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METHODOLOGY TO ANALYZE THE DEGRADATION OF STRUCTURAL TIMBER IN ACIDIC ATMOSPHERES

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Figure 1: *Active volcanoes in Costa Rica rsn.ucr.ac.cr (2017)*

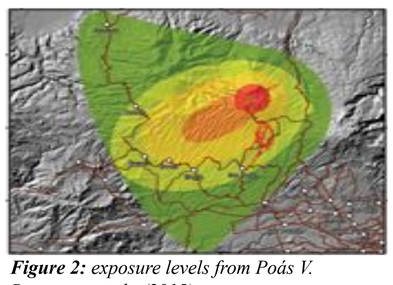

Figure 2: *exposure levels from Poás V. Barrantes et al., (2015).*

Figure 3: *Multirae SO_2 gas detectors.*

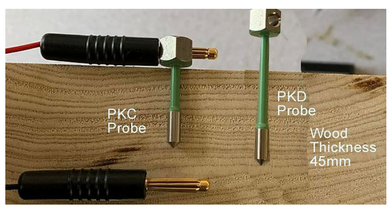

Figure 4*: Internal climate monitoring Lignomat*

Figure 5: *Sensor monitoring on-site*

Figure 6: *Ultrasound test NDT.*

Figure 7: *Structural size bending test.*

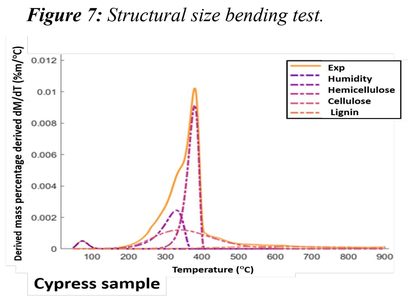

Figure 8: *Thermogravimetrically analysis*

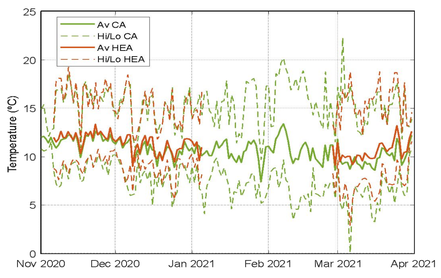

Figure 10: *Temperature profile in HEA*

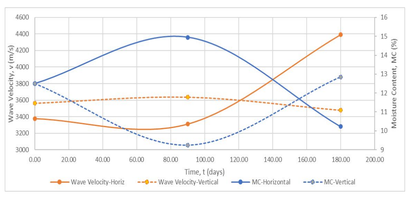

Figure 11: *MC, Wave Velocity HEA 6months*

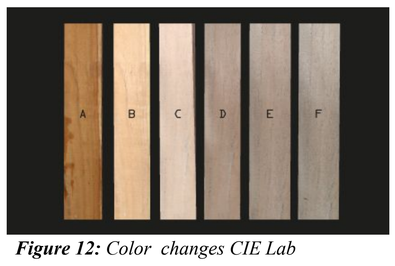

Figure 12: *Color changes CIE Lab*

The aim of this research is to propose a "methodology to analyze structural timber degradation in acid atmospheres caused by volcanic activity in CR. The importance of this project cannot be overlooked, for three main reasons: these environments accelerate natural degradation. Also, it has been found that wood shows a slow degradation in corrosive conditions for metals. Finally, literature on studies of wood degradation in volcanic atmospheres is nonexistent - as far as the authors are concerned-. For these reasons, outdoor wood degradation with field studies should be determined.

METHODOLOGY

Technical guidelines of wood degradation had been considered as well as the inclusion of the phenomena of acidic fiber degradation in order to identify its impact on mechanical properties.

Outdoor exposure site Different acid pollution levels were considered, 3 sites considering, high exposure area (HEA), intermediate exposure area (IEA) and a control area (CA) related to volcanic activity.

Environmental acidity Acidic atmosphere was characterized considering the weather parameters, acidity of rain (placing fog and rain collectors) Sulphur gases SO_2 and H_2S detection measured through constant monitoring.

Timber selection of commercial species from forestry plantations teak (*Tectona grandis*) and cypress (*Cupressus lusitanica*), specimens' dimensions corresponding to fulfill the requirements of standards test (ASTM D-198, ASTM D-143). Experimental units were defined above ground, exposing specimens in 2 position (horizontal and vertical) facing south. The methodology could be described in two lines:

1) **On-site analysis,** ultrasound wave velocity and colorimetric changes (CIELab system)

2) **In laboratory analysis** considers two scales:

A) Microscopic effects by internal climate monitoring controlling density and compositional changes.

