

# Mechanical strength and ring shake in chestnut (*Castanea sativa* Mill) wood

by Nicola MACCHIONI\*

## 1 - Forward

Ring shake is acknowledged by the most important papers on wood technology to be the most common defect of chestnut wood. Its presence is first noticeable through a gap between two consecutive annual growth which develops longitudinally along a tangential cleavage, thus greatly reducing the possibility of using the timber for its most remunerative processing (slicing or peeling) and uses (poles, beams and boards).

Although many studies have been made on ring shake from different viewpoints, concerning the most important species (see the two complete bibliographical collections of Chang - 1972 - and Cielo - 1993 -), specific research into chestnut ring shake has started to be practised on a wider scale only during the last ten years, if we are not to consider the works of Piccioli (1912) and Saya (1962). Thorough studies of how widespread ring shake is and research into the causes that trigger it off have been more recently undertaken in Italy and France, since it is in these coun-

tries that the chestnut tree, being a South European species, is mostly grown.

## 2 - Studies on chestnut ring shake

The University of Montpellier's research group began its investigations into the problems of chestnut wood defects, including ring shake, at the beginning of the eighties (Bonnetfoi et al. 1983). The same group, through various stages (Chanson 1982 and 1988, Leban 1985), followed this up by focusing their attention on the specific problem of ring shake, the results of which were drawn up in the work of Chanson, Leban and Thibaut (1989) and have remained until now the only reference point on the subject.

The same methods were used as far as possible to carry out studies of the same kind at the University of Torino (Cielo 1989).

In both cases it was established, following the hypotheses of the main causes, that two kinds of ring shake exist :

- *traumatic* ring shake, caused by a damage that in some way interferes with normal cambium activity (injury, disease, etc...);

- *"sound"* ring shake which apparently has no connection with damage undergone by the trunk.

More is known about the causes of the first form of ring shake and, after careful monitoring, the subsequent remedies to be carried out (mostly paying more attention during harvesting). Research is therefore now focused on the second form of ring shake.

Regarding "sound" ring shake, it is believed that this kind of transversal splitting is due to several factors of a mechanical nature (Chanson et al. cit.).

### 2.1 - Growth stresses

The internal growth stresses, caused by the development of the wood cells, is broken on felling the trees. Although most species of trees do not show signs of suffering from this sudden discharge of stresses, apart from an occasional small diametrical split near the pith, there are some that are made worthless by diametrical splits which almost reach the bark. The most common sign of these stresses being released in a chestnut tree, however, is found along the spring wood (that is round the porous ring) ; and the way in which ring shake is distributed longitudinally and radially suggests a relationship between the theoretical distribution of internal stresses and ring shake (Macchioni 1993).

### 2.2 - Stresses due to drying

Stress created in a piece of timber whilst losing moisture and shrinking

\* Doctorate in Wood science, external collaborator of Dipartimento di agronomia, selvicoltura e gestione del territorio, University of Torino, Italie. The study is in the sphere of a E.E.C. forest programme. Via della Villa 33/2 - 38050 Villazzano di Trento - ITALIA

