DEVELOPMENT OF SOUTHERN PINE CROSS-LAMINATED TIMBER FOR BUILDING CODE ACCEPTANCE

Daniel Hindman\(^1\) and John Bouldin\(^2\)

**ABSTRACT:** The current interest and growth of cross laminated timber (CLT) products has spurred interest in the manufacture of CLTs in the United States. The purpose of this paper is to explore the development of CLT materials from southern pine lumber commonly available in Virginia. A 5-layer CLT panel has been constructed using No. 2 southern pine lumber. Evaluation of mechanical properties, fire performance and acoustical performance were conducted. Results of these evaluations can guide the development and acceptance of CLT products in the International Building Code.

**KEYWORDS:** Cross-Laminated Timber, CLT, Southern Pine, Mechanical Properties, Fire Testing, Acoustic, Vibration

1 INTRODUCTION

Growing interest in the use of cross-laminated timber (CLT) products has increased in the United States, as evidenced by recent publication of a product standard, ANSI/APA PRG-320 [1] and the production of a United States version of the *CLT Handbook* [2], originally published in Canada [3]. As of the writing of this paper, at least one manufacturer (Smartlam Technologies Group in Whitefish, Montana) is currently producing CLT product [4].

While the sustainable aspects of CLT have been well established compared to competitive products, there is a desire to increase the manufacture of CLTs as a regional practice, accessible through many green building systems in the United States. The Leadership in Energy and Environmental Design (LEED) suite of green building certification systems recognizes a regional material credit, intended to “increase demand for building materials and products that are extracted and manufactured within the region, thereby supporting the use of indigenous resources and reducing the environmental impacts resulting from transportation.”[4]

Currently, in Virginia and the Southeastern United States, southern pine lumber represents the dominant wood resource available. The southern pine lumber group consists of loblolly pine (*Pinus taeda*), longleaf pine (*Pinus palustris*), shortleaf pine (*Pinus echinata*) and slash pine (*Pinus elliottii*) [5]. With the downturn in the United States housing market, many landowners have been examining other options for using southern pine lumber in forest products. While the housing market is starting to rebound, there is also pressure from trees damaged by the southern pine beetle to bring these products to harvest soon [6].

The purpose of this project was to examine the viability of a southern pine CLT product introduced as a building material in the United States. In cooperation with the Southern Virginia Higher Education Center, a series of CLT panels southern pine lumber were manufactured. These panels were tested for mechanical strength, fire resistance, and acoustic performance. Results of this testing would provide information crucial to the development of a southern pine CLT building product to the building code requirements in the United States.

2 MATERIALS AND METHODS

2.1 CLT PANEL MANUFACTURE

A set of 5-layer CLT panels were manufactured using nominal 2x4 (38.1 mm x 88.9 mm) No.2 southern pine lumber. Lumber was surfaced planed before manufacture to a thickness of 35 mm. A polyurethane adhesive obtained from a local supplier was used for fabrication of all panels. Each layer was edge glued for ease of fabrication. Layers were fly cut on a CNC table in lieu of planning. Final consolidation of panels used a pressure of 276 kPa. Final panel thickness was 175 mm. Panel sizes were dictated by the particular test methods used.

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2.2 MECHANICAL PROPERTY EVALUATION

ANSI/APA PRG-320 recommends a bending and shear testing of panel sections using various spans of a flatwise bending test [1]. All samples were 305 mm wide. Span of the bending tests was 4.73 m, and 1.22 m for the shear tests.

Bending tests used a third-point loading arrangement, where loads were applied 1.57 m from the support. A constant displacement rate of 6.35 mm/min was used. Beams were tested until failure. Load and center point deflection data were continuously recorded throughout the test.

Shear tests used two point loads applied 152 mm apart placed symmetrically at the midspan of the beam to prevent crush, as per ASTM D 198 [7]. A constant displacement rate of 2.5 mm/min was used. Ten specimens of each test were conducted.

2.3 FIRE TESTING

Fire testing of CLT panels is currently being conducted at the Forest Products Laboratory in Madison, WI. Fire specimens were 914 mm x 914 mm and placed horizontally in a fire chamber. A series of embedded thermocouples at different depths within the panel measured the temperature during testing. The test chamber follows a prescribed heating schedule and the range of temperatures is measured throughout the test. When the thermocouples in the center of the panel reach 300 degrees F or half of the panel has been charred, the test is ended.

2.4 SOUND TRANSMISSION TESTING

Sound transmission testing will be conducted at Architectural Testing in York, PA during the month of September. Testing will consist of ASTM E 90-09 (Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements) [8], and ASTM E 492-09 (Standard Test Method for Laboratory Measurement of Impact Sound Transmission Through Floor-Ceiling Assemblies Using the Tapping Machine) [9].

3 RESULTS AND DISCUSSION

3.1 Mechanical Property Test Results

At current time, only the mechanical testing of CLT panels has been completed. The experimental bending strength and stiffness are compared with the V3 (southern pine) CLT configuration given in ANSI/APA PRG-320 [1]. Both the bending strength and stiffness of the test panels exceeded the V3 level using the characteristic adjustment (2.1) for the bending strength. Current results appear favourable for the development of southern pine CLT panels.

<table>
<thead>
<tr>
<th>Property</th>
<th>Experimental SP CLT Value</th>
<th>V-3 Values from PRG-320</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bending Moment ((F_{b,eff}))</td>
<td>102,000 N-m/m</td>
<td>(2.1 \times \frac{23,100 \text{ N-m/m}}{858 \text{ GPa/m}} = 48,510 \text{ N-m/m})</td>
</tr>
<tr>
<td>Bending Stiffness ((E_{l,eff}))</td>
<td>904 GPa/m</td>
<td>858 GPa/m</td>
</tr>
</tbody>
</table>

4 CONCLUSIONS

Bending strength and stiffness results of CLT panels produced from southern pine lumber were found to exceed the current product standard in the United States. Results of fire and acoustic testing are pending to demonstrate whether southern pine CLTs can present a viable product able to meet these three criteria (mechanical, fire, acoustics) for building code acceptance.

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REFERENCES