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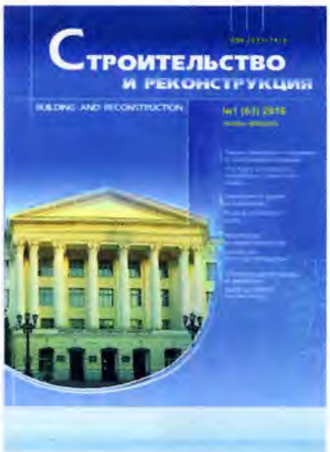

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R. MICHOZOUNNOU, A.E. FOUDJET

MECHANICAL CHARACTERIZATION OF THE LAPPING ZONE OF PALM WOOD TRUSSES IN THE CONCRETE

The present article opens a new axis of the study of the palm as vegetable truss in the concrete and is based on the mechanical characterization of the lapping zone of palm wood trusses in the concrete. More explicitly, the finality of our study is to identify the type of bond that will give a maximal rigidity in the lapping zone. For that, it was question in a first time to count the different types of lapping existing in the literature, then to identify among the different types of lapping counted those which are better adapted to our study and finally to determine the type of lapping that offers the maximum of rigidity in bending four points. From the counted and retained lapping, we have achieved five types of beam to which we have added a witness beam. From the bending four points tests achieved, some results have been obtained and allow us to conclude that the type of bond that gives a maximal rigidity in the lapping zone is the bond of type 5; assembly by sticking of palm truss with galvanized tubes in U shape.

***Key words**: palm wood, lapping zone, maximal rigidity, bending 4 points.*

1. Introduction

Today, with the persistent economic crisis in African countries, the valorization of the local materials of construction not only constitutes a solution (United Nations 1997), but also an advantage to answer the architectural heritage question valuably. Thus, the report done about the increase in prices of the construction materials, in particular the one of the steel generally imported, makes the construction get more and more costly. In order to solve this state of thing, some researches have been done since decades to substitute a material (local) for steel; material having the characteristics near steel and atlower cost.

Some researchers have, for the most part, thought about the use of the vegetable truss in the concrete. Among these last ones we can mention:

- FOUDJET and FOMO, in 1995, who used rattan in their study as truss in the weakly loaded elements and the beams of small span [1].
- In 2006, BLACKBURN was interested in the use of bamboo as vegetabletruss in the concrete within the context of the reconstruction of the habitat in Vietnam [2].
- KHENFER and al., in 2009, as for them recommend rather the use of the vegetablegrain of date palms to improve the resistance to the bending of the pieces made of concrete [3].
- Then in 2014, SOHOUNHLOUE is interested in the characterization of the inter-facial joints of the vegetable fibers: case of Cameroon rattan [4].

One of the local materials identified in Benin is the wood of the Borassus Aethiopum Mart.

The Borassus Aethiopum Mart commonly called palm in French is a vegetable species encounter in general in Sahelian Africa and in Benin in particular. It was the subject of several researches. CABANNES recognizes the Palm like a fibrous tree that grows in the temporarily flooded shallows of the zones sahelo soudanian of Africa [5]; GIFFARD as for him shows that the palm constitutes in Africa one the best woods in the zone sahelo-soudanian [6]. After having shown the socioeconomic importance of the Borassus Aethiopum Mart in Benin [7], some studies about the physical and mechanical characteristics of the Borassus Aethiopum Mart have been done and reported satisfactory results [8]. Fond of these conclusive results, some studies about the possibility of use of Borassus Aethiopum Mart as vegetabletruss in the elements made of concrete havebeen done with good report [9].

In the total mastery of the use of the Borassus Aethiopum Mart in the concrete, the present study aims at identifying the type of bond that will give a maximal rigidity in the lapping zone.

2. Methodology

The methodology of this work is based on the documentary research, of the works of land and the treatment to the laboratory.

The main object of the documentary research was to make a bibliographic synthesis that lead us to make an inventory of the previous works achieved, to have their results; that allowed us to realize the existence of an bibliographic emptiness with regard to the objective of our study which is the identification of the bond that will give a maximal resistance in the lapping zone.

We went therefore, for the beginning of the study, to the forest gallery of Pahou-Ahozon in the South of Benin where we carried out the felling, the cross-cut and the setting in boards of a foot of Borassus Aethiopum male Mart. After these stages, the following one was the drying of the boards of it to the ATC society of Wood in Allada to a moisture content of 12%. Following it, we have, in the wood workshop of the Technical Grammar School Coulibaly of Cotonou, carried the machining of these last in normalized test-tubes. In the same way to the previous activities, some tests of identification have been achieved on the samples of lagoonsand, of rounded gravel of Mono and the cement CPJ 35 of SCB Bouclier that will enter in the formulation of the reinforced concrete of Borassus Aethiopum Mart. The Laboratory of Materials and Structures (LAMS) of High Civil Engineering School of Véréchaguine A. K. was used as for the realization ofdifferent mechanical tests on the samples and the test-tubes.

To reach our main purpose, we have firstly listed some possible types of assembly in the lapping zone. Secondly, we have identified those which are better adapted to our sturdy. On the basis of the identified types of assembly, some beams have been prepared. And to finish, the type of assembly that offers the maximum of resistance in bending four (04) points has been identified.

