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IMPACT ENERGY ON NOTCHED AND UNNOTCHED SPECIMENS OF WOODEN EUCALYPTUS *GOMPHOCEPHALA* UNDER VARIATIONS OF MOISTURE

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Résumé

Le papier présente l'étude de la détermination de l'énergie d'impact sur des éprouvettes en bois d'Eucalyptus *gomphocephala*, espèce marocaine de bonne caractéristiques mécanique mais réputée par sa nervosité, qui nuit à son utilisation comme bois d'œuvre.

Dans bien des cas, le bois est exposé à subir des efforts temporaires et brusques, des chocs, des vibrations (étais de mine, glissière de sécurité, pont….). Pour certaines essences d'Eucalyptus, un retrait anormal peut entraîner un effondrement localisé des cellules du bois qui produit un collapse ou déformation apparente.

Au cours de notre étude, nous avons déterminé l'énergie absorbée par des éprouvettes avec et sans entaille, bien définies soumises à l'essai de choc Charpy, suivant différents états d'humidité à température contrôlée, par conséquent différentes variations de retrait volumétrique ont été observées.

Mots clés ***:*** *Energie de Charpy, Eucalyptus gomphocephala, Humidité, Retrait volumétrique*

Abstract

Paper presents the study of the determination of the energy of impact on wooden specimens of Eucalyptus *gomphocephala*, Moroccan species of good mechanical characteristics but deemed by his nervousness, which harms its use as timber.

In many cases, wood is exposed to undergo temporary and abrupt efforts, shocks, vibrations (pit props, crash barriers, bridges and footbridges….). For some species of Eucalyptus, an abnormal withdrawal may involve a localized failing-in of wood cells which produces an apparent deformation or collapse.

During our study, we determined the energy absorbed by notched or unnoched specimens, well defined subjected to the impact test of Charpy, under different states of moisture at controlled temperature, consequently various variations of volumetric withdrawal have been observed.

Key words: *Energy of Charpy, Eucalyptus gomphocephala, Moisture, Volumetric withdrawal*

ملخص

يقدم هذا المقال دراسة حول تحديد طاقة تأثير الصدمة على عينات من خشب الأوكالبتوس جنس gomphocephala، لصنف مغربي ذو خصائص ميكانيكية جيدة، غير أنه يعرف بعصبيته التي تمنع استخدامه كخشب أوراش.

في كثير من الحالات يتعرض الخشب لقوى مؤقتة و مفاجئة و صدمات و اهتزازات (دعامات المناجم، الحواجز الخشبية على الطرقات، الجسر...)، وبالنسبة لبعض الأنواع الأخرى من الأوكالبتوس يسبب التقلص الغير الطبيعي انهيارا محليا لخلايا الخشب والذي يترتب عنه طي أو تشوهات مرئية.

من خلال دراستنا، استطعنا أن نحدد تلك الطاقة المستوعبة من قبل العينات سواء ذات الحزات أو بدونها والتي خضعت لاختبار تأثير الصدمة Charpy في مختلف ظروف الرطوبة ودرجة الحرارة المضبوطة، والتي مرت بأشكال مختلفة من التقلص الحجمي.

الكلمات المفتاحية: الرطوبة، التقلص الحجمي، الأوكالبتوس *gomphocephala*، [illegible].

Wood is a natural renewable resource which is abundant in the majority of African and European countries; it is often employed in the civil construction industry. It is an anisotropic cellular material [1]. This material is very convenient for the design of impact energy absorbers and as core material in lightweight structures. In addition to its common usage in the structures, wood is traditionally used in the road construction, for the construction of footbridges and wooden bridges, and more recently, for the manufacture of wooden-steel crash barriers [2]. The impact resistance or impact strength is the ability of wood to absorb work by an impact bend and it characterizes the ability of material to withstand impact loads, this capacity of material to resist loads of impact is often required in many industrial applications.

The impact strength is expressed by the consumed energy for failure of wood with well defined dimensions. The aim of this work is to carry out the test of Charpy impact to examine the strength of wood at the brutal breaking, on specimen with and without notch according to the two plans RL and TL. In this work we study the aspect of the behavior of wood under such loads of impact, by taking into account the temperature variation that influences on the moisture of the wood specimen.

1. EFFECT OF PHYSICAL VARIABLES ON THE RESULTS OF IMPACT TEST

1.1. Mechanical notch form of wooden sample

The wood specimens designed for the Charpy test are manufactured in accordance with the standard B 51-003. Figure 1 shows the configuration of the specimen used.