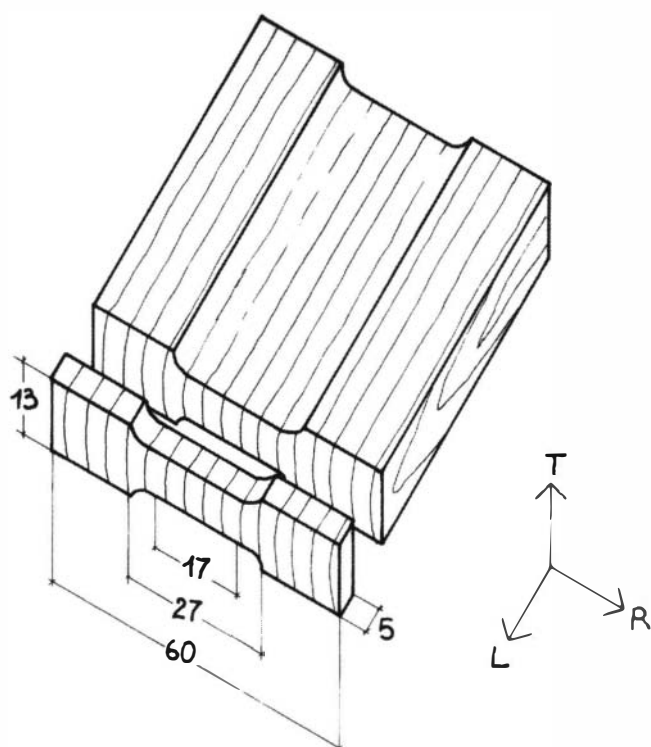
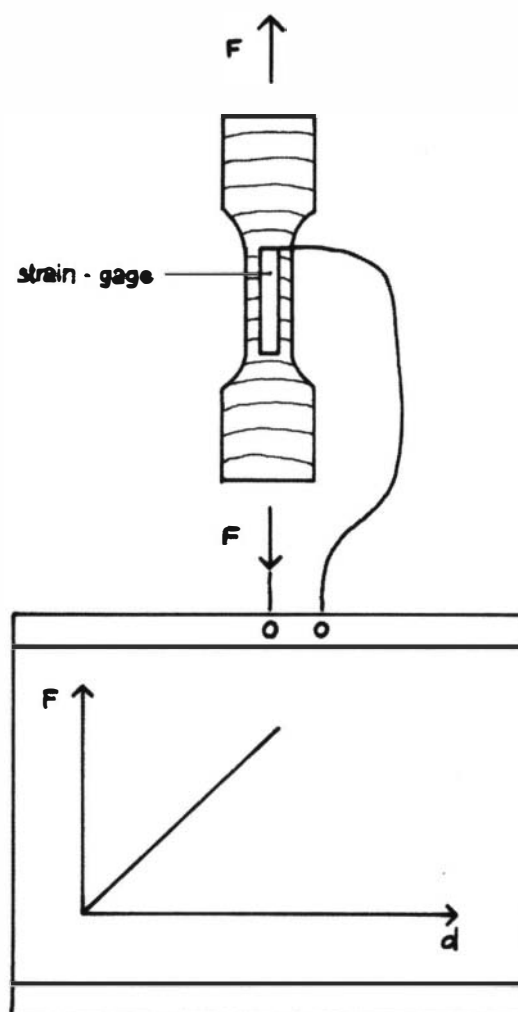


Fig. 1 : Shape of the specimen for the radial tension test (from Leban, cit.)

Fig. 2 : Position of the strain gage on the specimen for the evaluation of the ratio of deformation (from Leban, cit.)



normally causes radial splitting, starting from just inside the bark. Felled chestnut trees, however, often split in a different manner whilst shrinking in that the crack starts off radially just inside the bark, like other felled trees, but then keeps changing direction often going off at a tangent. This happens if the resistance to the splitting process is weaker tangentially than it is radially (Leban cit.).

### 2.3 - Transversal (radial) mechanical cohesion

Chestnut timber tends to split on a transversal plane both tangentially and radially, which consequently weakens its resistance to radial tension and to splits formed earlier. It must also be added that in very recent studies in the field of transversal mechanical cohesion, trunks suffering from ring shake have a lower average resistance

(Leban cit. ; Frascaria et al. 1992, Macchioni 1992).