Below, we have the different reinforcementscoming in the confection of the beams and the assembling achieved at the LAMS laboratory (fig. 1, 2, 3, 4, 5, 6).

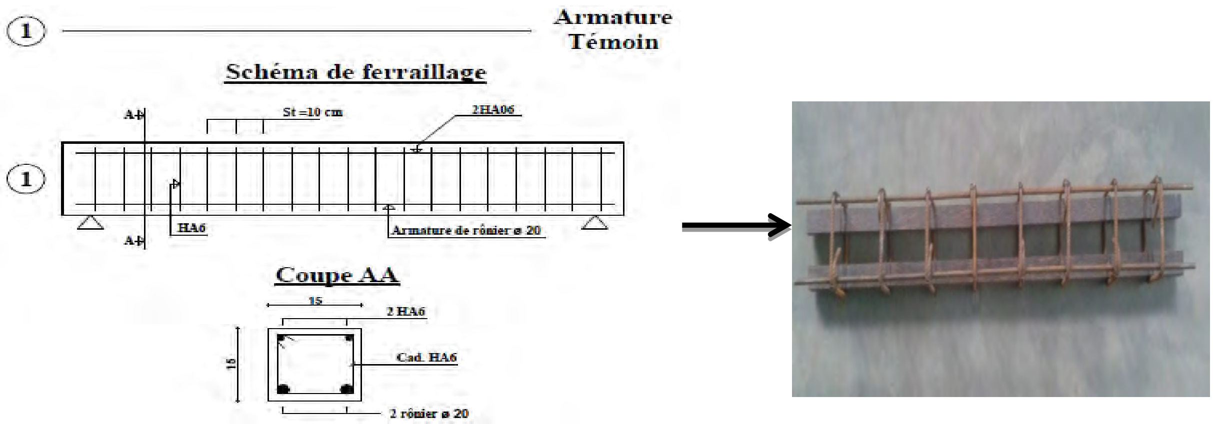

Figure 1 – Beam reinforced of continuous palm

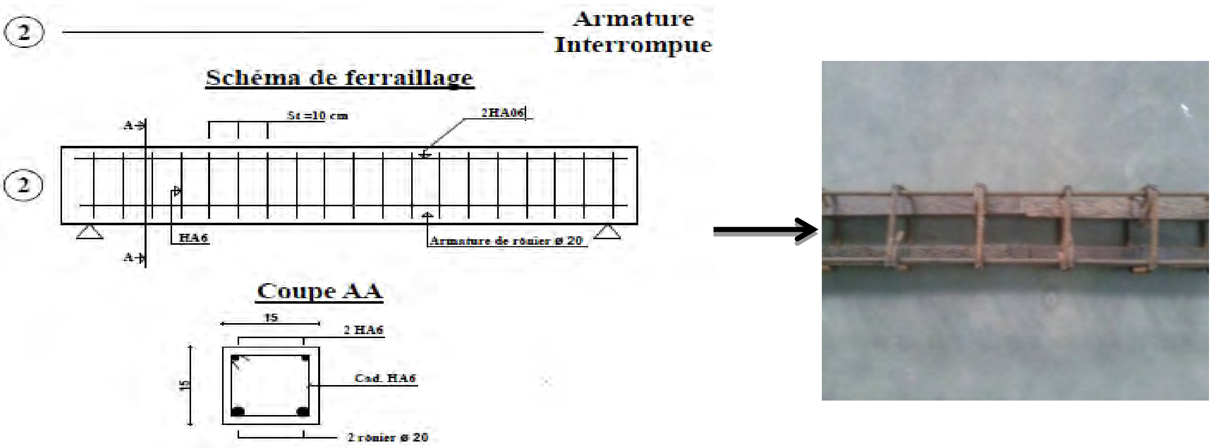

Figure 2 – Beam reinforced of interrupted palm