Figure 1 : Standard specimen of Charpy Impact test

1.2. Moisture influence at controlled temperature

The temperature has a very marked effect on resistance of the impact of the notched samples. Indeed, the quality of wood lies in its properties of use. These properties depend on the state considered of the temperature and the moisture but also on the extraction way. Professionals were oriented towards the artificial drying which allows better to control the hygrothermic conditions of the drying air, the air velocity and/or the gas pressure to impose on a stack wood [6].

The wood left sufficiently in a medium where the parameters of temperature, moisture and pressure remain constant, it reaches a state of balance known as hygroscopic. The state of wood moisture and its variations play a very important part with respect to its mechanical behaviour.

The moisture of a green wood can be higher than 100%; water becomes dominating compared to the dry matter. Water moves inside the wood from the wet area towards others less wet. Anhydrous wood is, by convention a state obtained after spending 48 hours in a drying oven at 103 °C until stable mass.

Indeed the amplitude of drying time influences the development of internal stresses and the eventual appearance of cracking in wooden sample and consequently, a great variation of its mechanical properties [7].

1.3. Withdrawal influence

The water content variations, in the hygroscopic field of wood, involve dimensional variations. The wood drying consists in removing some of that water to bring it to a final content compatible with its use. To dry such material, it is necessary to supply energy to evaporate this water by a heat contribution which is traditionally done by forced convection [6].

The output steam left by wood is evacuated by a draft whose evaporating power is controlled. During this process the wood material is likely to undergo large deteriorations, prejudicial to its quality and its usual properties especially its impact bending strength.

2. MATERIALS AND METHODS

2.1. Testing machine: swinging pendulum of Charpy

We measure energy provides by an impact blow delivered through the use of dropping weight or swinging pendulum of 20Kg into wooden samples notched or not, the necessary energy to break them is given by the dial needle of the machine. We carried out these tests, at the laboratory of wooden technology at the forest research centre of Rabat. The standard swinging pendulum used is Wolpert Testor Pw15 type.

The swinging pendulum machine is located in the vicinity immediate to the drying oven to keep good precise details of the temperature and moisture regard to the energy of Charpy. The strain rate is extremely fast, the material may behave in a much more brittle manner than is observed in the static bending test. In the case of a not notched specimen, we employ the equation of the energy of impact strength :

$$R_{CU} = \frac{E}{b.h} \qquad (1)$$

With :

E : Absorbed energy by the specimen in Joules

h : Thickness of specimen in mm

b : Width of specimen in mm

For a not notched specimen, the term b is replaced by bN which represents the remaining width, at the base of the notch.

2.2. Vegetal matter

Wood that we characterized is the wood of Eucalyptus *gomphocephala*, coming from Arboretum Menager of “Maamora”, its trees are approximately 38 years old. These Eucalypts of plantation are distinguished by the extreme variability of their properties and their behaviours. However, the use to timber of most species is typically limited by technical problems that raise their first transformations.

After cutting down, slicing, sawing, edging and drying, we prepared a standard specimen (B 51-003), whose dimensions are 20x20x340mm^3 with a V-notch of 2mm in depth, an angle of 45° and a notch root radius of 0.25mm. To determine energy in the radial direction, the notch is carried out perpendicular to the rings on the semi-span of the specimen. On the other hand, energy in the tangential direction, the notch is tangent to the rings and perpendicular to fibers on the semi-span of the specimen; Figure 2. We took 12 samples per level of moisture, 6 specimens in the radial direction and 6 in the tangential direction. The moisture content varies from 0% to 30%.

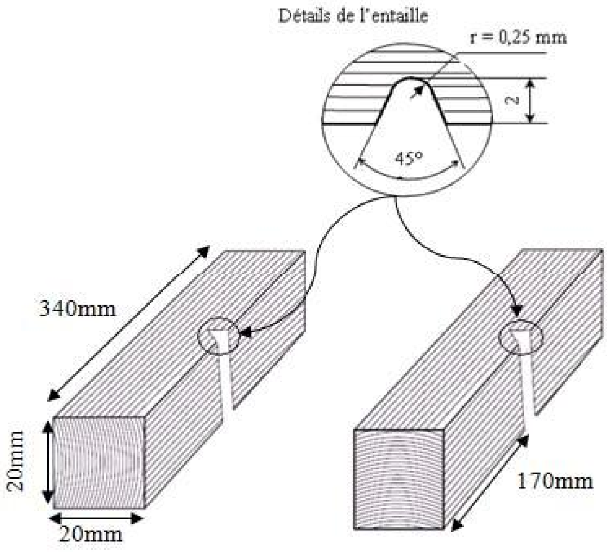

Figure 2 . Normalized specimen notched in plans RL and TL

According to the kinetics curve of the wood of Eucalyptus *gomphocephala* which we determined by measuring the mass of the similar samples each 3min in the drying oven set at 103°C, we could define the time which can still a lot of specimens in the drying oven to reach a certain moisture content.