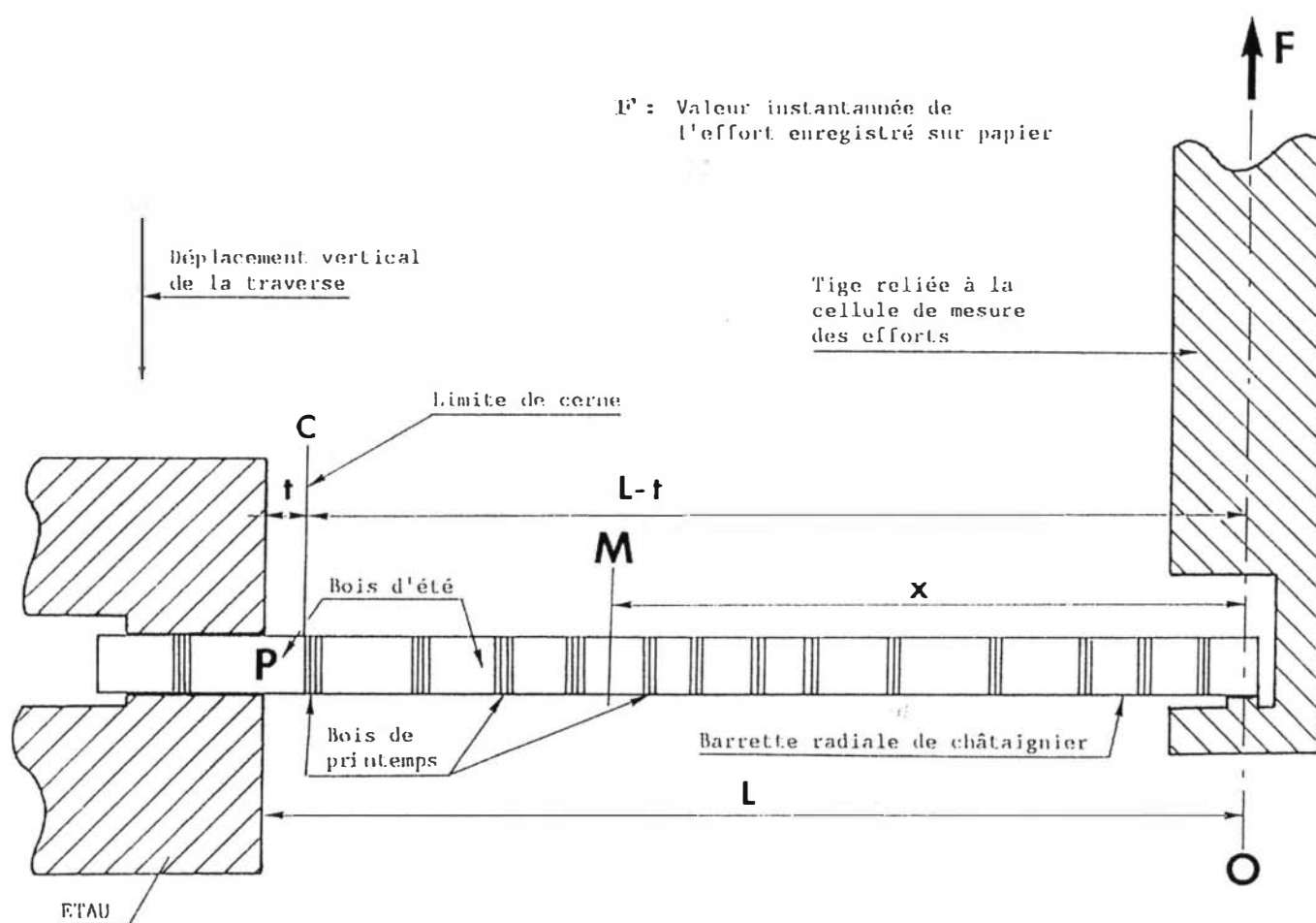
## 3 - Aim of the paper

The aim of this report is to evaluate the relationship between transversal radial cohesion and ring shake, according to the most recent reports on it, and to review the methods that have been developed to measure the above property from a mechanical point of view (the results about torsion tests are unpublished). Research in this field may make it possible to distinguish trunks with lower radial cohesion (and therefore more likely to present ring shake) from the healthy ones whilst still in the ground, if the results reached so far are backed up by the tests at present being made on a wider scale.

## 4 - Mechanical tests for measuring transversal cohesion

### 4.1 - Tension test

One of the aspects of the study of ring shake is mechanical testing to establish the characteristics of the wood's resistance to split radially and the first example is Leban's tension testing. Tests were made on chestnut shoots taken from an experimental plot in a coppice. The samples, specially shaped (Fig. 1), were cut from the bottom log of each trunk in a number of three from each log. The ratio of deformation was gauged simultaneously (using a strain gage) on the samples under stress so as to calculate the Young module (Fig. 2). Each sample provided only one element of



**Fig. 3 : Device for the radial bending test (from Frascaria et al. cit.)**

information.

The following conclusions were drawn from the results :

- variability within one trunk is small, whilst it is greater amongst different trunks regarding both the amount of stress at breaking point and the Young module ;

- the average breaking point of trees without ring shake is higher than the average of the total number of trees ; it is the exact opposite regards trees affected by ring shake.

