17TH INTERNATIONAL NONDESTRUCTIVE TESTING AND EVALUATION OF WOOD SYMPOSIUM

APPLICATION OF ESCLEROMETER TEST METHOD IN SPECIMENS OF EUCALYPTUS SALIGNA

Julio Soriano, Raquel Gonçalves, Cinthya Bertoldo Pedroso, Alex Trinca, Monica Ruy
University of Campinas (UNICAMP)
School of Agricultural Engineering (FEAGRI)
Nondestructive Testing Laboratory (LabEND)

LABORATÓRIO DE ENSAIOS NÃO-DESTRUTIVOS

UNICAMP

-31 thousand undergraduate students (66 courses)

-16 thousand graduate students (135 Programs)

- 10% of the master's and doctoral thesis in the country.

-1,733 faculty members

-15 % of all research done in Brazilian universities

Even within the Brazilian context, in which the oldest university is 70 years old, Unicamp can be considered a young institution (only 43 years old) but has already a strong tradition in education, in research and services to society.

Context

- The esclerometer testing is a technique used for the hardness evaluation of the concrete.
- The value obtained by this method is named esclerometric index.
  - Ratio between the returned and the applied energy

However, there are little results of this technique in timber applications.

Objective

- **Analyze preliminary results of the esclerometer testing in wood as a method of inference of the compressive strength.**

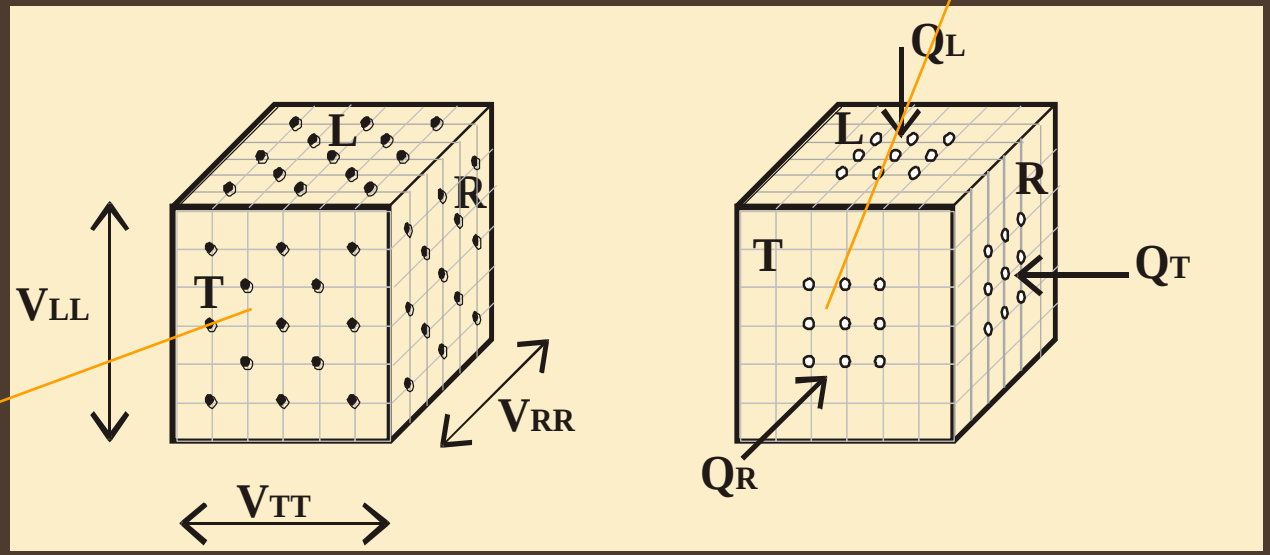
For compare the results with other nondestructive testing, were also carried out, on the same specimens, ultrasonic tests.

Sample

- Obtained from logs of Eucalyptus saligna recently felled, with 4 to 5 m length and 540 mm to 700 mm in diameter.
- 42 cubes with 150 mm for ultrasound and esclerometer tests
  - in green condition
- After Ultrasound and Esclerometer tests, 82 cubic prisms (50 mm edge and 100 mm and150 mm length) were cutting from the cubes to the compression (parallel and normal) tests according to the Brazilian Standard NBR 7190 (1997).