At the beginning we put the specimens in water at 24° for a week until total saturation; table 1 gives the duration period in the drying oven according to the desired moisture content.

Table 1: *Moisture content for each lot of samples determined by the holding time passing in the oven*

Moisture (%)	Holding time in the oven
0	48h
16	Just after being dried under shelter
25	15min
20	57min
30	Saturated state

At every measure of the mass of the specimens; we take parallel measures of size (Radial, Tangential and Longitudinal) to determine the various withdrawals in order to define the influence of dimensional variation on the absorbed energy. Thus we evaluated energy by impact test on the same kind of specimen except they do not contain any defect or notch. We present hereafter the results we have obtained during this testing partner and their interpretations.

3. RESULTS QND DISCUSSIONS

3.1. Influence of moisture

Figure 3 shows the relationship between the impact energy and the moisture of specimens at each level from 0% to 30%. Moisture has a direct influence on the impact energy measured on the notched samples in the tangential E_t and radial E_r direction. The impact energy of the notched samples in the radial direction is weaker than that of the notched samples in the tangential direction.

It is found that wood is more resistant in the tangential direction i.e. in the tangent plan to the rings, when the moisture of the specimens lies between 10% and 20%. This is why drying on the wood of Eucalyptus has a great importance in order to avoid the distortions and to decrease as possible the mechanical stresses.

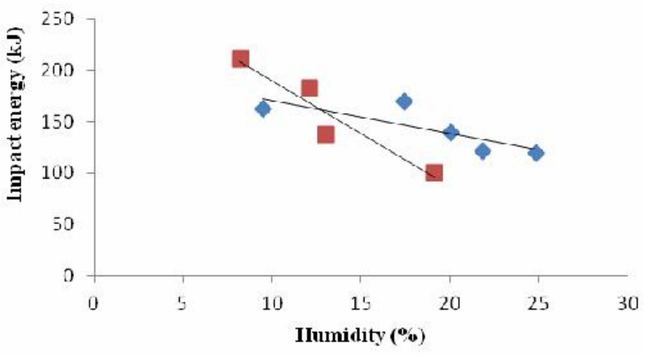

Figure 3 : Relationship between the impact energy and the moisture of the notched samples in radial and tangential direction

There on unnotched specimens figure 4, the impact energy in the tangential direction is much larger compared to that obtained in their radial direction at average moisture of 16%. Wood behaves in the axial direction as a matter fibrous, resistant, tough, rigid and hard. While in the radial direction, it behaves like a plastic matter, deformable and weak.

This explains the facility to split easily in the radial direction. We also meet a very great dispersion in the results (from simple to double sometimes) between the two directions of application of efforts, in the same individual, and according in particular to the density of the wood which remains the prevalent characteristic.

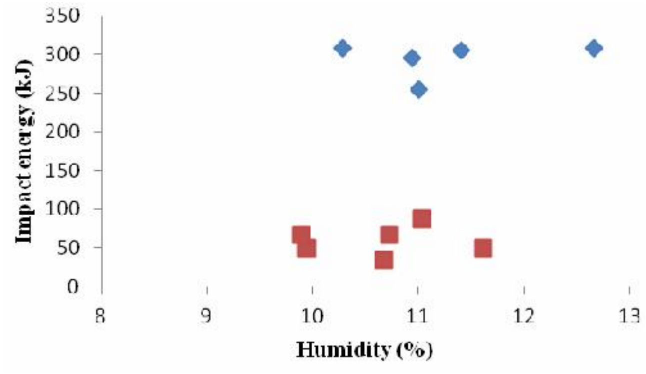

Figure 4 :. Relationship between the impact energy and the moisture of the unnotched samples in radial and tangential direction

3.2. Influence of retractibility on the impact energy

The variation of moisture below the fiber saturation point (field of dependant water) causes dimensional variations in the material appointed by the withdrawal. This property is highly dependent on material directions of wood. It is defined according to the principal directions of material: radial, tangential and longitudinal.

The experiments show that the withdrawal varies about linearly with moisture content between the fiber saturation point and the anhydrous state. Wood is a heterogeneous and anisotropic material; it offers different mechanical resistances according to the direction of the effort compared to the cross section, radial or tangential, which will be often influenced by these dimensional variations [3; 4].