The writer feels, however, that these results should be regarded with some caution as the use of mechanical tests does not seem sufficiently reliable as far as discriminating between trunks affected by ring shake and healthy trunks are concerned (Tab. I).

## 4.2 - Bending test

A further work (Frascaria et al. 1992) aimed at evaluating the relationship between genotype and the characteristics of radial mechanical resistanc-

ce, in order to define whether one of the most important factors regarding the appearance of "healthy" ring shake is to be considered under genetic control. Four fairly uniform radial sticks (about 15 mm wide, 8 mm thick and the same length as the radius) were cut from the same disc of shoots belonging to the same coppice. The tests were made on samples that had seasoned naturally and that were fastened at one end so as to act like a shelf. For every test, the measurements of the section at the breaking point and

of the corresponding leverage involved were taken to the hundredth with a calliper so as to calculate the maximum stress at breaking point (Fig. 3). The vise-type jointing was made to coincide with the ring area just inside a year-ring limit. Unlike the last experiment, it was possible to obtain several data from the same test material, by fixing the remaining piece of wood again after each test. The subject dealt with in this paper, which is mainly concerned with the mechanical aspect, obviously does not take into consid-

	$F_R$ (MPa)		$\sigma_R$ (MPa)		N
	Mean	St. Dev.	Mean	St. Dev.	
Ring shaken	1859	176	9,96	1,3	129
Non ring shaken	1913	206	11,51	2,51	56
Total	1875	232	11,11	2,08	185

**Tab. I : Average results of the radial tension test (from Leban, cit.)**

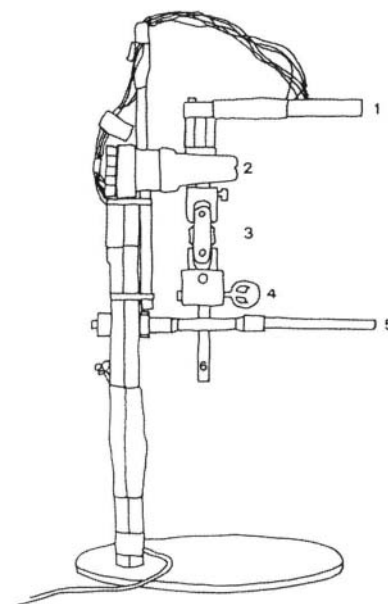
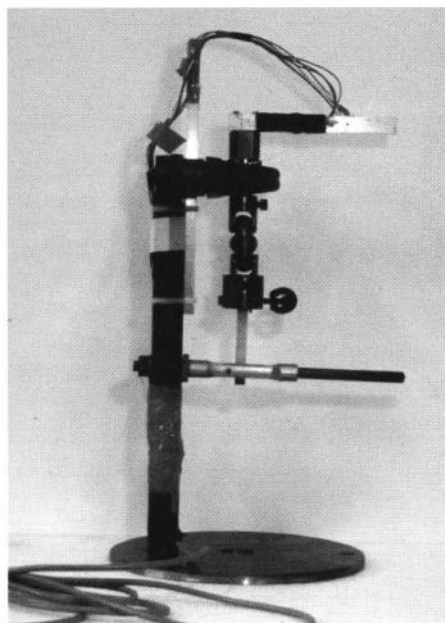
ration the techniques of genetic analysis which were used. The results obtained allowed the following conclusions :

- no particularly fragile ring edges were come across that would reveal the "ring shake years" of a trunk or a part of it ; radial breaking resistance is sufficiently stable in a shoot to be taken as a mechanical characteristic of the whole tree ;
- the histogram of the average resistance values of a shoot shows us a bimodal distribution within which it seems possible to detect a smaller number of trees that were stronger ;
- the areas of wood whose characteristics denote rapid growth or tension wood, seem to be indicative of areas with a higher rate of radial resistance ;
- the shoots from the same stump (genetically identical) have no significant differences in their breaking point value ;
- enzymatic systems may well be identifiable as characteristic of stronger trunks.

This first study, which was made on a limited number of trunks all coming from the same experimental plot, seems therefore to confirm that the radial breaking point strength on the edge of the growth ring is a functional characteristic of the tree, even if, from the results, it is still impossible to divide the sound shoots from the ring shaken ones in a statistical reliable way ; it also seems possible to state that the production of poor cohesion wood takes place under genetic control.