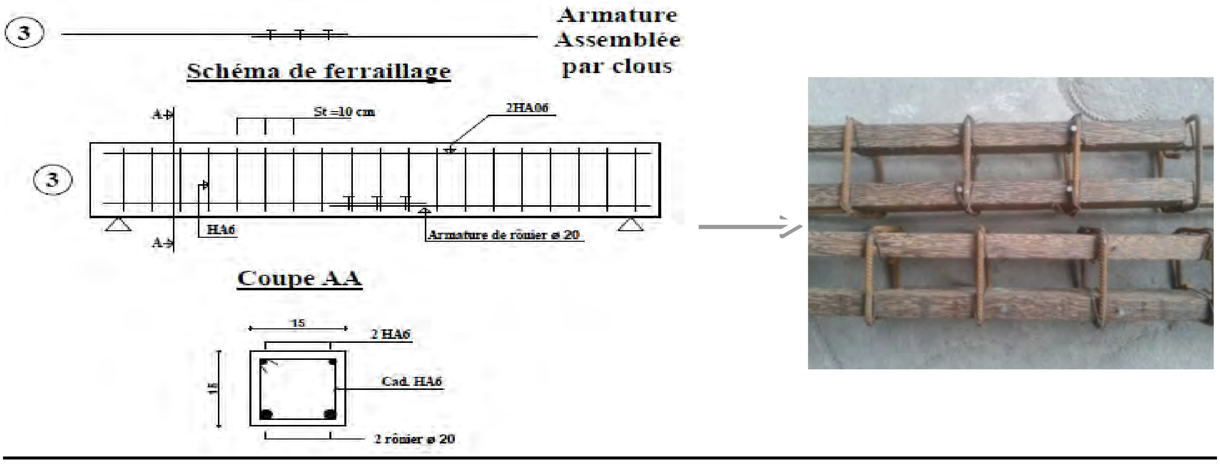

Figure 3 – Beam reinforced with palm assembled by nails

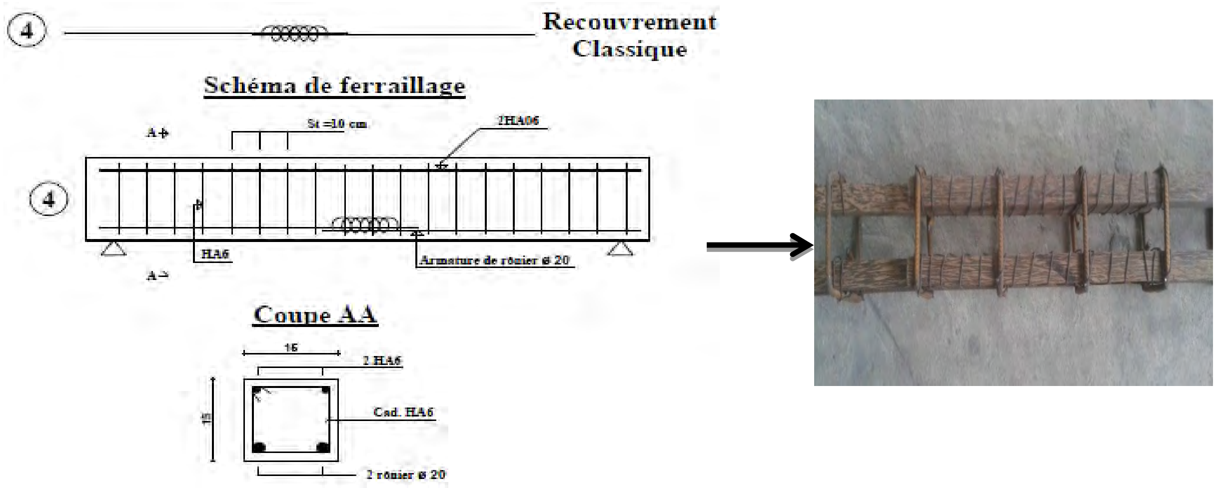

Figure 4 – Beam reinforced with palm assembled by wire

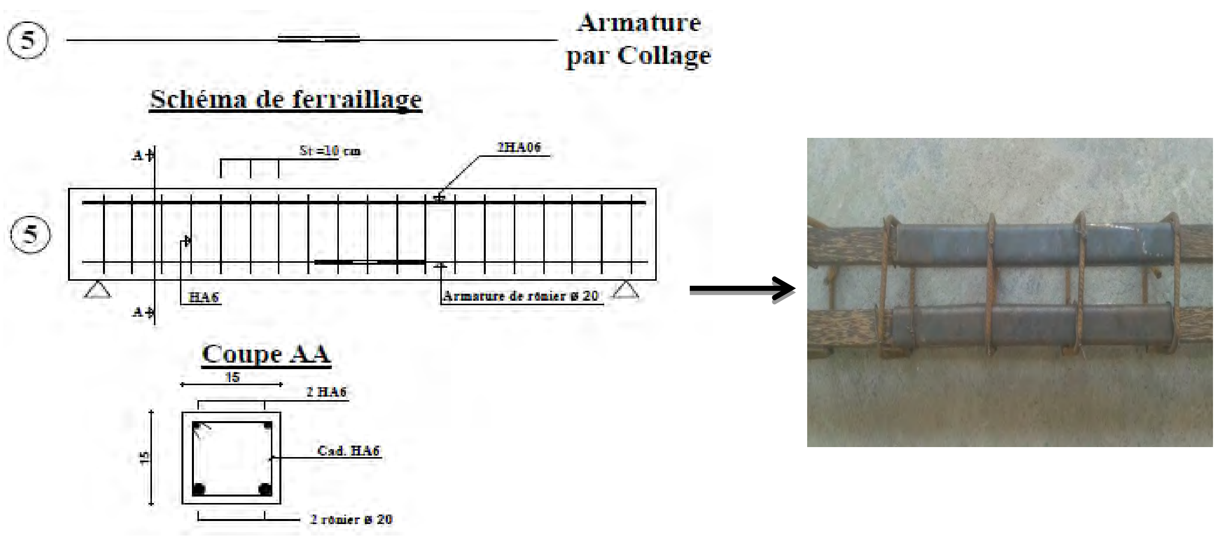

Figure 5 – Beam reinforced with palm assembled by sticking with iron galvanized tubes in U shape