Indeed, figure 5 shows that the impact energy of specimens with notches generated a significant volumetric withdrawal, especially for the notched samples in radial direction. The energy of impact is important in the tangential direction in the range between 4% and 16% of the volumetric withdrawal. Knowing that the withdrawal is the source of important dimensional variations in the tangential and radial directions, these variations induce a reduction of the inertia of the cross section of the specimen.

Consequently, the energy obtained on unnotched samples in the tangential direction is higher. From 3% of the volumetric withdrawal, the value of energy is slowly increasing for unnotched specimen of tangential or radial direction except that the energy gap between the two batches of specimen is quite outstanding in figure 6. Note from both figures 5 and 6, which dispersion of results is more significant for the values of the impact energy of wood in the tangential direction as well as the volumetric withdrawal kept the same interval of variation according to the impact energy that is for the specimens with or without notch.

From this study, wood is very resistant to the impact in its tangential direction, except that we have to permanently take care not to excessively increase the evaporation rate at the time of artificial drying in the oven, to prevent that wood suffers very large dimensional variations which could harm its mechanical behaviour.

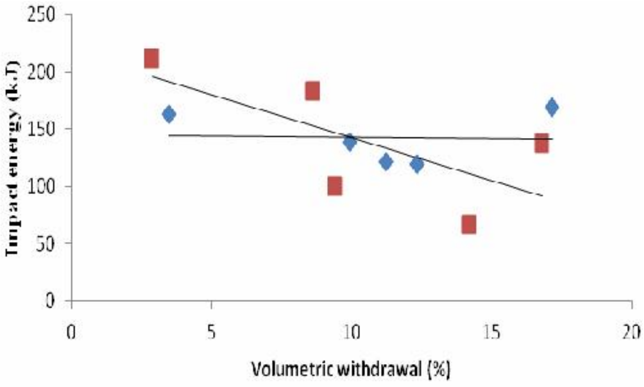

Figure 5 : Relationship between the impact energy and the volumetric withdrawal of the notched samples in radial and tangential direction

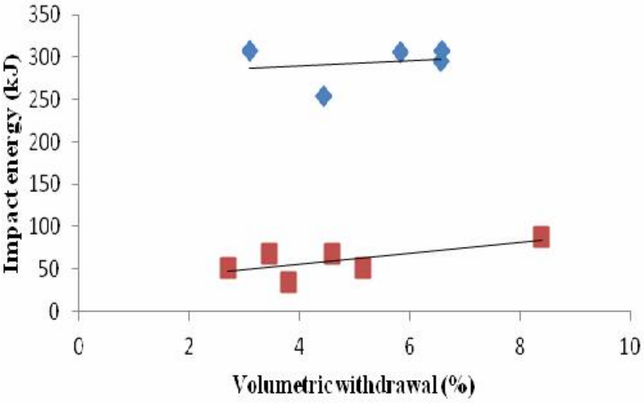

Figure 6.:. Relationship between the impact energy and the volumetric withdrawal of the unnotched samples in radial and tangential direction

3.3. Impact results on the samples

At moisture H = 30%, the notched specimens in the plan TL figure 7 (b), the rupture is flat and regular in the direction of the impact. But in the figure 7(a), the fracture is tilted in the RL plan of specimen. We also observe a bursting on the rings of growth for the notched samples in the RL plan, implying that the rupture presents a rigid and random character than that of the notched samples in the TL plan.

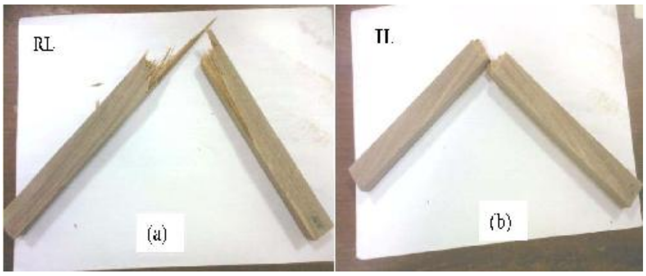

Figure 7: Disturbance of the specimens after impact Charpy test at H = 30%

With moisture H = 25%, the rupture of notched samples in the RL plan figure 8 (a) is less nervous compared to that which moisture is H = 30%, we also observe that the rupture occurred along the fiber. The notched specimens in the TL plan, figure 8 (b), have undergone a fracture flat but fibrous, demonstrating the strength of the fibers to the shock rise sharply when the humidity decreases (25%).