### 4.3 - Torsion test

The search, inside a E.E.C. Forest project, of a new kind of test that would simulate as realistically as possible the Pressler drill core and would yield several results from the same test, brought up the idea of applying a new kind of stress ; moreover was necessary to know the zone of the sample submitted to the test in which the breakage would occur. A breaking point test through torsion was thus considered suitable to satisfy the cited requirements (Macchioni 1992). A machine prototype was specially designed to give a purely torsion



**Fig. 4 : Prototype of the machine for torsion test :**  
**1 : strain gaged aluminium shelf (force transducer) ;**  
**2 : ball bearing ;**  
**3 : swivel coupling ;**  
**4 : swivelling vise ;**  
**5 : fixed vise ;**  
**6 : specimen.**

movement (and therefore a pure shear) to the sample, put in a vertical position, by applying the stress with the help of a swivelling devices for the vise jointing.

From a mechanical point of view, it is not at all possible to describe the pattern of the stress distribution within the wood substance, hence to know the position of the critical section and the value of maximum stress, since wood is ortotropic and not homogeneous. This being so, it was decided that the value to be registered would be the torque at breaking point during torsion. This was also possible due to the samples all being of exactly the same size (square section 1 x 1 cm), having been cut with a double bladed saw.

Having no bibliographic references to follow, the distribution pattern of the strength to this type of stress within the trunk had to be registered in both a longitudinal as well as radial direction.

The samples, naturally seasoned, were all taken from trunks in an experimental plot in a coppice. They all came from the trunks at five different heights.

The wide differences registered bet-

ween the breaking values in a longitudinal direction were much smaller (Fig. 5 & 6).

It is important to note that almost all the breakage point values along the radius were the same as the ones illustrated in the diagram, which are very different from the ones obtained from the bending tests, when each single sample gave homogeneous data.

The tests made to see the difference in valuation between healthy trunks and ring shaken trunks were therefore completed at only two different levels, as the differences in height on the trunks made very little change.

The results showed that all the radial breaking point values followed the same pattern, whereas the discrimination of ring shaken trunk (divided in two classes : basal and diffuse ring shaken stems ; the first one is for the trunks with ring shake only in the basal part of the stem and the second when the distribution pattern of ring shake along the stem is irregular) from the healthy ones followed the patterns of the previously made tests ; the graphs which show the pattern of values are, in fact, bimodal with a lower average of breaking point values for ring shaken trees (compared

