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RESEARCH ARTICLE

COMPARATIVE STUDY OF CONCRETE BEAMS CONVENTIONAL REINFORCING WEAPON AND CONCRETE BEAMS WOOD WEAPON OPPOSITIFOLIUS MALLOTUS

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Abstract

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The objective of this work is to compare the mechanical performance of concrete beams reinforced with convention reinforcement (iron) and concrete beams reinforced with oppositifolius mallotus wood with a view to building an innovative construction system for habitable or non-habitable floors of pavilions in rural areas. For this fact, nine (09) specimens of section 10x10x40cm^3 were made at the rate of three (03) unreinforced concrete specimens; three (03) reinforced concrete with Mallotus oppositifolius wood (vegetable reinforcement) without prior treatment and three (03) reinforced concrete specimens of conventional reinforcement (iron) which were subjected to the four-point bending test after twenty-eight (28) of age. At the end of the tests, it was found that the oppositifolius mallotus wood frame improves the four-point bending strength of the beams compared to unreinforced beams without achieving the mechanical performance of reinforced beams in conventional reinforcement. We also note a lower arrow compared to unreinforced beams. A visual analysis of the beams reinforced with mallotus oppositifolius wood (plant frame) after a total rupture shows us a need to treat the surface of the mallotus oppositifolius wood to make it rougher in order to increase its adhesion with the concrete. We thus retain the possibility of using mallotus oppositifolius wood as a vegetal frame in the construction of social housing in rural areas after its waterproofing and treatment.

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Introduction:-

In a world in constant struggle with the economic crisis and its consequences on the socio-cultural and economic life of the population, especially in rural areas in African countries, the valorization of local building materials is not only a solution (United Nations, 1997) but also has the advantage of validly answering the question of architectural and cultural heritage (Stella &Dosseh, 2008). It is therefore a necessity for all to direct our research towards locally available and technically suitable building materials to replace conventional materials. Researchers rightly turn their attention to non-industrial materials, such as plant fibres, clay and wood. Among the local building materials, mallotus oppositifolius wood has already been adopted by the rural population in its habitat construction technique.

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It is a semi-heavy foliage with regard to its high density and resists well to termites and marinexylophages. Studies have shown that mallotus oppositifolius wood is used as rib and lost formwork in the construction of traditional housing (mixed structure) (Damien Agagbè, 2019). With its properties and thanks to its longitudinal fibers that give it a high tensile strength, the mallotus oppositifolius seems like the ronier, likely to replace steel as reinforcement in concrete elements, such as beams and floors. To date, there has been no work on its use in concrete, nevertheless, we note a lot of work on the use of plant reinforcements such as ronier, bamboo and rattan. All authors agree that design equations and procedures for steel-reinforced concrete can be safely used for the design of bamboo-reinforced concrete beams. But the great difficulty they face is the adhesion between the two materials (Blackburn, 2004; Foudjet&Fomo, 1995).

This work therefore regains all its originality especially since it will be the appreciation of the visual and mechanical behavior of beams armed with conventional reinforcement and that armed with plant frame (mallotus oppositifolius)

Experimental/ Materials & Methods

As part of this study, we subjected our specimens to three-point bending tests. In total, nine prismatic beams measuring 10 cm x 10 cm x 40 cm were made. They include three witness beams (unreinforced concrete beams), three beams reinforced with oppositifolius mallotus wood with a diameter of 12 mm (4BM12) and three beams reinforced with conventional reinforcement with a diameter of 12 mm (4HA12). This wood is a shrub with great geographical cover in southern Benin and on the African continent (Table 1; Figure 1).

Table 1:- Vernacularnames of M. oppositifolius in different countries (Addai, 2019 ; Sierra et al., 2007).

COUNTRIES	VERNACULARNAMES
Benin	Kissè-kissè (Fon);Gnantchivi (Adja)
Republique de la centre Afrique	Molo-Katabunga, Molo-Ndungbwa(Lissongo)
Congo	Amamambamamba
Ghana	Sroti (Ewe);Sratadu (Fanti);Osratadua (Twi)
Ivory Coast	Tomida (Abron)
Nigeria	Kafar, Mutuwaa (Hausa);Ija (Yoruba); NneOkpoKirinya (Igbo)
Soudan	Diabizo
Tanzania	Matarawanda, MbuniMwitu (Bondei), Mchachamai, Mkumbanguruwe, Mkunguriuza (Kizigua), Mtumbika, Nngaje(Kimatumbi), Sankulamnale

Mallotus oppositifolius is commonly found in semi-deciduous, wet, or dry evergreen forests, grasslands and swamps, and savannah vegetation with forest patches (Sierra et al., 2007). It has been found in Benin, Togo, Ivory Coast, Burkina Faso, Ethiopia, Nigeria, Ghana, Cameroon, Madagascar, Senegal, Angola, Malawi, Zambia, Zimbabwe, Mozambique, Uganda, Kenya, etc. Figure 3 shows a map showing the distribution of Mallotus oppositifolius in Africa.

