17TH INTERNATIONAL NONDESTRUCTIVE TESTING AND EVALUATION OF WOOD SYMPOSIUM

# JANKA AND ESCLEROMETER METHODS TO PREDICT THE HARDNESS OF EUCALYPTUS SALIGNA

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LABORATÓRIO DE ENSAIOS NÃO-DESTRUTIVOS

# Context

- **Hardness** is an important property for applications in furniture and in floors.
- The Brazilian standard establish the test to determine the wood hardness
  - based on the force required by static loading to embed a steel hemisphere with a 100 $mm^2$ cross section
- Janka is a test easy to do in laboratory but directly in the field its is difficult to obtain accurate results.

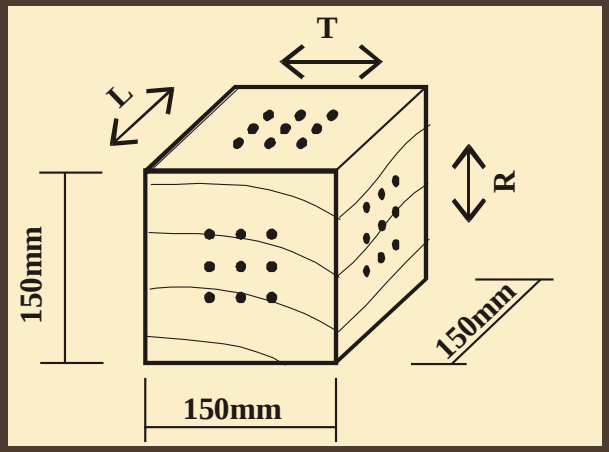
# Objective

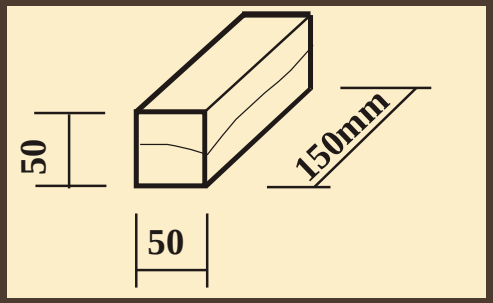
Evaluate experimental results obtained by application of the esclerometer and Janka tests in wood.

# Sample

- Obtained from logs of Eucalyptus saligna recently felled
- 84 cubes with 150 mm edges
  - 42 tested in green condition
  - 42 tested in equilibrium moisture content
- After Esclerometer tests cubic prisms (50 mm edge and 150 mm length) were cutting from cubes  to the Janka hardness tests according to NBR 7190 (1997).

# Specimens




Esclerometer test

Janka test

# 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).

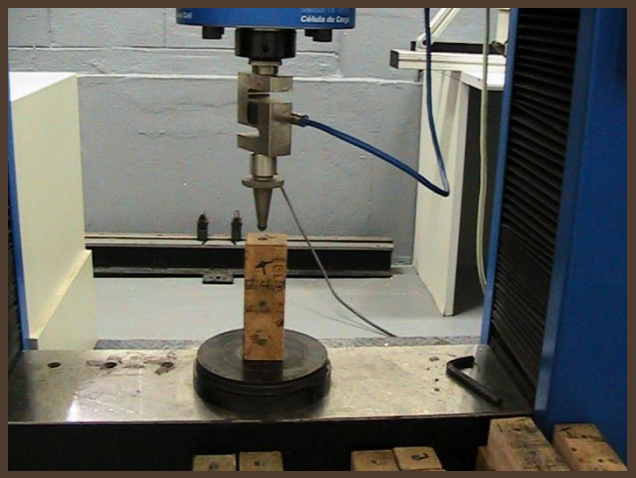
Digital Siver Shmidit, Proceq, Switzerland

# Esclerometer test

- The esclerometer provide the rebound coefficient
  - 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 1 MPa.

# Janka test

- Determining the force for half-sphere (with cross section of 100 $mm^2$) to be embedded in the specimen
  - Normal and Parallel directions
- Universal testing machine (DL30.000, EMIC, Brazil)