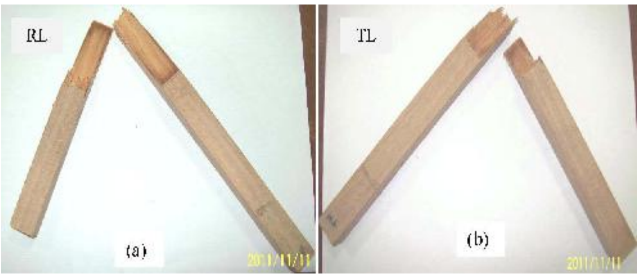

Figure 8 : Disturbance of the specimens after impact Charpy test at H = 25%

For the moisture of H = 20%, the ruptures are practically similar in both RT and TL plans, fracture occurs along the fibers and the resistance becomes higher as the humidity decreases, that is to say for the notched samples on RL plan figure 9 (a) or TL figure 9 (b).

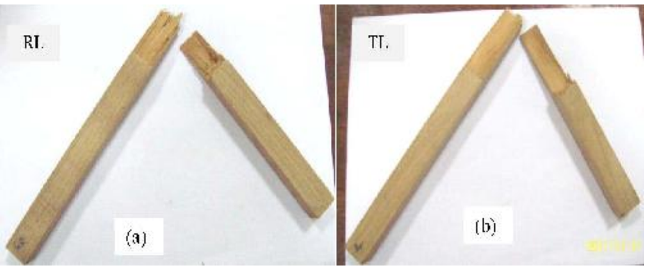

Figure 9 : Disturbance of the specimens after impact Charpy test at H = 20%

The specimens with H = 16% broke differently in both directions. The notched specimens on the RL plan; figure 10 (a), have undergone a regular failure with disrupted facies. However, the notched specimens on the TL plan failed in bursting of the rings of growth with presence of debris, figure 10(b). The two images of fig. 10, show dislocations of fibers caused by the violent rupture of specimens. The humidity 16% is the ordinary state of use of wood after a drying under shelter.

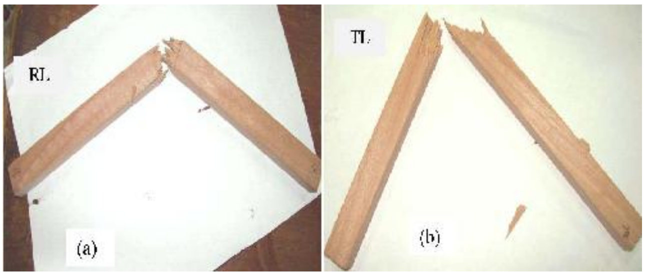

Figure 10 : Disturbance of the specimens after impact Charpy test at H = 16%

In the anhydrous state where moisture is null H = 0%, the samples of wood are strongly burst which gives rise to dislocations of fibers, and even the presence of the wood debris. On the notched specimens in the TL plan, figure 11 (b), the rupture produced along the fibers (over the whole length). But on the notched samples in the RL plan, figure 11 (a), the rupture is slightly tilted; the bursting on the rings is less violent.

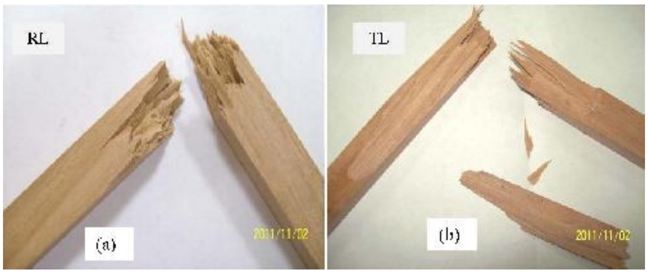

Figure 11 : Disturbance of the specimens after impact Charpy test at H = 0%

CONCLUSION

We examined the bending strength of impact at different levels of moisture 0%, 16%, 20%, 25% and 30% on V-notched samples on the semi-span and others in witness not notched.

We determined energy on the two plans RL and TL and perceive the influence of moisture and volumetric withdrawal, the most indicative parameters of the state of wood.

Knowing that the mechanical properties of wood depend on the direction in which they are observed (anisotropic material), the impact energy is strongly based on dimensional variations of this kind of hardwood [8].

The Eucalyptus wood *gomphocephala* is resilient when struck in tangential direction than in radial direction under the influence of moisture or the withdrawal.

More energy is absorbed by the wood of Eucalypts *gomphocephala* proves that it is more adapted to be usable in the structural construction exhibiting to the high load for example: pit props.

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