Figure 1:- Distribution of Mallotus oppositifolius in Africa.

The reinforcement samples were taken in the Atlantic department (Commune of Toffo: Latitude: 6.85, Longitude: 2.08333 6° 51′ 0" North, 2° 4′ 60" East) and were subjected to physical and mechanical characterization (AGAGBE Damien). For the preparation of the reinforcements, we took mallotus antlers in adulthood that we machined. The beams reinforced with oppositifolius mallotus include as longitudinal reinforcement, smooth oppositifolius mallotus woods of cross-section machined in sawmill over 12 mm and used at a water content of less than 20%. These longitudinal reinforcements are mounted by means of high-adhesion iron of diameter 6 mm (HA6) as a transverse reinforcement of said beams. These frames are divided into three rows and shaped on a square section with a rounded edge of 5 cm x 5 cm and the nine (09) beams are poured with concrete dosed at 350 Kg/m3 (Figure 2). For the formulation of concrete, the Dreux-Gorisse method was used. The three-point bending test (Figure 1) was carried out on these beams, according to standard NF P 98-302. The oppositifolius mallotus wood frames with smooth, untreated surfaces have a cross-section of 113,143 mm² (12 mm x 12 cm x 22/28). Thewooden reinforcements total a cross-section of 452.571 mm² against the same section of HA12 steel reinforcement of 452.571 mm² (Photo 1 and 2). This option of uniform section is made in order to first assess the contribution of the plant frame (mallotus oppositifolius) to the reinforced beam and in a second time evaluate the relationship between the plant frame (mallotus oppositifolius) and the conventional frame. The coating used is 2.5 cm. The beams were subjected to 28 days of age using a hydraulic pressure with a three-point digital bending test display; deformations (arrows) at mid-span are recorded automatically (Photo 4;5 and 6). In these tests, we identified the forces of first appearance of cracks and those of failure. After representing the force-arrow curve of each category of beams we calculated the stiffness of each category of beams. This stiffness K represents the slope of the linear zone on the effort-arrow curve; It is equal to:

$K = \frac{\Delta F}{\Delta d}$ (1)

Where:

Δd : is the variation of the displacement (the arrow) caused by a variation ΔF of the forces.

Photo 1:**-** Shaped vegetal and conventional frame.

Photo 2:**-** Specimen 10cm x 10cm x 40cm in progress.

Photo 3:**-** Beam 10cm x 10cm x 40cm in unreinforced concrete (witness beam).

Photo 4: Beam 10cm x 10cm x 40cm in concrete reinforced with oppositifolius mallotus wood.

Photo 5:- Beam 10cm x 10cm x 40cm in unreinforced reinforced concrete (witness beam).

Results and Discussion:-

An analysis of the different curves allows us to notice that the effort-arrow curves give different paces. Note that for a series of specimens of the same category we have drawn a curve from the average of the data with regard to the similarity of these paces. These curves overlap well for the same category of beams and have the same appearance from one category to another; This shows that the oppositifolius concrete-mallotus composite material behaves during the tests similar to that known from the usual materials (iron-concrete and ronier-concrete).