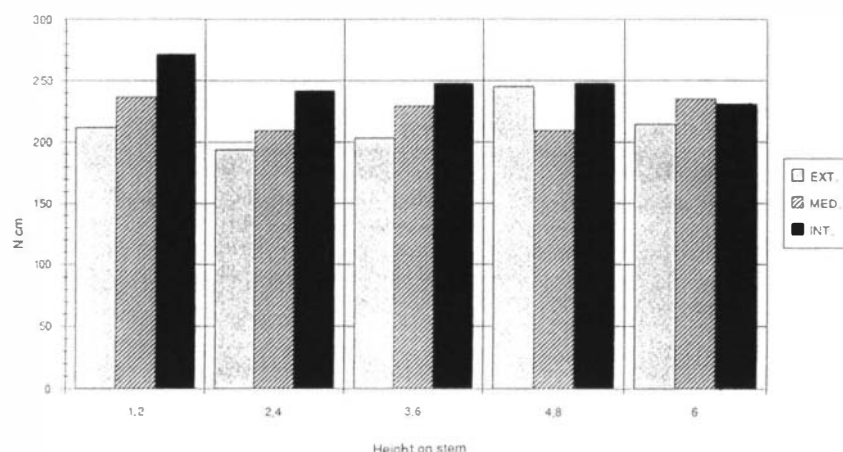


Fig. 5 : Radial breakage values distribution (mean values) for torsion test

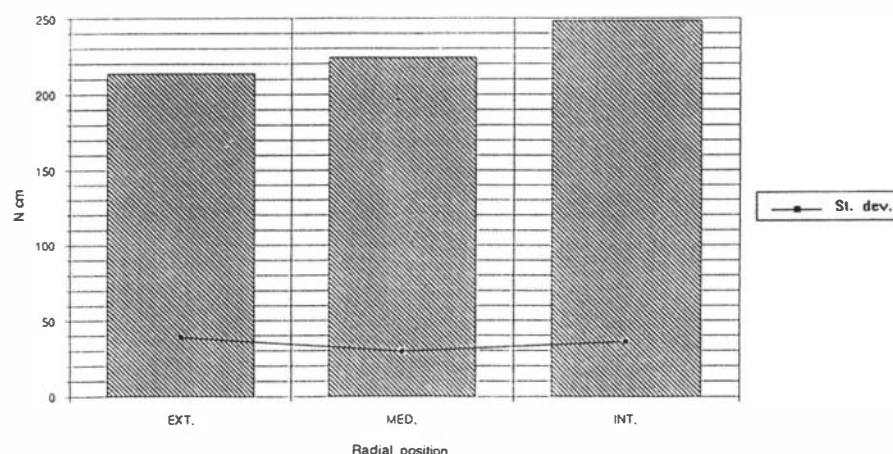


Fig. 6 : Distribution of mean torque breakage values along the stem, with radial distribution for each sampling height

to the healthy ones) without, however, allowing us to establish a discriminating set of values (Fig. 7), even if from a statistically point of view the differentiation of the two population is significant.

In order to simulate the evaluation of green wood samples, trial pieces of wood were taken from the same trunks and with the same methods as used previously and were soaked in water for 3 - 4 weeks, then to be submitted to breaking point tests by torsion. The results obtained showed that the radial breakage points within the same sample vary very little, compared to those occurring in the seasoned wood, and that the difference between average breaking points in ring shaken trees and in healthy ones is much greater (Fig. 8). It should be pointed out,

however, that the sample used was very small (43 specimens and 169 values), and that it is not absolutely certain that the fibres were completely saturated. Therefore it is necessary to repeat the test on green wood specimens, to confirm these first impressions.

## 5 - Comparison of tests types

From a mechanical point of view, it is possible to say that the methods described above lead substantially to the same answer : there is a link between radial cohesion and ring shake in chestnut wood, but since the direct field test is our final aim, we can make a comparison between the three

methods described. The points that should be considered are : the possibility to make more than one test on the same sample, in order to know the radial distribution pattern of the mechanical strength ; the simplicity of the test operations ; the feasibility of the test on a sample core ; the transportability of the whole measurement system in order to make tests in the field. For all the methods it is fundamental that the sample is tested radially, so that the growth rings are nearly perpendicular to the axis of the sample, or with a very low angle (for the torsion test, with used prototype, the limit is a 25° angle).

- The first test, that of tension, is a typical laboratory test which requires a characteristically shaped sample that allows only one test on each specimen ;

- the bending test requires a specimen that is easy to make, but at present the test apparatus is only suitable for the laboratory, even though it would be fairly simple to design a field testing machine. At present it is impossible to work with a sample core without a further sawing operation as the series of measuring after each breakage value takes a long time ;

- the torsion test requires a time-consuming preparation of the specimen, but the testing machine is very simple and easy to carry into the forest for the test operations which are very simple and not very long ;

- the mechanical interpretation of the testing methods i. e. the pattern of stress distribution within the sample during the test seems to be not so important because at present it is impossible to discern it properly, but mostly now we only need to find discriminant values ; then probably it will be sufficient to have rigorous, well - conceived testing methods that allow repetition of the test on all the samples to achieve results for the comparison.

## 6 - Conclusions and prospects

It is evident, from the results set forth, that there is a connection between ring shake and the radial mechanical properties of chestnut wood.

