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VIBRATION SERVICEABILITY PERFORMANCE OF MASS TIMBER FLOORS UNDER VARIOUS SUPPORT CONDITIONS

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ABSTRACT: Mass timber floors are prone to human-induced vibration due to their light weight. Vibration serviceability limit design often governs the maximum allowable span of mass timber floors. The current design methods including the vibration-controlled span equation in CSA O86-19 and the design method in EC5 usually assume the mass timber floors are simply supported on rigid walls, which can't be directly applied to floors being supported by beams. In this study, the vibration performance of mass timber floors including nailed laminated timber, dowel laminated timber, and cross-laminated timber floor panels was investigated experimentally. The effect of various support conditions on the dynamic properties of mass timber floors was studied through modal testing, and the vibration acceptability of these floors under normal human walking was assessed by subjective evaluations. The test results indicated that the stiffness of the support significantly impacts the dynamic properties and vibration performance of the entire floor slab. The performance criterion specified in CSA O86 demonstrated potential for accurately predicting the vibration performance of beam-supported mass timber floors. However, both the vibration-controlled span equation and the beam stiffness equation were found to be insufficient for designing such floors. The vibration response-based design methods that utilize the ISO 10137 baseline curve showed inconsistencies across all groups. Dunkerley's system frequency prediction equations yielded overestimated results, while Kollar's method exhibited an average error within 5%, demonstrating promising potential for practical use. Further research is required to develop a reliable design approach for beam-supported mass timber floors.

KEYWORDS: Mass timber floors, vibration performance, support conditions

1 INTRODUCTION

Mass timber panels (MTPs) are a category of large-dimension panelized wood products, including cross-laminated timber (CLT), nailed laminated timber (NLT), dowel laminated timber (DLT), or glued-laminated timber (GLT) panels [1]. They are used mainly as load-bearing floors, walls, and roofs in mid-rise or high-rise wood buildings. In comparison to alternative materials, such as concrete and steel, MTP-constructed floors possess a relatively lighter weight and lower damping ratio, thereby making them susceptible to human-induced vibrations [2].

The vibration performance of mass timber floor is significantly dependent their edge support conditions [3-4]. Beside the rigid wall supports often found in platform CLT buildings, there are a large portion of mass timber building projects that uses post-and-beam combined with mass timber panel floors. It should be noted that the structural design of supporting beams is to meet ultimate limit state (ULS) including moment compacity and shear resistance strength as well as serviceability limit state (SLS) including deflection limits of the beams only. The effect of the beam flexibility on the floor vibration performance is not considered.

Current design methods including the vibration-controlled span equation in Canadian standard CSA O86 [5] and the vibration design method in Eurocode5 [6] are based on the assumption that the mass timber floors are simply supported on rigid walls. Due to the flexibility of beams that support the floor panels, these design equations cannot be applied to such beam-supported floors. Thus, FPInnovation [7] proposed a beam stiffness equation to limit the beam's stiffness to ensure the supporting beams are sufficiently rigid, which enables the applicability of the vibration design method in CSA O86 to beam-supported CLT floors. However, this beam stiffness equation was developed based on the subjective evaluations of a few beams under heel drop excitations in a laboratory condition, without experimental verifications on beam-supported CLT floors.

The current engineering practice also adopts vibration response-based design methods using the ISO 10137 [8] baseline curve and multiplying factors for mass timber floor vibration design [9]. To conduct a response-based vibration serviceability design, it is inevitable to calculate the system's natural frequencies of floors with flexible supports, with the fundamental natural frequency being a key parameter. Dunkerley's method is widely used and adopted in American Institute of Steel Construction (AISC) DG-11 [10] for the prediction of system natural

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frequency, which are being used for mass timber floors with beam supports. However, the validity of such criteria as well as the frequency prediction equations for mass timber floors remains unverified to date. In addition, Kollar [11-13] proposed a model and equations for the calculation of the fundamental natural frequency of plates which considered the deflection of the supporting beams. However, these equations have yet to be verified through experimental studies.

The aim of this study is to examine the dynamic properties of mass timber floors under varying support conditions and evaluate their vibration serviceability performance through both physical parameter measurements and subjective evaluations. Additionally, the study will assess the validity of commonly-used vibration design criteria for mass timber floors with supporting beams, and assess the accuracy of prediction equations for system frequency.