a. Control material

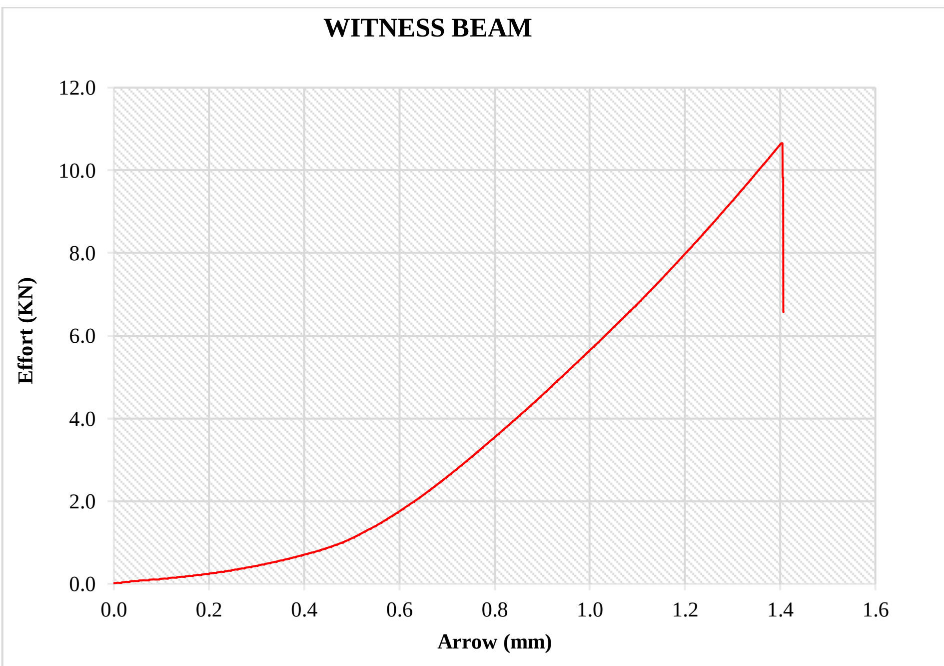

Figure 2:- Average deformation curves of unreinforced beams; breaking load is of the order of 10.655 KN. Three-point bending test.

This curve reflects the evolution of the effort and the arrow which is translated into three phases, a first phasewhich results in a small evolution of the effort against a large evolution of the boom, a second phase which results in a significant evolution of the effort-arrow curve proportionally followed by a last phase characterized by a sudden break. We note that the first two phases characterize the elastic domain of the material. This material has no plastic domain (Figure 2).

b. Concrete reinforced with mallotus oppositifolius wood

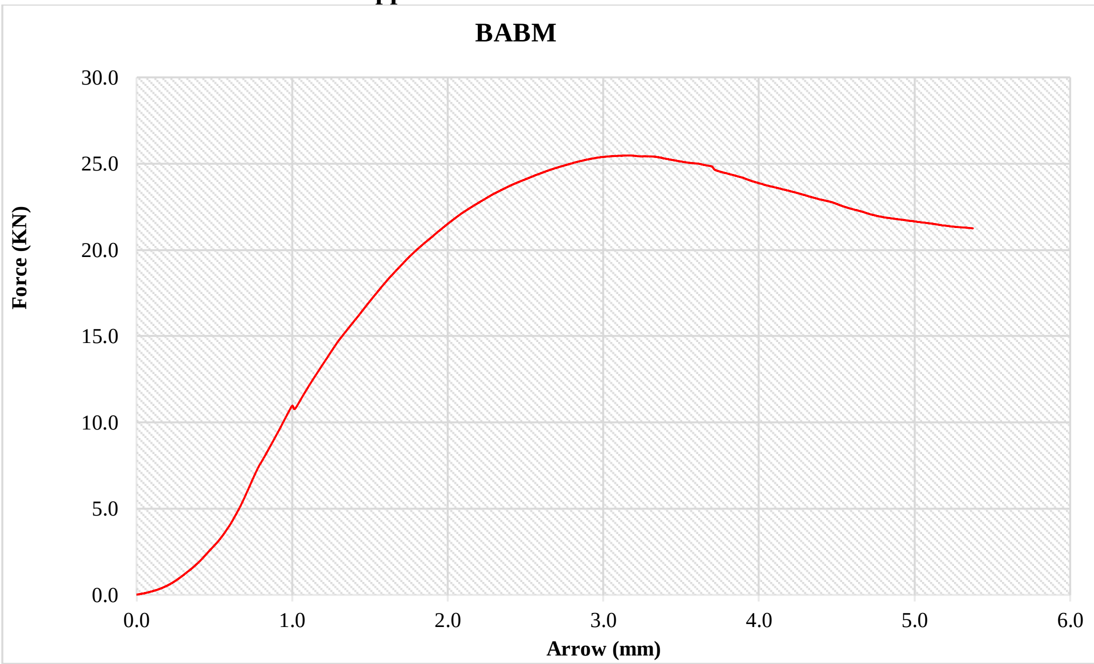

Figure 3:- Average deformation curves of beams reinforced with oppositifolius mallotus wood (4BM12); breaking load is of the order of 25.678 KN. Three-point bending test.