B) Macroscopic changes measured on mechanical properties. Combining: Non destructive technique Ultrasound test and bending test to obtain dynamic and static elasticity modulus E_{dyn} and E_{st} respectably. Before laboratory tests specimens were acclimatized in a room with controlled conditions to obtain best performance. Young modulus and chemical composition changes are the response variables.

Preliminary results – discussion

Initial parameters were E_{app} 11.17± 0.67Gpa for Cypress, and 14.78± 0.79 GPa for Teak; and E_{dyn} 10.21± 0.34 GPa for Cypress and 15.88±0.55 GPa for Teak. For both species, an appreciable decreasing in the E_{app}, and E_{dyn} values at 90 days and then at 180 days was observed. Cypress E_{dyn} decreased in average 2.2±0.68 GPa and 2.1±0.31 GPa for Teak. For both species, an appreciable decreasing in the E_{app}, and E_{dyn} values at 90 days and then at 180 days was observed. Cypress E_{dyn} decreased in average 2.2±0.68 GPa and 2.1±0.31 GPa for Teak.

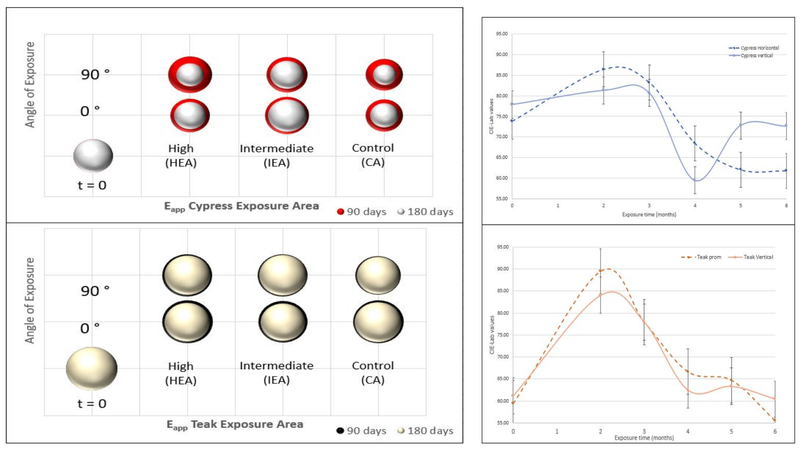

Figure ***13.*** *Cypress E_{app} and E_{dyn} decreased during 180 day of exposure CIE-Lab color 6 month of exposure Teak (left) and Cypress (right).*

An estimated decline rate of 5-7% in E_{dyn} and 8-11% in E_{app} was found. A tendency of 3% more decrease in Cypress than in Teak was documented. The ultrasonic wave velocity and E_{dyn} were sensitive to environmental conditions, and changed as a function of species and exposure time. Even though the reduction in the elastic modulus is appreciable in both species, Teak is more resistant to the environment than the softwood, Cypress, unless so far this report had been carried out. Therefore, the degradation impact shall be more noticeable in three years to comply with this methodology.

Conclusions

A methodology to analyze the degradation and performance of structural timber in acidic atmospheres was successfully established.

It was obtained a decline rate of 5-7% approximately in E_{dyn} and 8-11% in E_{app}, respectively, due to timber degradation in acidic atmospheres.

E_{app} decreased 2.43% more than E_{dyn} in horizontal position than vertical position, and 2.71% more in Cypress than in Teak. Both modules significantly decreased in HEA compared to IEA and CA.

The acidic atmosphere remained between 0.5ppm and 1 ppm of SO_2 gas concentration, with some higher concentration points during the study period. It affected the rain, dropping-down the pH to 3.92. Thus, it is anticipated the potential influence of the volcanic environment that can act in the wood materials.

Significant modification of color on average ΔE 12.67 for Cypress and ΔE 17.24 for Teak were registered; further analysis is required to understand the correlation of color changes with other factors.

The challenge of not isolating degrading agent's contributions must be considered since they are according to the campaigns (exposure periods) with the expected environmental conditions variability. For that reason, research data leading to aging, weathering, degradation, or decay, from this research cannot be easily compared to another context. Consequently, more control to complement with assays in a degradation chamber for further dynamic mechanical analysis DMA investigation may be considered.

Main references

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