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EFFECT OF END SUPPORT CONDITIONS ON THE VIBRATIONAL PERFORMANCE OF CROSS-LAMINATED TIMBER FLOORS

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ABSTRACT: This study focuses on the vibrational behaviour of 3, 5 and 7-layer cross-laminated timber (CLT) plates supported on two sides with different support conditions. Three end support setups are proposed; 1) top load over the two supported edges, 2) direct fastening to support using self-tapping screws, 3) steel angle bracket support. The measured response parameters are natural frequencies, damping, and static deflection under a point load. The rotational stiffness with load, screws and steel angle brackets will be characterized through static tests. In addition, the effect of the span is studied by varying the test span and repeating the vibration and deflection tests. The laboratory tests will be supplemented with analytical modelling. The expected outcome is the development of approaches to more accurately calculate the natural frequency and static deflection under a point load, which can account for the influence of common support conditions encountered in service.

KEYWORDS: end support condition, cross-laminated timber, natural frequency, damping, static deflection

1 INTRODUCTION

The use of cross-laminated timber (CLT) in floor systems has resulted in studies that concentrated on its serviceability design to minimize disturbing vibrations. Recent floor vibration design criteria are presented for CLT floor systems by Hu and Gagnon [4] and Hamm et al. [3]. Both criteria assume a simple end support condition and require the calculation of the fundamental natural frequency and deflection at the centre of the CLT floor under a concentrated load. Nevertheless, support conditions have been shown to be more complex as observed in a study by Jarnerö et al. [6]. These researchers report differences in natural frequencies and damping when comparing their test results on floors in laboratory and in-situ. This suggests that actual end support characteristics in practice should be reflected in any design calculations.

Thus, it is assumed that the end support condition in the CLT floor to wall connection is affecting the vibrational behaviour of the floor. This connection at the boundaries of the floor can be responsible for the differences between predicted and measured natural frequencies observed in previous CLT floor studies. From a mechanics standpoint, the end support condition can be characterized by the parameters of rotational stiffness and translational stiffness. These stiffness properties have been proven to be of importance in the calculation of natural frequencies of beams by several researchers, among others Huang [5], Beglinger [1], Chui and Smith [2], and Leichti et al. [7].

This study will focus on characterizing the stiffness properties of common support conditions and their influence on vibrational behaviour and static deflection response of CLT floor systems.

2 METHODOLOGY

The CLT specimens used in this study are 1m wide 3, 5 and 7-ply strips with spans of 4.5, 6 and 8.3 m respectively. In all tests the strips are supported at two ends. There will be an initial reference test having the panels simply supported on steel rods. Three end support conditions will be studied. These include the application of load over the supported end, the use of self-tapping screws, and the use of steel angle brackets. The load, number of screws and steel angles will be sequentially increased

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during the tests. After every sequential increase, dynamic and static tests will be conducted. The dynamic test will be a modal test to measure natural frequencies and damping. The static test applies a 1kN load at mid-span and measures the deflection there. Additional tests include the characterization of the stiffness properties of the three end support conditions through testing of CLT floor-to-wall connections under applied load, with the use of wood-screws and the use of steel angle brackets respectively.

Since the influence of end support condition will likely be dependent on the span, to study this effect the test span will be sequentially reduced and the tests repeated. Finite element models will be developed to predict the behaviour of the test specimens incorporating the various end conditions. The measured end support stiffness properties will be used as input. Validation of the models will be achieved by comparing the test results with the predicted responses. Once the models are validated, they will be further expanded to simulate the dynamic properties and deflection response to a static point load of two-dimensional CLT floor systems. These analyses will provide an indication on how common end support conditions affect natural frequency and static deflection behaviour. Recommendations will be drawn on how existing floor vibration design procedures may be modified to reflect the influence of end support conditions.

3 EXPECTED OUTCOMES

The study will assist in understanding the effect of end support condition and span on the natural frequencies, damping and deflection of CLT panels. The results will include natural frequencies, damping, deflection, mode shapes, and end support stiffness, for 3, 5 and 7-layer CLT panels in single span. It is expected that the gathered knowledge will be of use in the vibration design of CLT floors.

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