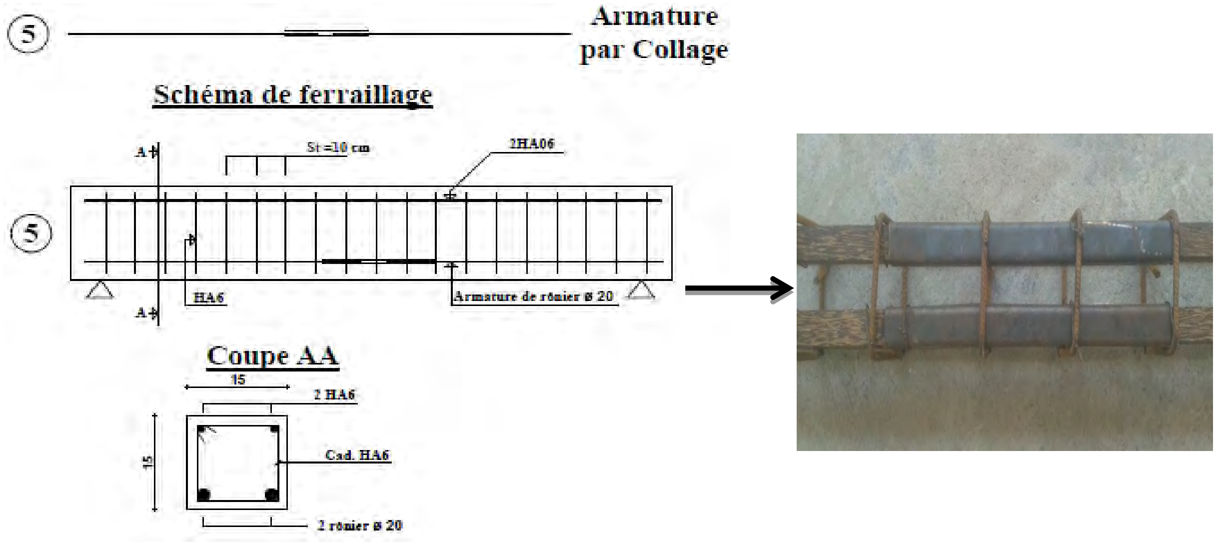

Figure 6 – Beam reinforced with palm assembled by sticking with fiiron galvanized tubes in laminations shape

The results of the tests achieved in the reach our goals were the subject of analysis and discussions.

3. Results and discussions

Physical characteristics of materials. The tests of physical characterization have been achieved on the lagoon sand, rounded gravel of Mono and the cement CPJ coming in the confection of the concrete. About the number of these tests, we have the particle analysis by sifting, the specific density, the bulkspecific gravity and the sand equivalent.

The table 1 below presents the results of all the physical characterization tests of materials used.

Table 1 – Summary of the characteristics of materials

Characteristics	Lagoon sand	Rounded gravel of Mono	Cement
Granular class	0,08/5	5/15	-
Coefficient of finenessCF	2,55	-	-
Uniformitycoefficient U_c	2,81	2,06	-
Curvature coefficient C_c	1,003	1,01	-
Specific density(g/cm^3)	1,50	2,05	-
Bulk specific gravity(g/cm^3)	1,42	1.91	3,10
Densité « SSS »	2	-	1,00
Absorption percentage	2,05	1,60	-
E.S	79	-	-
E.S.V	91,5	-	-

From the different results obtained, we formulated the concrete having to serve to the casting of the beams.

Physical characteristics of the fresh concrete. The formulation of the concrete has been made according to Dreux-Gorisse method [10] where we want to make a plast concrete for the achievement of the beams with a maximal dimension Dmax=31,50 mm for the granulates. The wished resistance is σ'n=300 bars. The granulatesare of common quality, rounded with a normal vibration.

- **Data of basis**
- Maximal dimension of the granulates D = 31,5 mm

- Nominal resistanceσ’n = 300 bars
- Settlement to the cone: A = 5 cm
- Means of compaction: common or normal vibration
- The granulatesthat we have at our disposal are:
· Clean lagoon sand:

Mf = 2,35
Specific mass: 1,5 g/cm3
Bulkspecific gravity: 1,42 g/cm3
Sand Equivalent: Clean sand

· Rounded clean gravel

Specific mass: 2,05 g/cm^3
Obvious density: 1,91 g/cm^3

- The used cement is the CPJ 35 of SCB BOUCLIER with. σ’c = 480 barsand of specific weight equal to 3,1 g/cm^3.

According to the physical characteristics of our materials and the data of basis, the table 2 below presents the summary of the materials dosage.

Table 2 – Summary of the materials dosage

Materials	**Mass (Kg)**	**Specific Weights (g/cm^3)**	**AbsoluteVolumes (Litre)**
Sand	323	1,5	215
Gravel	1029	2,05	502
Cement	350	3,1	113
Water	172	1	172
Density(Kg/m^3)	-	1874	-

Mechanical characteristics of the formulated concrete. The different tests have been achieved in the Laboratory of the Materials and Structures (LAMS) of High Civil Engineering School of Véréchaguine A. K. (HCES-VAK). To the number of these tests, we have:

– Test of settling to the cone of Abrams achieved on the cool concrete (Norm NF EN 12350-2)

This test has been done all the times that we sank the concrete for the confection of beams. To every casting we made four (4) test-tubes. The results are consigned in the following picture:

Table 3 – Test of settling to the cone of Abrams

Confection des poutres	**Settlement to the cone of Abrams obtained (cm)**
1st confection	5,30
2nd confection	4,70
3rd confection	4,85
4th confection	5,15
Average	**5,00**

From the analysis of these results, we note that the settlement to the cone of Abrams obtained is included between 4,70 and 5,30; we conclude therefore that the concrete is tough and of good vibration.