2 THEORETICAL BACKGROUND

2.1 COMMONLY-USED MASS TIMBER FLOOR VIBRATION DESIGN CRITERIA

In an effort to establish standards for acceptable vibrational behavior in mass timber floors, numerous approaches have been proposed. In Canada, Hu [14] first proposed a performance criterion which used the combination of fundamental natural frequency and the deflection under 1 kN point load. This performance criterion was derived through a comprehensive analysis of field floor data and the results of occupant perception surveys, utilizing logistic regression analysis, as shown:

$$\frac{f_1}{d^{\,0.39}} \geq 15.3 \tag{1}$$

where d is the measured static deflection under 1 kN concentrated load at the center of the floor, and f_1 is the measured fundamental natural frequency of the floor.

The accuracy of the criterion was confirmed through a comparative analysis of 58 lightweight flooring systems, using subjective evaluation ratings as a reference. The results indicated that when the ratio calculated through the equation exceeded 15.3, the flooring system was highly likely to meet the vibrational performance requirements and be deemed acceptable to occupants.

This approach was adopted for the development of the vibration-controlled span equation for CLT floors in accordance with CSA O86-19 [5]. The same form of design criterion which used the calculated parameters is shown in equation (2), the equations to calculate the parameters are also shown as follows:

$$\frac{f_1}{d^{\,0.7}} \geq 13.0 \tag{2}$$

$$f = \frac{\pi}{2l^2}\sqrt{\frac{EI}{m}} \tag{3}$$

$$d = \frac{1000Pl^3}{48EI} \tag{4}$$

where m is the mass per unit area, kg/m^2; l is the floor span, m; EI is the bending stiffness of the 1-meter-wide floor, N·m^2; P= 1000 N.

The performance criterion equation takes into account the measured results to assess the vibration serviceability performance of a built timber floor. However, the vibration design of CLT flooring systems is achieved through the second equation, referred to as the "design criterion", which was developed based on the lab tests of CLT floors with three different thickness. Both the performance and design criteria will be used to analyze the test data obtained in this study.

The direct method for evaluating floor vibration serviceability takes into account human perception of whole-body vibration and requires appropriate response measurements. According to ISO 10137 "Bases for design of structures—Serviceability of buildings and walkways against vibrations" [8], the baseline curve representing the acceleration in the z-axis provides a limit for human perception of vibration. Within the frequency range of 4 to 8 Hz, vibrations at a level of 0.005 m/s^2 are considered to be negligible. ISO 10137 also provides multiplying factors for different occupancies, suggesting a factor of 2 to 4 for continuous or intermittent vibrations in the case of residential buildings during daytime hours. The AISC DG 11 [10] uses peak acceleration based on the principles outlined in ISO 10137. Although this guide was initially developed for steel-framed floors, it has been widely adopted in the timber engineering community [9] for the design of mass timber flooring systems.

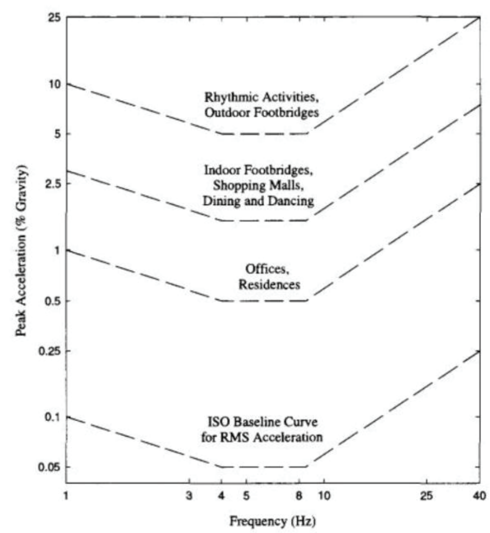

Figure 1: *Recommendation of acceleration for human comfort in AISC 2016*

2.2 SUPPORTING BEAM STIFFNESS LIMITATION

Since Eq. 2 was developed with CLT floors with rigid supporting walls, FPInnovation [7] proposed a beam stiffness equation so that Eq. 2 can be used for beam-supported CLT floors. This equation limits the beam's

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stiffness to ensure the supporting beams are sufficiently rigid to avoid negative effect on floor vibration performance.

$$EI \geq F_{span} 132.17 l^{6.55} \quad (5)$$

where EI=the supporting beam apparent stiffness (N/m^2), l=the clear span of supporting beam (m), F_{span} is taken as 1 for simple span beam and 0.7 for multi-span continuous beam.