End hardness

Side hardness

- Radial
- Tangential

# Results
# Specimens in green condition

| | Esclerometer | | | *Janka [N]* | | |
|---|---|---|---|---|---|---|
| | *Direction* | | | | | |
| | *L* | *R* | *T* | *L* | *R* | *T* |
| | | | **Log 1** | | | |
| ***mean*** | 30.8 | 41.7 | 39.5 | 5610 | 5780 | 6224 |
| ***s*** | 2.5 | 3.4 | 3.9 | 291.0 | 450.4 | 265.9 |
| ***CV* [%]** | 8.1 | 8.2 | 9.9 | 5.2 | 7.8 | 4.3 |
| | | | **Log 2** | | | |
| ***mean*** | 28.6 | 38.9 | 39.7 | 4753 | 5458 | 5402 |
| ***s*** | 2.9 | 2.8 | 2.5 | 325.8 | 255.5 | 417.0 |
| ***CV* [%]** | 10.0 | 7.2 | 6.4 | 6.9 | 4.7 | 7.7 |
| | | | **Log 3** | | | |
| ***mean*** | 25 | 40.6 | 41.0 | 3351 | 4129 | 3837 |
| ***s*** | 3.6 | 1.6 | 1.5 | 487.7 | 394.3 | 1004.5 |
| ***CV* [%]** | 14.5 | 3.9 | 3.6 | 14.6 | 9.6 | 26.2 |

- For both tests the lower value was obtained in the longitudinal direction.

- For both tests there is a statistically significant difference among directions, but the multiple range test shows that there are no differences between radial and tangential directions

- Only in the longitudinal direction there is a statistically significant relationship between Janka and esclerometer results with R = 0.71

# Green condition

- For this moisture content , results obtained for Janka tests in Brazil for 8 species from Central Amazonia* shows that for species with densities close to the Eucalyptus tested in this research presented similar results.
  - In longitudinal direction the Janka values are bigger than in the radial and tangential directions

*Silva Filho, Rocha, Moura.

# Green condition

- Kollman and Coté (1968) indicates in a publication of USDA a good correlation between Janka Hardness and modulus of elasticity in bending and compression parallel  to the grain but not between Janka and MOR.

# Results
# Specimens in equilibrium moisture content

| | *Esclerometer* | | | *Janka [N]* | | |
|---|---|---|---|---|---|---|
| | *Direction* | | | | | |
| | ***L*** | ***R*** | ***T*** | ***L*** | ***R*** | ***T*** |
| | | | **Log 1** | | | |
| *mean* | 33.0 | 43.5 | 43.3 | 9325 | 7213 | 7169 |
| *s* | 1.7 | 2.0 | 1.6 | 1771.6 | 2483.9 | 1270.0 |
| *CV* [%] | 5.1 | 4.5 | 3.6 | 19.0 | 34.4 | 33.1 |
| | | | **Log 2** | | | |
| *mean* | 28.3 | 38.8 | 40.8 | 8766 | 6830 | 6698 |
| *s* | 1.7 | 1.7 | 1.0 | 608.4 | 387.2 | 413.5 |
| *CV* [%] | 6.0 | 4.3 | 2.6 | 6.9 | 5.7 | 6.2 |
| | | | **Log 3** | | | |
| *mean* | 28.8 | 37.7 | 39.6 | 7587 | 5359 | 5179 |
| *deviation* | 1.7 | 2.1 | 2.7 | 522.9 | 292.4 | 384.4 |
| *cvar* [%] | 5.8 | 5.5 | 6.7 | 6.9 | 5.5 | 7.4 |

- For the esclerometric impacts the lower value was obtained in the longitudinal direction but for the Janka test the values in longitudinal direction are bigger than radial and tangential directions.

- For both tests there is a statistically significant difference among directions, but the multiple range test shows that there are no differences between radial and tangential directions

- Although for all directions there is a statistically significant relationship between Janka and esclerometer results (P-value < 0,05) the correlation is very weak (R= 0.38, 0.39 and 0.45)

# Results
# Specimens in equilibrium moisture content

- The same behavior for Janka test was reported by other Brazilian authors* for wood in equilibrium moisture content using 8 hardwoods species from Amazonia.

*Silva Filho, Rocha, Moura.

# Results
# Influence of moisture content

- The decrease of the moisture content from green to equilibrium condition caused an increase in values of Janka hardness of the 86.0, 25.7 and 22.4% for the longitudinal, radial and tangential directions, respectively
- For the esclerometric coefficient, the increase with decrease of moisture content is less evident
  - The increase of the longitudinal coefficient with decrease of moisture content was only 7%.
  - The statistical analysis demonstrated that only in the longitudinal direction the values in green and equilibrium content are statistically different.
- The regression analysis showed weak correlation between values obtained in green and equilibrium conditions.
  - In longitudinal direction the coefficient of correlation (R) was 0.43 for esclerometer and R = 0.44 for Janka.

# Conclusions

- In longitudinal direction and in green condition there is a moderately relationship between the two methods.
- In radial and tangential directions for green condition and for all direction in equilibrium moisture content, there are no correlation between the two methods.
- Both methods are able to detected differences between hardness in longitudinal and normal directions, but none are able to detected differences between hardness in radial and tangential directions.
- Janka hardness is much more affected by the moisture content than the esclerometric coefficient and both are more affected in longitudinal direction.

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**You, for your attention!**

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