- Test of compression on the hardened concrete (NF P 18. 406)

In order to appreciate better the concrete that we used the point of view resistance to the compression for the confection of our beams, we also achieved some tests of compression according to the norm NF P 18 - 406 on cylindrical test-tubes of diameter 16cm and 32cmhigh by means of a hydraulic press as shows the figure 7.

The tests have been achieved after 7, 14, 21 and 28 days on three (3) different samples. The results of this test are consigned here in the tables 4 - 9 below:

Table 4 – Test of compression on the cylindrical test-tubes of 7 days

Nº of test-tubes	Breaking load (KN)	Breaking strain (MPa)
Nº 1	90	18,10
Nº 2	92	18,50
Average	18,30	

Table 5 – Test of compression on the cylindrical test-tubes of 14 days

Nº of test-tubes	Breaking load(KN)	Breaking strain(MPa)
Nº 1	94,5	19,00
Nº 2	96	19,30
Average	19,15	

Table 6 – Test of compression on the cylindrical test-tubes of 21 days

Nº of test-tubes	Breaking load(KN)	Breaking strain(MPa)
Nº 1	99,99	20,10
Nº 2	100,5	20,21
Average	20,16	

Table 7 – Test of compression on the cylindrical test-tubes of 28 days

Nº of test-tubes	Breaking load(KN)	Breaking strain(MPa)
Nº 1	109	21,92
Nº 2	115	23,12
Average	22,52	

Table 8 – Summary of the averages of the Breaking strain of the compression test on the cylindrical test-tubes of different dates

Averages	Breaking strain (MPa)
7 Jours	18,30
14 Jours	19,15
21 Jours	20,16
28 Jours	22,52

The breaking strain of the concrete used for the confection of the beams is $f_{c_{28}} = 22{,}52\text{Mpa}$.

Table 9 – Summary of the test of compression on the cylindrical test-tubes

N° test-tubes	Breaking pressure (bar)	Area ofstraight section of the test-tube (cm²)	Breaking force (daN)
N° 1	151,16	201,06	30392,07
N°2	156,50	201,06	31466,05
N°3	162,91	201,06	32754,81
Average	156,86	201,06	31537,65
Standard deviation	4,036	0	811,45

Mechanical characteristics of the lapping zone of different types of assembly. In order to be able to make the choice of the best lapping, we had to prepare several samples of beams on which we achieved the test of bending 4 points according to the norm NF P 98 - 302. These different samples have been previously described in the methodology. All the beams are reinforced with construction trusses at the superior part.

So therefore we have:

Beams 1: Witness beams: these are beams reinforcedat the bottom part of two continuous Borassus trusses of square section of 20x20 cm² (2Bo20).

Beam 2: These beams are reinforcedat the inferior part of 2Bo20 discontinuous or interrupted to mid bay.

Beam 3: These beams are reinforced to the inferior part of 2Bo20 assembled by nails.

Beam 4: These beams are reinforced to the inferiorpart of 2Bo20 with a classic lapping (trussesassembled by wire).

Beam 5: These beams are reinforced to the inferior part of 2Bo20 with a lapping by sticking (iron galvanized tube in U shape).

Beam 6: These beams are reinforced to theinferiorpart of 2Bo20 with a lapping by sticking (iron galvanized tube of two blades).

The prepared beams have a dimension of (15 x 15 x 91) cm^3. The Borassus used atmoisture content equal to 12% and has for section (2 x 2) cm². For the confectionof the beams, the adopted coating is 3 cm. The tests on the beams have been done of 28 days. For every type of we achieved three (03) test-tubes.

The figure 8 shows the device of the bending 4 points test on the hydraulic press. The results of the bending tests 4 points have been summarized in the tables 10 - 16 below.

Figure 7 – Hydraulic press for the compression

Table 10 – Test of bending 4 points on the beams reinforced with trusses of 2Bo20 continuous

Beam 1: Beams reinforced with construction trusses at superior part and of 2Bo20 continuous at inferior part	**1. TEST TUBEN°1**			**2. TEST TUBEN°2**			**3. TEST TUBEN°3**		
	AppliedPressure (bar)	**Deflection of the beam (mm)**	**Breaking force (daN)**	**Pression appliquée (bar)**	**Deflection of the beam (mm)**	**Breaking force (daN)**	**AppliedPressure(bar)**	**Deflection of the beam (mm)**	**Breaking force (daN)**
	1,60	0,22	62,34	1,60	0,20	62,34	1,60	0,18	62,34
	6,94	0,50	270,99	6,94	0,35	270,99	6,94	0,56	270,99
	12,28	0,72	479,64	12,28	0,73	479,64	12,28	0,78	479,64
	17,62 Cracking	1,08	688,29	17,62	1,00	688,29	17,62	0,89	688,29
	22,96	1,15	896,95	22,96 Cracking	1,05	896,95	22,96 Cracking	1,20	896,95
	28,30 Breaking load	1,22	1105,60	28,30 Breaking load	1,07	1105,60	28,30 Breaking load	1,65	1105,60