This curve reflects the evolution of the effort as a function of the arrow and presents two areas. A first linear domain that characterizes the elastic domain of the composite material with a maximum force of 25.6 KN (Figure 3). A second zone referring to the plastic deformation domain but which has the particularity of being almost linear showing a decrease in forces with increase in the deflection. This particularity can be justified by the difference in resistance between the two materials: concrete is in its plastic domain while oppositifolius mallotus wood continues to work in its elastic domain. This result perfectly confirms the role of reinforcement played by oppositifolius mallotus wood and thus allows the composite to develop a plastic domain and improves its bending strength by 2.4 times compared to the unreinforced beam (Table 2).

c. Reinforced concrete conventional reinforcement (iron)

Figure 4:Average deformation curves of iron-reinforced beams (4HA12); breaking load is of the order of 33.383 KN. Three-point bending test.

This curve reflects the evolution of the effort as a function of the arrow and presents two areas. A first linear domain that characterizes the elastic domain of the composite material with a maximum force of 33.3 KN. A second area referring to the plastic deformation domain. This particularity can be justified by the difference. This result shows that conventional reinforcement improves the bending strength of concrete by 3.1 times compared to the unreinforced beam (Table 2).

Tableau 2:- Test results.

DATA PROCESSING							
Ep	*F*	*MF*	*R*	*Dt*	*Md*	*RDt*	*T*
T1	10,6	10,4	1,0	1,40	1,41	1,00	44
T2	11,2			1,44			47
T3	10,4			1,39			42
BM1	22,3	25,6	2,4	2,90	3,22	2,30	91
BM2	29,7			3,08			100
BM3	24,9			3,67			116
F1	32,0	33,3	3,1	3,05	3,96	2,82	147
F2	35,4			5,29			166
F3	32,6			3,53			131

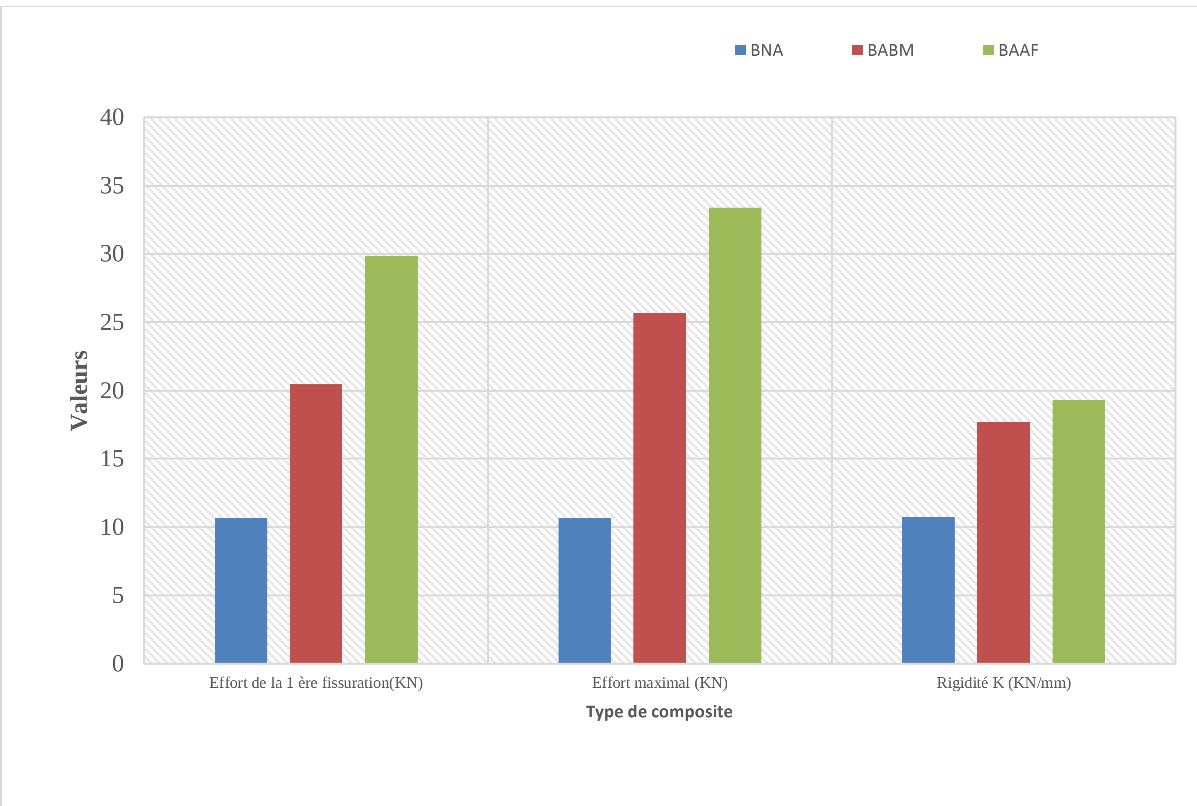

Figure 5:- Average values of the forces (in KN) of the 1st cracking, fracture and stiffness (KN/mm) of the different categories of beams.