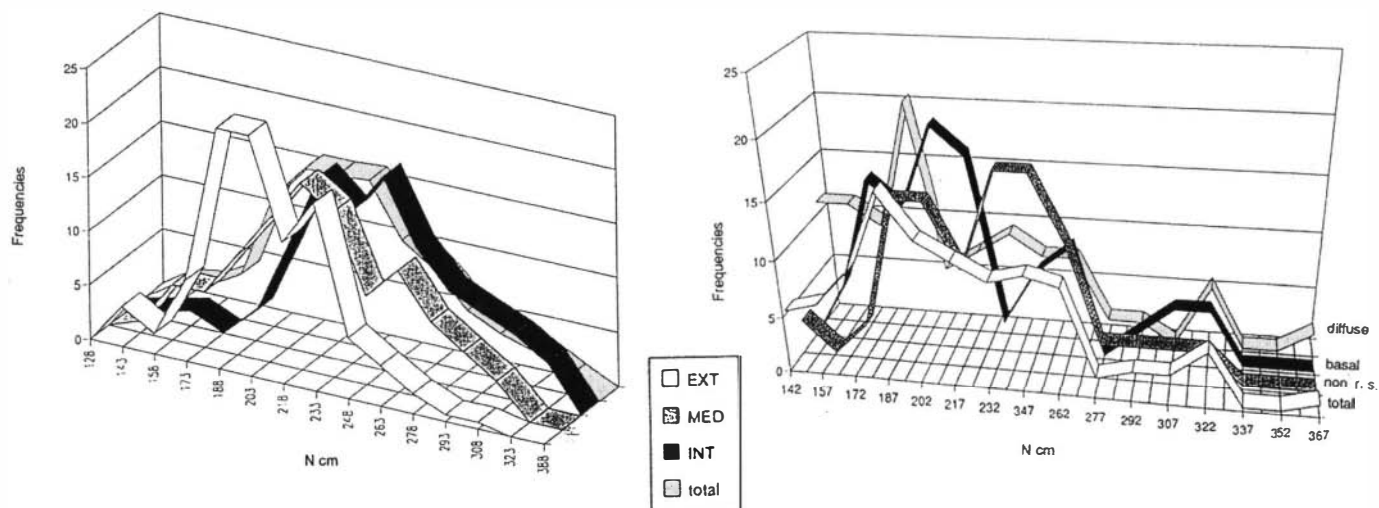


Fig. 7 : Distribution frequencies (%) of torque values for the three classes of ring shaken trees

This kind of evidence, however, does not explain the whole phenomenon. In fact the experiments carried out did not establish a statistical value of performance that distinguishes the ring shaken trees from the sound ones.

We must therefore persevere in these experiments, particularly the bending and torsion tests, in order to have new values from as many different viewpoints as possible. The goal is to establish a set of critical values that determine when we can talk of ring shake risk on a given stem, stool or stand.

At the same time other studies on genetic, soil chemistry, silviculture and growth stresses measurement must be carried on in order to have a complete screening on the several factors that affect the opening of ring shake in chestnut wood.

N.M.

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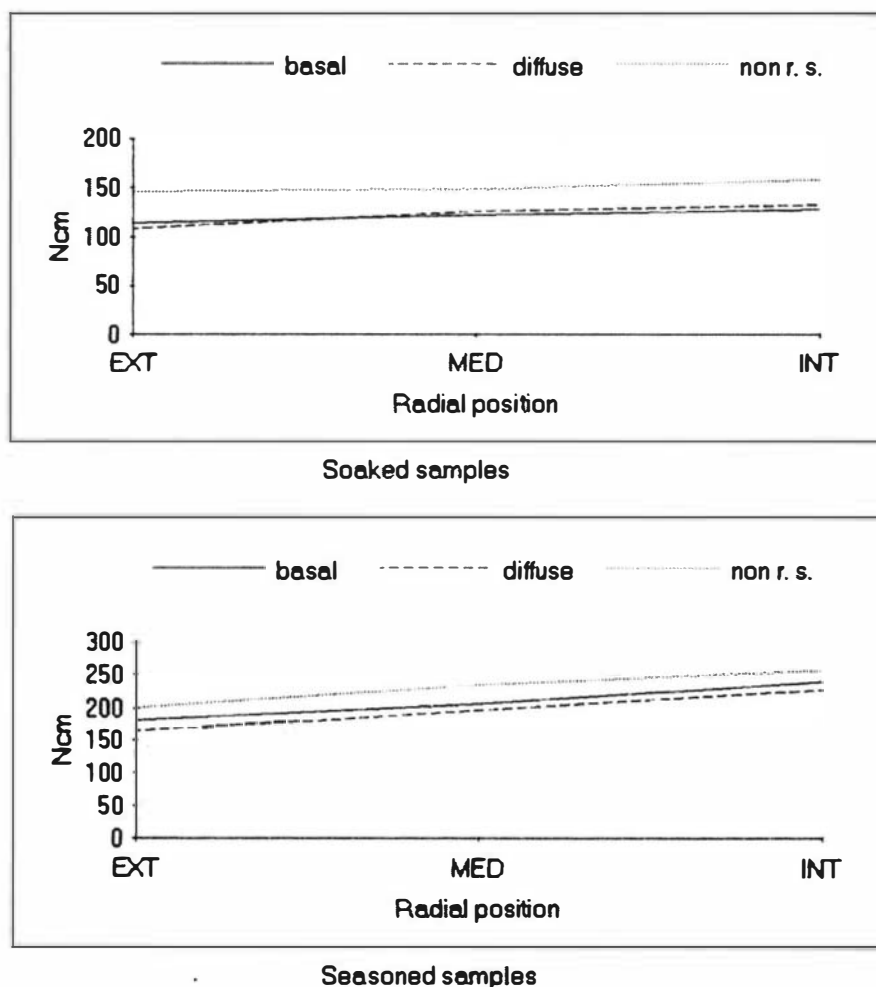