Table 11 – Test of bending 4 points on the beams reinforced with 2Bo20 interrupted

	4. TEST TUBEN°1			5. TEST TUBEN°2			6. TEST TUBEN°3		
Beam 2: Beams reinforced with 2Bo20 interrupted at the inferior part	**AppliedPressure (bar)**	**Deflection of the beam (mm)**	**Breaking force (daN)**	**Pression appliquée (bar)**	**Deflection of the beam (mm)**	**Breaking force (daN)**	**AppliedPressure (bar)**	**Deflection of the beam (mm)**	**Breaking force (daN)**
	1,60	0,00	62,34	1,60	0,00	62,34	1,60	0,00	62,34
	6,94	0,06	270,99	6,94	0,30	270,99	6,94	0,45	270,99
	12,28 Cracking	0,35	479,65	12,28 Cracking	0,60	479,64	12,28 Cracking	0,60	479,64
	17,6203 Breaking load	0,80	688,29	17,62 Breaking load	0,80	688,29	17,62 Breaking load	0,85	688,29

Table 12 – Test of bending 4 points on the beams reinforced with2Bo20 assemblies by nails

	7. TEST TUBEN°1			8. TEST TUBEN°2			9. TEST TUBEN°3		
Beam 3: Beams reinforced with2Bo20 assembled by nails at the inferior part	**AppliedPressure (bar)**	**Deflection of the beam (mm)**	**Breaking force (daN)**	**Pression appliquée (bar)**	**Deflection of the beam (mm)**	**Breaking force (daN)**	**AppliedPressure (bar)**	**Deflection of the beam (mm)**	**Breaking force (daN)**
	1,60	0,08	62,34	1,60	0,02	62,34	1,60	0,03	62,34
	6,94	0,20	270,99	6,94	0,08	270,99	6,94	0,05	270,99
	12,28 Cracking	0,28	479,64	12,28 Cracking	0,15	479,64	12,28 Cracking	0,09	479,64
	17,62	0,3	688,29	17,62	0,10	688,29	17,62	0,15	688,29
	22,96	0,4	896,95	22,96	0,50	896,95	22,96	0,30	896,95
	28,30 Breaking load	0,55	1105,6	28,30	0,55	1105,6	28,30	0,70	1105,6
	-	-	-	33,65 Breaking load	0,60	1314,25	33,65 Breaking load	0,70	1314,25

Table 13 – Test of bending 4 points on the beams reinforced with2Bo20 assembled by the wire

	10. TEST TUBEN°1			11. TEST TUBEN°2			12. TEST TUBEN°3		
Beam 4: Beams reinforced with2Bo20 assembled by the wire at the inferior part	**AppliedPressure (bar)**	**Deflection of the beam (mm)**	**Breaking force (daN)**	**Pression appliquée (bar)**	**Deflection of the beam (mm)**	**Breaking force (daN)**	**AppliedPressure (bar)**	**Deflection of the beam (mm)**	**Breaking force (daN)**
	1,60	0,00	62,34	1,60	0,00	62,34	1,60	0,00	62,34
	6,94	0,10	270,99	6,94	0,06	270,99	6,94	0,06	270,99
	12,28	0,50	479,64	12,28	0,47	479,64	12,28	0,47	479,64
	17,62 Cracking	0,85	688,29	17,62 Cracking	0,74	688,29	17,62 Cracking	0,74	688,29
	22,96	1,00	896,95	22,96	0,97	896,95	22,96	0,97	896,95
	28,30	1,20	1105,60	28,30	1,02	1105,60	28,30	1,02	1105,60
	33,65 Breaking load	1,55	1300,91	33,65 Breaking load	1,35	1300,91	33,65 Breaking load	1,35	1300,91

Table 14 – Test of bending 4 points on the beams reinforced with2Bo20 by sticking with a lapping of iron galvanized in U shape

Beam 5: Beams reinforced with 2Bo20 lappedof iron galvanized tube in U shape by sticking in the lapping zone at the inferior part	**13. TEST TUBEN°1**			**14. TEST TUBEN°2**			**15. TEST TUBEN°3**		
	AppliedPressure (bar)	**Deflection of the beam (mm)**	**Breaking force (daN)**	**Pression appliquée (bar)**	**Deflection of the beam (mm)**	**Breaking force (daN)**	**AppliedPressure (bar)**	**Deflection of the beam (mm)**	**Breaking force (daN)**
	1,60	0,00	62,34	1,60	0,00	62,34	1,60	0,00	62,34
	6,94	0,16	270,99	6,94	0,18	270,99	6,94	0,15	270,99
	12,28	0,36	479,64	12,28	0,30	479,64	12,28	0,20	479,64
	17,62 Fissuration	0,42	688,29	17,62 Fissuration	0,40	688,29	17,62 Fissuration	0,50	688,29
	22,96	0,50	896,95	22,96	0,45	896,95	22,96	0,65	896,95
	28,30 Breaking load	0,55	1105,60	28,30 Breaking load	0,55	1105,60	28,30 Breaking load	0,70	1105,60

