RESEARCH ARTICLE

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

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Abstract

The aim of this scientific work is to investigate the effect of moisture content on the behaviour of borassus in concrete. At the beginning of this study, characterisation tests are carried out on the materials used. These materials include Nokoué lagoon sand, rolled gravel from the Mono, concrete and cut-to-length rônier. After formulating the concrete using the DREUX - GORISSE method, the Borassus plant reinforcements were treated with a hydraulic waterproofing binder (cement glue, bitumen and Flintkote Be3) and nine (09) beams were made, three (03) per category of waterproofing treatment. 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 waterproofing products for the treatment of the surfaces of rônier wood before they are introduced into the concrete, because the smaller the variation in the moisture content of the beams (example of PARB beam: 2.36%), the greater the resistance they develop to the applied load (example of PARB beam: 19.36 ± 1.84 kN) and consequently the lower the deformability of the beams. It then appears that bitumen and Flintkote Be3 can therefore act as a product that eliminates the dimensional variations of borassus reinforcements in concrete and provides good resistance of borassus-reinforced structures.

Introduction:

As hygroscopicity is a property of borassus wood which causes dimensional instability when in contact with moisture, its association with concrete should not be left to chance without perfect control of its behaviour when used as a structural element in real service situations. This leads us, in view of the studies previously carried 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 it is one of the determining factors that can weaken the adhesion and even the strength of the Borassus-concrete composite.

In view of the enormous potential that borassus represents in construction, its association in concrete as a reinforcement in the same way as steel is of increasing interest to research. This raises questions about its behaviour in concrete. Substituting borassus for steel in concrete and ensuring that the concrete-borassus composite will work as a...
single material over time. Borassus is a hygroscopic material and is therefore subject on the one hand to
dimensional instability depending on its state and on the other hand to slippage within the concrete when subjected to stress. These instabilities can affect adhesion, which seems very detrimental. L’échange d’humidité entre les deux matériaux au cours du mûrissement du composite provoque soit une diminution dimensionnelle (retrait) ce qui entraîne 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.

**Material And Methods:**

**Material:**
It consists essentially of a MIGM four-point multi-speed bending device; a 10 N resolution; a hydraulic press for compression tests.

The plant material used for our tests comes from the Pahou-Ahozon forest gallery in southern Benin. A stand of male Borassus Aethiopum Mart was felled, cut and sawn into planks and, after these various stages, the resulting rônier planks were dried at the ATC timber company in Allada to a moisture content of 12%. Finally, the plant material was transported to the wood workshop of the Lycée Technique Coulibaly in Cotonou where it was machined into standardised test specimens of dimensions 20 x 20 x 85 cm³.
Method for the water-repellent treatment of roofter plant reinforcements:

Three (03) waterproofing products were used:

- Flintkote Be3, which is a cold bitumen emulsion without harmful vapours for all protection and waterproofing works, was applied in two layers of 2mm each to the walls of the rônier reinforcements and dried for 24 hours.

- Oxidised bitumen offers good protection against moisture, noise, vibration and heat loss. Due to its efficiency and usefulness in the construction field, it was applied hot to a thickness of 2mm on the rônier reinforcements after a heating operation. The treated reinforcement is dried for 24 hours.

- Cement-glue mortar consists of a mixture of cement, very fine sand and fixing additives. This mixture is sold ready to use, either in powder form, in bags of various quantities (from 1 to 25 kg), or in pots as a ready-to-use paste. In our case, we used the grey powder in a 20 kg bag. To obtain the cement glue mixture, we followed the instructions on the packaging. Once the mixture had been obtained, we applied it to the plant reinforcement of the rônier to a thickness of 5 mm.

