PROPERTIES OF ORIENTED STRANDBOARDS (OSB) UNDER DIFFERENT TECHNOLOGICAL CONDITIONS AND THE USE OF ACOUSTO-ULTRASONICS IN THEIR TESTING

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ABSTRACT

ORIENTED Strandboard (OSB) is a nonveneered composite panel that has been developed recently to perform as a structural replacement for plywood in house construction.

This dissertation investigate the use of aspen strands (Populus tremuloides) and paper birch strands (Betula papyrifera) in manufacturing laboratory scaled OSB under different technological conditions. Aspen as a low-density species is well known to be suitable for OSB industry, while birch as a medium-density species is less acceptable for the same purpose. However, the objective of this work was to maximize the use of paper birch in the core layer of OSB having aspen in the face layers without much loss in the strength and dimensional stability properties. To achieve this object, three phases of experiments were performed as the following:

1. At the first phase, single species boards were made to represent the basic properties of pure species at two density levels (650 and 750 kg/m^3), and three different board orientations (oriented, 3-layers, and random oriented boards). The results of this experiment revealed that pure aspen boards were mechanically superior and more dimensionally stable than the birch boards at the same technological conditions, and high density boards are superior to low density ones. In parallel direction, oriented boards had the highest bending strength values and the lowest linear expansion values, followed by the 3-layers boards and random boards at the same technological conditions.

2. At the second phase, 3-layer boards of mixed species were designed with aspen strands in the face layers and birch in the core layer at three different face to core ratios (50:50, 60:40, and 70:30). The objective of this experiment was to maximize the use of birch strands in the core layer. The results of this phase indicated that the boards with 70:30 face to core ratio were higher in bending strength properties than the other two ratios and almost equal to all aspen 3-layer boards. These results revealed that paper birch would be an excellent substitute to aspen in the core layer of OSB having a 3-layer board design.

3. At the third phase, boards were designed to improve the core properties for the boards having 70:30 and 60:40 face to core ratios. Improving the core properties included random orientation of the core strands and increasing the resin level from 4% to 5% in the core layer. The results of this phase revealed that this technique might improve the internal bond property up to 20-25% than the oriented core boards.

The multiple-regression analysis approach was used to determine the most effective variables that control the behavior of each of the OSB mechanical and dimensional stability properties. The analysis showed that increasing the board density, and orienting the strands in the face and core layers parallel to the longitudinal axis of the board were the most important variables to improve both modulus of rupture and modulus of elasticity properties. For the internal bond, increasing both the strand thickness and resin level in the core layer, and increasing board density would improve this property.

Regarding dimensional stability properties, orienting the core strands parallel to the longitudinal axis of the board, increasing face to core ratio, and using aspen strands in the face layers would reduce the linear expansion property. For water absorption, increasing both the board density, strand thickness and resin level in the face layer would improve thisk property, while increasing the strand thickness and resin level in both face and core layers and increasing the board density would reduce the thickness swelling property.

Acousto-ultrasonic (AU) as a new non-destructive technique for testing materials was used and evaluated in testing the manufactured OSB. Single species boards under different technological conditions were selected and tested. The results showed that acousto-ultrasonic signal features of root mean square of voltage (RMS), area under time domain (AT), and the maximum peak amplitude under time domain (MPAT) were the best parameters that could be regressed with a specific change in the OSB design. For example, both of RMS, AT, and MPAT can detect the difference between the three resin levels of 2, 4, and 6% Phenol Formaldehyde in bending strength samples. The possible explanation for detecting such differences between resin levels is the wave reflections caused by weak bonds (or the less contact areas between the strands) in the case of lower levels of resin.

Au-signal features of RMS, AT, and MPAT also can distinguish between two different levels of density (650 and 750 kg/m^3), or two different species (aspen and birch), and/or different strand thickness if the other technological parameters were held constant. These variations in the signal waveform can be explained by the amount of the partial reflections in the signal path caused by the tiny voids or lower compaction (in case of the lower density boards), or by the thicker strands (in case of the thick strands). The partial reflections in the signal path also can be caused by the natural variations in the morphology of wood elements (in case of different species).

RMS, AT, and MPAT also can detect the difference between different strand orientations or different transmission angles across the board. The difference in the amount of the cell wall material between the radial and tangential directions of the strands, and the grain angle may affect the signal path and thus cause significant variations on the features of the received signal.