Table 15 – Test of bending 4 points on the beams reinforced with2Bo20 by sticking iron galvanized tube of two blades

Beam 6: Beams reinforced with2Bo20 lapped of iron galvanized tube of2blades by stickingat the inferior part	**16. TEST TUBEN°1**			**17. TEST TUBEN°2**			**18. TEST TUBEN°3**		
	AppliedPressure (bar)	**Deflection of the beam (mm)**	**Breaking force (daN)**	**Pression appliquée (bar)**	**Deflection of the beam (mm)**	**Breaking force (daN)**	**AppliedPressure (bar)**	**Deflection of the beam (mm)**	**Breaking force (daN)**
	1,60	0,00	62,34	1,60	0,00	62,34	1,60	0,00	62,34
	6,94	0,16	270,99	6,94	0,18	270,99	6,94	0,15	270,99
	12,28	0,36	479,64	12,28	0,30	479,64	12,28	0,20	479,64
	17,62 Cracking	0,42	688,29	17,62 Cracking	0,40	688,29	17,62 Cracking	0,50	688,29
	22,96	0,50	896,95	22,96	0,45	896,95	22,96	0,65	896,95
	28,30 Breaking load	0,55	1105,60	28,30 Breaking load	0,55	1105,60	28,30 Breaking load	0,70	1105,60

The table 16 summarizes the values of the strengths of ruptures, the arrows and of the modulus of YOUNG for every type of assembly.

Table 16 –Summary of determination of the modulus of Young

Descriptions	**Breaking Force (daN)**			**Average of Breaking Force (daN)**	**Average deflection (mm)**	**Modulus of Young (MPa)**
Type 1	1335	1310	1315	1315,00±10	1,38	**1651**
Type 2	710	690	670	690,00±13,33	0,85	**1407**
Type 3	1110	1105	1095	1103,00±5,55	0,70	**2732**
Type 4	1320	1290	1310	1307,00±11,11	1,55	**1461**
Type 5	1523	1530	1537	1530,00±4,67	0,70	**3788**
Type 6	1100	1115	1105	1106,67±5,56	0,60	**3197**

On the basis of the results of the modulus of Young, a histogram has been constructed, to the figure 9, in order to conduct the analyses on the type of assembly of beams that would give a maximal rigidity in the lapping zone.