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 tensile strength is then taken up by the tensioned reinforcements which 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 better assess the tensile strength of the Borassus-concrete composite material in the case of water repellent treatments.
Assessment of moisture content:
The samples of the plant reinforcement extracted from the concrete were immediately weighed on the digital display scale with an accuracy of 0.01g to prevent the evaporation of moisture from the wood (Wet weight scale setting: Mh). To finally know the exact amount of water contained in these reinforcements by weight loss, they were steamed at a temperature of 105°C + or - 5 and dried at a constant water content. This last drying operation enabled us to find the dry mass of the samples of the rônier reinforcement (dry mass balance: Ms).
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-repellent treatment, we note that rônier wood is a living material that reacts to water and to variations in the humidity level of its environment.

According to the histogram opposite, this ability of these plant reinforcements to absorb a certain amount of water depending on the humidity is a major determining characteristic 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 after crushing (W= 30.21 ± 5.54 %), the greater the deflection resulting from 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 breaking load (11.70 ± 0.80 kN).

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

![](image-url)
Based on the histogram of quantitative results from the bending tests of PARCC beams and compared to the data from tests on specimens of beams reinforced with rônier reinforcement without any prior treatment (PAR beam), it follows that cement glue is an element that substantially improves the strength of the concrete-rônier reinforcement composite material.

This is explained by the fact that the first cracking load (11.63 ± 1.30 kN) and the breaking load (15.88 ± 0.45 kN) of the PARCC beams are higher than those 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 cementitious adhesive did not reveal itself as a product that would 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 stress.

**Reinforced Beams of Borassus treated with heated Bitumen bread, PARB**

Wood is said to be "green" or "wet" when its moisture content is above 19% and "dry" when it is below. According to the analysis of the histogram of the PARB beams, the bitumen played its role 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 breaking load (19.36 ± 1.84 kN) was much higher than that of the untreated reinforcements (11.70 ± 0.80 kN), we note in this respect that the PARB beams developed a high breaking strength thanks to their better mechanical properties.

**Summary of the results of the physical measurements of the different beams:**

**Table 1:** Values of 1st cracking loads, breaking loads and moisture content variation of the different Borassus plant-reinforced beams.

| NAME OF THE TEST TUBES                      | 1st crack load (kN) | Breaking load (kN) | Deflection at 1st crack (mm) | Moisture content in % |
|---------------------------------------------|---------------------|--------------------|------------------------------|-----------------------|
| Borassus beam without treatment (UBRB)      | 10.37 ± 0.86        | 11.70 ± 0.80       | 3.41 ± 0.15                  | 12.00⇒30.21           |
| Borassus beam treated with Cement Glue (RBBCG) | 11.63 ± 1.30       | 15.88 ± 0.45       | 2.66 ± 0.04                  | 12.00⇒23.56           |
| Borassus beam treated with Flintkote Be3 (RBBF) | 15.50 ± 0.46       | 19.05 ± 0.73       | 1.03 ± 0.2                   | 12.00⇒15.21           |
| Borassus beam treated with Bitumen (RBBB)   | 16.08 ± 1.20        | 19.36 ± 1.84       | 1.05 ± 0.27                  | 12.00⇒14.63           |

The above table and histogram show the values of 1st cracking loads, breaking loads 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 already pointed out, are very effective waterproofing products for the treatment of rônier wood surfaces before their introduction into concrete, because according to the histogram, the lower the variation in the moisture content of the beams (example of PARB: 2.36%), the greater the resistance they develop to the breaking load (example of PARB beam: 19.36 ± 1.84 kN) and therefore the deformability of the beams is less. It then appears that bitumen and Flintkote can therefore act as a product that eliminates dimensional variations of borassus reinforcements in concrete and provides good resistance of borassus-reinforced structures.

**Conclusion:**

At the end of our study on "the effect of moisture content on the behaviour of borassus in concrete", it was generally found that treatment with waterproofing products such as Flintkote Be3 or Bitumen allows the improvement of resistance through dimensional stabilisation via the stabilisation of the moisture content of the borassus plant reinforcements and its optimisation through the application of cement glue. Indeed, it is sometimes necessary to specify that this work carried out is taken into account in the study of a prestressed borassus reinforced beam.
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