The evaluation of the rigidity of the beams was conducted by doing a heel drop test on the center of the beam, the specimen can be treated as rigid if the evaluator does not feel any movement after the heel drop. It should be noted that the beam stiffness requirement is not dependent on the mass timber floor thickness and span according to Eq. 5.

2.3 SYSTEM FREQUENCY PREDICTION

In the AISC DG 11 [10] for the vibrations of steel framed structural systems and the revised version of EC5 [15], Dunkerley's method was suggested for the estimation of system frequency:

$$\frac{1}{f_n{}^2} = \frac{1}{f_j{}^2} + \frac{1}{f_g{}^2} \quad (6)$$

where $f_j$is the beam or joist panel mode frequency, f_g is the girder panel mode frequency.

Kollar [11-13] proposed a model and equations using Dunkerley's method and Southwell's method for the calculation of the fundamental natural frequency of orthotropic plates which considered the flexibility of the supporting beams. The equations considered different configurations when the floor was supported by one to four beams on edge, and the equations were applied to timber and timber-concrete floors and verified by numerical models. The equations for floors with two opposite beams are simplified as shown, more details can be found in [13].

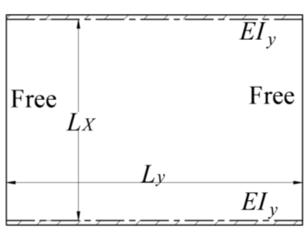

Figure 2: *Floor supported on two opposite beams*

$$D_{11} = \frac{E_x h^3}{12(1-\gamma^2)} \quad (7)$$

$$D_{22} = \frac{E_y h^3}{12(1-\gamma^2)} \quad (8)$$

$$f_x^2 = \frac{\pi^2 D_{11}}{4mL_x^4} \quad (9)$$

$$f_y^2 = \frac{\pi^2 D_{22}}{4mL_y^4} \quad (10)$$

$$f_{EIy}^2 = \frac{\pi^2 EI_y}{2mL_x L_y^4} \quad (11)$$

$$\delta_y = \frac{1}{1 + f_y{}^2 / f_x{}^2} \quad (12)$$

$$f^2 = \left(\frac{1}{f_x^2} + \frac{1}{f_{EIy}^2 + \delta_y f_y^2} \right)^{-1} \quad (13)$$

where E_x and E_y is the Young 's modulus, m is the mass over unit area, h is the thickness, γ is the Poisson's ratio, L_x and L_y are the dimensions of the plate in the x and y direction,EI_y is the supporting beams' stiffness.

3 MATERIALS AND METHODS

3.1 MATERIALS

The dowel laminated timber (DLT) panels, nail laminated timber (NLT) panels and cross laminated timber (CLT) panels were investigated. The DLT and NLT panels were assembled with one 11-mm oriented strand board (OSB) panel as the sheathing, in accordance with construction practices.

Three floors with varying dimensions and layouts were constructed in the laboratory at the University of Northern British Columbia for testing purposes. DLT floor and NLT floor were both made by three 4.3 m × 1.8 m panels, CLT floor was made by three 4.0 m × 1.8 m panels. The panels were spanned in the major strength direction at 4.1 m o.c and 3.9 m o.c respectively. The non-destructive test developed by Zhou [16] was used to simultaneously measure the elastic constants of each panel including modulus of elasticity in major and minor strength directions (E_x and E_y) as well as in-plane shear modulus G_{xy}. These parameters are required if the floor plate is modeled as a two-dimensional orthotropic thin plate. The floor dimensions and measured elastic constants are shown in Table 1 and 2. It is important to note that the CLT panels were obtained from prior testing and contained some internal cracks, which led to a lower E_x value than its design value. However, this did not impact the floor's vibration performance with the tested span.