Specimens

9 impacts for face

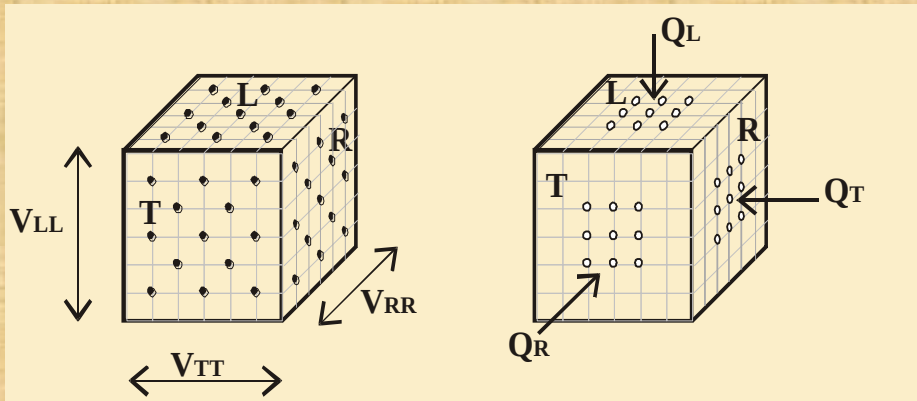


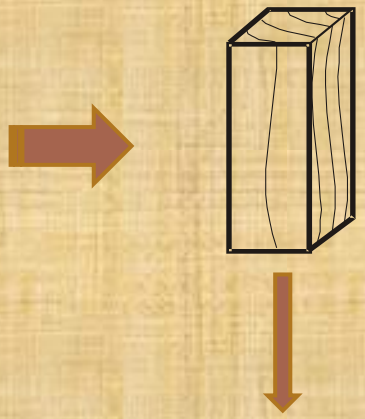
13 measurements points

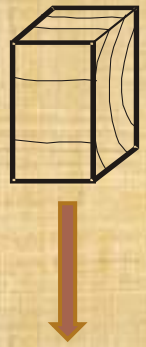
Ultrasound test

Esclerometer test

Specimens







Parallel to the grain
(50 mm x 50 mm x 150 mm)

Normal to the grain
(50 mm x 50 mm x 100 mm)

Ultrasound test

- Identification of the anatomical directions
  - Longitudinal, Radial and Tangential
- For each direction were pointed 13 positions for the ultrasound tests (39 points per cube).

USLab, AGRICEF, Brasil

45 kHz transducer

Esclerometer test

- Identification of the anatomical directions
  - Longitudinal, Radial and Tangential
- For each direction were pointed 9 positions for the impacts application with the rebound hammer (27 points per cube).

Digital Silver Schmidit, Proceq, Switzerland

Esclerometer test

- The esclerometer provide the rebound coefficient
  - Dimensionless ratio between the returned and applied energy
- To restrain the movement of the specimen during the test, the cube was fixed using a stress of near 1 MPa.

Compression test

- The compression tests, for obtainment of the compression parallel to the grain (f_{c0}) and the compression perpendicular to the grain (fc_{90}), were accomplished, according to the Brazilian Standard Normal and Parallel directions
- Universal testing machine (DL30.000, EMIC, Brazil)

Paralell

Normal

Results of the esclerometer test Specimens in green condition

Esclerometric impact	Groups 1	2	3	All groups *mean*	*s*	CV (%)	skewness	kurtosis
Q_L	30.8	28.6	25.0	28.3	3.8	13.4	-0.91	-0.24
Q_R	41.7	38.9	40.6	40.4	2.9	7.2	-0.27	-0.87
QT	39.5	39.7	41.0	40.1	2.9	7.1	-2.0	-0.19

The lower value was obtained in the longitudinal direction.

Results of the ultrasound test Specimens in green condition

Velocity of Waves propagation	Groups			All groups				
	1	2	3	mean	s	CV (%)	skewness	kurtosis
V_{LL} (m.s^{-1})	3838	3824	3629	3762	178	4.7	-1.71	2.42
V_{RR} (m.s^{-1})	1851	1805	1491	1721	166	9.7	-1.98	-1.54
V_{TT} (m.s^{-1})	1660	1661	1487	1605	90	5.6	-1.37	-1.53

As expected, the velocity in longitudinal direction has the maximum value followed by the velocity in radial direction and finally the velocity in tangential direction. These results are in according with the bases of ultrasonic wave propagation in wood.

Results of the compression tests Specimens in green condition

Compression strength	Groups			All groups				
	1	2	3	mean	s	CV (%)	skewness	kurtosis
f_{co} (MPa)	46.3	46.0	32.2	41.7	7.0	16.8	-1.55	1.99
f_{c90} (MPa)	11.9	9.9	6.4	9.5	2.42	25.5	-0.67	-1.63

Table from NBR 7190 (1997) for Eucalyptus saligna indicates f_{c0} = 46,8 MPa and is expected 11,7 MPa for f_{c90}

Results of the Multiple Range Test

	Count	*Average*	*Homogeneous Groups**
Esclerometer			
L	41	28.2	A
R	41	40.1	B
T	41	40.4	B
Ultrasound			
L	41	3762	A
R	41	1721	B
T	41	1605	C

Results of the Regression analysis

Model	R	R^2(%)	P-value
$f_{c0} = 10.2 + 1.12Q_L$	0,60	36,6	0.00000
f_{c90} x Q_R	-	-	0.62*
f_{c90} x Q_T	-	-	0.07*
f_{c0} x V_L	-	-	0.45*
$f_{c90} = -12.7 + 0.01V_R$	0.89	78.6	0.00000
$f_{c90} = -24.4 + 0.02V_T$	0.80	64.4	0.00000
Q_L x V_L	-	-	0.19*
Q_R x V_R	-	-	0.85*
Q_T x V_T	-	-	0.18*

Conclusions

- The esclerometer test was able to distinguish properties in longitudinal and normal (radial or tangential) directions, but not between radial and tangential directions.
- There was a correlation between the esclerometric impact in longitudinal direction and the compression strength parallel to the grain, but not for the esclerometric impact in radial or tangential directions and compression strength normal to the grain.
- There was no correlation between the esclerometer and the ultrasonic tests in any direction.
- More tests with esclerometer must be conducted with other species, to allow more conclusive results about the application of this method in timber.

ACKNOWLEDGMENTS

FAEPEX-UNICAMP for the financial support

Wood NDT Organizing Committee for the opportunity.

You, for your attention!

Raquel Gonçalves
raquel@agr.unicamp.br