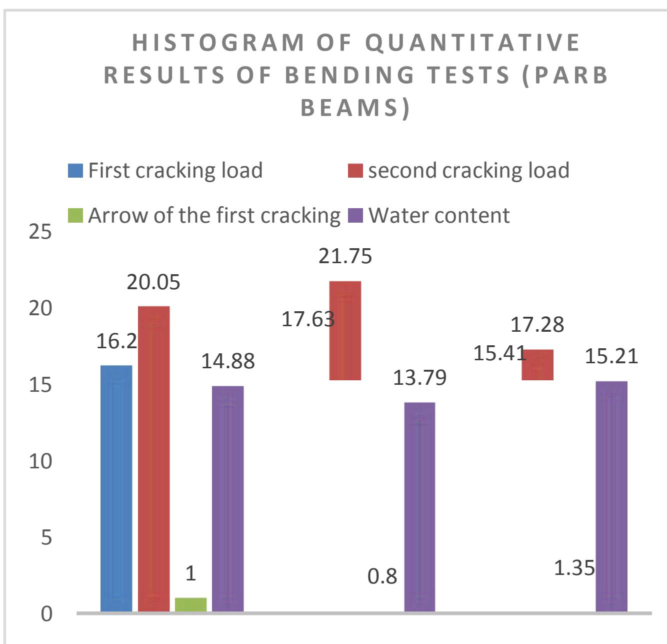
Reinforced Beams of Borassus treated with Flintkote Be3, PARF:



After the extraction of the rônier frames having undergone flintkote water-repellent treatment we notice - according to the histogram below - a relatively small increase in water content of 3.21 % (12 % ⇒15.21 %) with a rather high breaking load (19.05 ± 0.73 kN) compared to the first two treatments and a rather smaller first cracking deflection.

Therefore, we conclude that flintkote is not only a waterproofing product but also a product that improves the resistance of the composite material to bending stresse

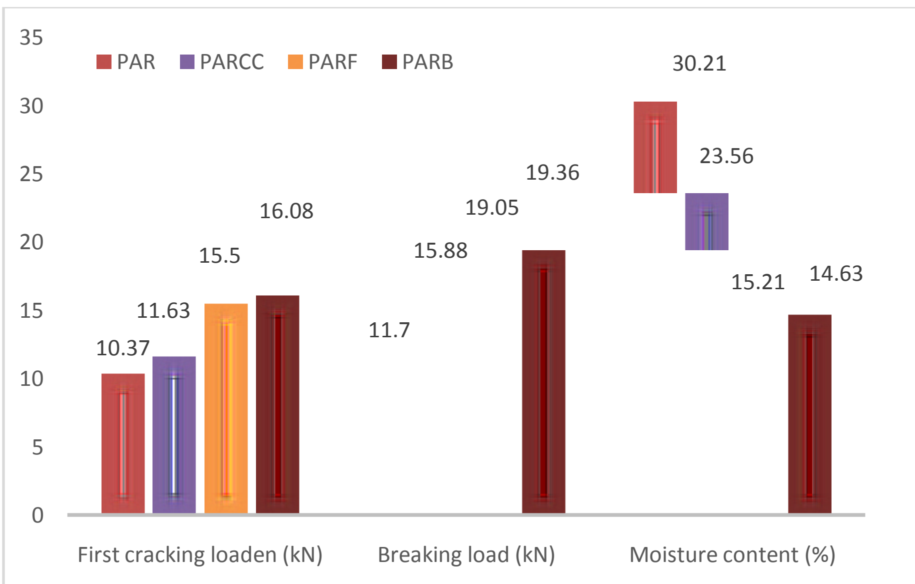
Reinforced Beams of Borassus treated with heatedBitumenbread,PARB



Wood issaid to be "green" or "wet" whenitsmoisture content isabove 19% and "dry" whenitisbelow. According to the analysis of the histogram of the PARB beams, the bitumenplayeditsrole in waterproofing the walls of the rônier plant reinforcements in contact with the concrete by keeping the wood in its dry state (14.63% moisture content at 28 days). As the breakingload (19.36 ± 1.84 kN) wasmuchhigherthanthat of the untreatedreinforcements (11.70 ± 0.80 kN), we note in this respect that the PARB beamsdeveloped a high breakingstrengththanks to theirbetter mechanical properties.

Summary of the results of the physical measurements of the differentbeams:
Table 1 :- Values of 1st cracking loads, breakingloads and moisture content variation of the different Borassus plant-reinforced beams.

NAME OF THE TEST TUBES	1st crack load (kN)	Breakingload (kN)	Deflection at 1st crack (mm)	Moisture content in %
Borassus beam withouttreatment(UBRB)	10.37 ± 0.86	11.70 ± 0.80	3.41 ± 0.15	12.00⇒30.21 ΔH=+18,21
Borassus beam treated with Cement Glue (RBBCG)	11.63 ± 1.30	15.88 ± 0.45	2.66 ± 0.04	12.00⇒23.56 ΔH=+11,56
Borassus beam treated with Flintkote Be3 (RBBF)	15.50 ± 0.46	19.05 ± 0.73	1.03 ± 0.2	12.00⇒15.21 ΔH=+3.21
Borassus beam treated with Bitumen(RBBB)	16.08 ± 1.20	19.36 ± 1.84	1.05 ± 0.27	12.00⇒14.63 ΔH=+2.63



The above table and histogram show the values of 1st cracking loads, breakingloads and moisture variation of the different Borassus plant reinforced beams.

The table and the histogram show us that Flintkote Be3 and Bitumen, as we have alreadypointed out, are very effective waterproofingproducts for the treatment of rônier wood surfaces beforetheir introduction into concrete, becauseaccording to the histogram, the lower the variation in the moisture content of the beams (example of PARB: 2.36%), the greater the resistancetheydevelop to the breakingload (example of PARB beam: 19. 36 ± 1.84 kN) and therefore the deformability of the beamsisless. It thenappearsthatbitumen and Flintkote canthereforeact as a productthateliminatesdimensional variations of borassus reinforcements in concrete and provides good resistance of borassus-reinforced structures.

Conclusion:-

At the end of ourstudy on "the effect of moisture content on the behaviour of borassus in concrete", itwasgenerallyfoundthattreatment with waterproofingproductssuch as Flintkote Be3 or Bitumenallows the improvement of resistancethroughdimensional stabilisation via the stabilisation of the moisture content of the borassus plant reinforcements and its optimisation through the application of cement glue. Indeed, itisalsonecessary to specifythatthisworkcarried out istakenintoaccount in the study of a prestressed borassus reinforced beam.

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