Fig. 8 : Radial distribution of average torque values for soaked and seasoned samples, and the three classes of ring shaken trees

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## Summary

### Mechanical strenght and ring shake in Chestnut

*The paper deals with an analysis of the most important studies about ring shake in chestnut wood and of the causes that nowadays the researches guess for this defect. Among these causes a particular weak mechanical strenght in the radial direction of the wood from the ring shaken trees is considered to be very important. This kind of mechanical strenght is called radial or transversal cohesion.*

*Each researcher developed his own test for the evaluation of the transversal cohesion, and found that the mean strenght valuable from the ring shaken trees seems to be lower than the mean value from the non ring shaken trees.*

*Afterwards are analysed the different types of tests, evaluating qualities and defects, and the probable implications in the course of the studies on ring shakes in chestnut wood.*

## Riassunto

### Resistenza meccanica e difetto in esame del legno di castagno

*La nota si svolge attraverso una presentazione del problema della cipollatura del legno di castagno come difetto tecnologico. In seguito vengono descritti i lavori più importanti svolti sul tema da parte di alcuni Autori francesi ed italiani. Argomento principale sviluppato è quello dei rapporti esistenti tra il difetto in esame e la resistenza meccanica del legno, segnatamente quella in direzione radiale ; vengono quindi esaminate le prove specifiche messe a punto : la prova a trazione, quella a flessione ed infine quella a torsione, che rappresenta la parte originale del lavoro.*

*Dai risultati sembra essere possibile affermare che esiste un legame tra la presenza della cipollatura all'interno*

*dei fusti e la relativa resistenza meccanica in direzione radiale, benché dal punto di vista statistico tale rapporto non risulti sufficientemente significativo. Se ne deduce pertanto che quello della resistenza meccanica non è che uno degli aspetti da tenere in conto tra quelli che si ritiene che intervengano nella formazione della cipollatura del legno di castagno.*

*Infine viene effettuato un confronto tra le tre metodologie di prova, in vista di un loro utilizzo per una prova speditiva in campo, per la valutazione del rischio di cipollatura.*

## Résumé

### Résistance mécanique et roulure du bois de Châtaignier

*Ce travail débute par une présentation du problème de la roulure du bois de Châtaignier comme défaut technologique. Ensuite on décrit les travaux les plus importants traités sur ce sujet par des auteurs français et italiens. L'objet principal de cette étude est le rapport entre la roulure et les résistances mécaniques du bois, la résistance en direction radiale en particulier. On examine donc les essais spécifiques mis au point par les chercheurs : en traction, en flexion et en torsion ; l'expérimentation de l'essai de résistance à la rupture par torsion représente la partie originale de ce travail.*

*Les résultats obtenus permettent d'affirmer l'existence d'une liaison entre la présence de la roulure à l'intérieur des tiges et leur résistance à la rupture en direction radiale, quoique cela ne soit pas suffisamment significatif du point de vue statistique. De là on déduit que la résistance mécanique n'est pas le seul facteur à considérer entre ceux qui provoquent la roulure du Châtaignier.*

*Enfin on propose une comparaison entre les trois méthodologies d'essai, en vue de les utiliser pour une expérience en forêt, dans le but d'évaluer le risque de roulure.*