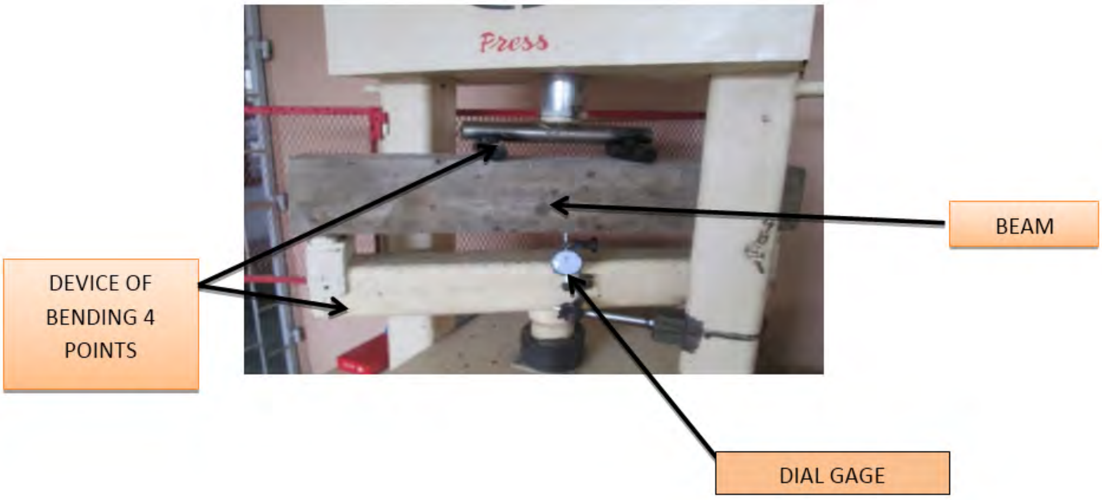

Figure 8 – Device of bending 4 points on the hydraulic press

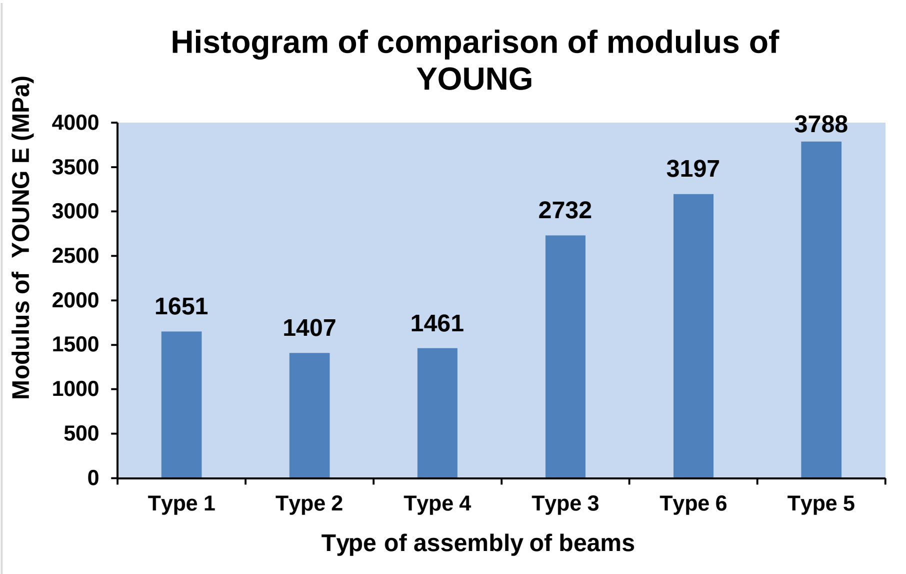

Figure 9 – Histogram of comparison of the modulus of YOUNG

The Table 16 above gives the values of the average breaking force of beams, of the average deflection and the modulus of YOUNG of beams made of reinforced concrete of 2BO20 gaugedat 350 Kg/m^3 and 28 days old where are experimented the factors influencing the rigidity in the lapping zone. From this table, we note that the modulus of YOUNG of the beams reinforced with type 5 (3788 MPa) is superior to the modulus of all other types of beams reinforced with palm (Borassus). It proves that the increase of their rigidity depends on the system assembly of woodtrusses.

The observation made about the histogram of comparison of the modulus of Young (***Figure 3.3***), showsthat the Type 1 (witness beam of 2Bo20 continuous) is compared to the other types of assembly. It shows that after the type 1 the histogram evolves in an increasing way until the type 5 that respects the aimed objective.

The comparison between the modulus of Young ofcontinuous trusses (1651 MPa), of interrupted trusses(1407 MPa), of trusses assembled by wire (1461 MPa), of trussesassembled by nails

(2732 MPa), of trussesassembled by sticking with the iron galvanized tube in the blades shape (3197 MPa) and those assembled by sticking with the iron galvanized tube in the U shape (3788 MPa), shows that the presence of the iron galvanized tube by sticking on the area of contact of the palm in the lapping zone increases the modulus of Young. This increasing of modulus of the beam shows that the iron galvanized tube plays an important role in this lapping zone. We can deduct therefore that the rigidity improved and this because of the presence of iron galvanized tube.

The modulus of Young of the beams reinforced with palm trusses assembled by sticking with the iron galvanized tube in U shape or blades is superior to the one of the other beams reinforced with palm truss (by nails, continuous, by wire, and interrupted). It allows us to say that the beams reinforced withpalm trusses assembled by the iron galvanized tube offer the best rigidity in lapping zone.

4. Conclusion

This work was about the mechanical characterization of the lapping zone of the palm trusses in the concrete and integrated in a general problematic of valorization and development of local materials. It had therefore for purpose to identify a type of bond of palm trusses having a better rigidity in thelapping zone.

At the end of a brief bibliographic synthesis pointing the possibility to use the palm as trusses in the construction up, we achieved six (06) different types of beams of dimension (15x15x91) cm^3made of reinforced concrete with palm especially as the aimed goal is to identify the type of bond that will give a maximal rigidity in the lapping zone. The technique adopted to manufacture the beams sums up in two essential points:

- To achieve the reinforcement of the aforesaid beams with six (06) different assemblies of palm trusses in the lapping zone (witness truss, interrupted truss, truss reinforced by nail, classic assembly by wire and two (02) assemblies by sticking with of iron galvanized tube in U shape and blades);
- To prepare three beams by type of assembly with a concrete formulated by the Dreux-Gorisse method.

In order to determine the mechanical properties of the beams obtained we have submitted these last tests of bending 4 points.

The mechanical characteristics (breaking forces and modulus of Young) recorded for the beams allow to deduct the beam of type 5 as being the most rigid. Thus, it follows that it is the lapping ofpalmtrusses by sticking with the iron galvanized tube in U shape (Type 5) that offers the best rigidity in the lapping zone.

Although the studied aspects are numerous and various, this study is only anexploratory-phase in the characterization and the complete mastery of lapping of palm trusses.

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МЕХАНИЧЕСКИЕ ХАРАКТЕРИСТИКИ ЗОНЫ СТЫКА АРМАТУРНЫХ КАРКАСОВ ИЗ ДРЕВЕСИНЫ ПАЛЬМЫ В БЕТОНЕ

Данная статья открывает новое направление в исследовании применения древесины пальмы в качестве арматуры в бетонных конструкциях и основана на изучении механических характеристик зоны стыка арматурных каркасов из древесины в бетоне. Целью исследования было установить конструктивные решения в зоне стыка, обеспечивающей наибольшую жесткость стыка. Были изучены имеющиеся работы по теме контактного взаимодействия материалов, среди которых были выделены наиболее адаптированные к теме нашего исследования, на основании чего предложено пять вариантов конструктивных решений для последующего экспериментального исследования контактной жесткости при чистом изгибе. На основании полученных в ходе исследования результатов установлено, что наибольшая контактная жесткость достигается при выполнении стыков с использованием U-образных профилей из оцинкованной стали.

Ключевые слова: *древесина пальмы, зона стыка, максимальная жесткость, чистый изгиб.*