BNA: Unreinforced concrete
BABM: Concrete reinforced with mallotus oppositifolius wood
BAAF: Reinforced concrete of conventional reinforcement (iron)

Conclusion:-

At the end of this work, we come to the conclusion that the oppositifolius mallotus wood, when substituted for iron as reinforcement in concrete, can take the place of reinforcement in beams. Although this option does not achieve the performance of the conventional material, the values obtained offer us the prospect of using this composite in the construction of short-range social housing. We therefore foresee in our future work the study of the adhesion between mallotus oppositifolius wood and concrete as well as the techniques for improving this parameter.

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References:-

1. Gérard Léopold Gbaguidi Aïsse, Victor Senouhoua Gbaguidi ; Mohamed Gibigaye, TA Amadji 2011: Study of the possibility of using the roner as a vegetal reinforcement in concrete elements: Case of beams
2. Arouna and P. Y. Adégbola: Bulletin de la Recherche Agronomique du Bénin - Special Issue 2: Economic aspects of maize storage and conservation in South Benin – September 2011
3. Damien AGAGBE 2022: Physical and mechanical characterization of oppositifolius mallotus wood for use as reinforcement in flexed parts
4. Sierra, S.E.C., Aparicio, M., Gebraad, M.J.H., Kulju, K.K.M., van Welzen, P.C., 2007. The morphological range in Mallotus (Euphorbiaceae) and a taxonomic revision of its section Rottleropsis (including Axenfeldia) in Malesia, Thailand and Africa. Blumea - Biodiversity, Evol. Biogeogr. Plants 52, 21–113. https: // doi.org / 10.3767 / 000651907x612355.
5. Tomi Lois Adetunji: Mallotus oppositifolius (Geiseler) Müll. Arg.: The first review of its botany, ethnomedicinal uses, phytochemistry and biological activities
6. Addai, E.O., 2019. Antinociceptive Activity of the Hydro-Ethanolic Extract of the Leaves of Mallotus oppositifolius (Geiseler) Mull. Arg. in Acute and Chronic Pain Models.University of Ghana.
7. Panshin, A.J., and de Zeeuw, C. 1980. Textbook of wood technology. 4th ed. McGraw-Hill, New York. 772p.
8. Scientific group composed of the eminent Professors of UAC GIBIGAYE Mohamed; GBAGUIDI Aissé ; GBAGUIDI Victor and ADJOVI Edmond (2010) In Benin, the wood rônier is the subject of research initiated within the
9. GOSSOU Y. D. 2008. Typology of subpopulations of the plant species Borassus and state of knowledge on its endogenous use as timber in southern Benin. Mémoire de Diplôme d'Ingénieur / Ecole Polytechnique d'Abomey-Calavi., Université d'Abomey-Calavi, Bénin, 104 p.
10. BLACKBURN D. 2004. The development of a constructive floor system for the urban habitat of Hanoi: the light concrete slab, Master's thesis in architecture science-Vietnam Project, LAVAL University, Canada. www.arc.ulaval.ca.
11. BOUKARY B. H. 2000. Architecture and Structure of Colonial Buildings in Historic Cities of Benin: Case of Porto-Novo in the Context of the Popularization and Promotion of Local Materials, Thesis of DIT, Polytechnic School of Abomey-Calavi, University of Abomey-Calavi, Benin.
12. BOUSSARI A. M. 2008. Physical and mechanical characterization of Borassus aethiopum Mémoire de Diplôme d'Ingénieur / École Polytechnique d'Abomey-Calavi., Université d'Abomey-Calavi, Bénin, 108 p. CABANNES Y. & CHANTRY G. 1987. The ronier and the sugar palm: Production and implementation in the habitat. France, Edition GRET, dossiers technologiques et développement, 81p.
13. DIALLO A. K., DIOP I. & SOW M. B. 1998. Problematic of the sustainable management of the rônier in the West African sub-region, Atelier technique,374p.