Table 1: *Information of the constructed mass timber floors*

Floor Material	Length (m)	Width (m)	Thickness (m)	Density (kg/m^3)
DLT	4.3	5.4	0.151	448
NLT	4.3	5.4	0.151	446
CLT	4.0	5.4	0.245	470

Table 2: *Measured elastic constants of the constructed mass timber floors*

Floor	E_x (MPa)	E_y(MPa)	G_{xy} (MPa)
DLT	7491	81	58
NLT	7909	29	80
CLT	2900	42	124

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In this study, the rigid wall and glulam beams were both selected as floor supports. The design and construction of two beams with varying cross-sectional configurations were carried out to meet both ULS and SLS requirements first with a structural grid of 6×6 meters according to NBCC 2020 [17]. The 20f-E sprue-pine glulam beams with a span of 6 meters and a density of 435 kg/m^3 were selected. In this study, the 175*494 mm supporting glulam beams B1 were designed based on Eq.5 which is expected to has the adequate stiffness to avoid negative effect on floor vibration performance. The 175*608 mm beam B2 was then selected which has a stiffness two times higher than B1. The elastic constants of the two groups of beams were obtained through the methodology established by Chui [18] and are presented in Table 3.

Table 3: *Information of the supporting beams*

Beam	Width (mm)	Thickness (mm)	E (MPa)	G (MPa)
B1	175	494	11705	693
B2	175	608	12090	629

3.2 FLOOR CONSTRUCTION

The floors were sitting on wood walls resting on the ground along the major span direction, which can be treated as rigid supports (Figure 3). Panel-to-panel connections were achieved by installing full-thread self-tapping screws at 45˚ (Holz CLC, 8 mm diameter and 160 mm length,), with a spacing of 400 mm. Panel-to-support connections were also installed by using half-thread self-tapping screws at 90˚ (HBS, 8 mm diameter and 220 mm length,), with a spacing of 450 mm.

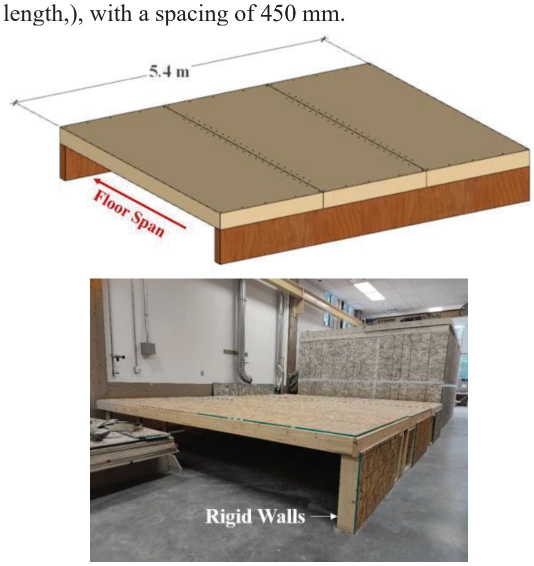

Figure 3: *Floor with rigid supports*

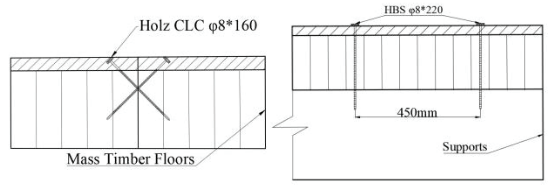

Figure 4: *Panel-to-panel connection and panel-to-support connection*

The floors were then supported on two groups of beams respectively, the beam-to-column connections were achieved by PITZL-HVP connectors with a dimension of 80*220 mm, the screws used are φ 5 mm*100 mm. When the beams were connected with columns on both sides, the floor panels were placed on the two beams along the longitudinal direction with the same panel-to-panel and panel-to-support connections.

Figure 5: *Floors with supporting beams*

Figure 6: *Beam-column connectors*

3.3 METHODS

3.3.1 Modal tests

Experimental modal test was performed to obtain the dynamic properties including natural frequencies, damping ratios and mode shapes. To accurately capture the corresponding mode shapes, a 7×7 grid was divided on the floor, and each point is impacted by an instrumented impact hammer [PCB Model 086D05] for three times to obtain an averaged frequency response function (FRF) curve. Five accelerometers [PCB Model 352C04, nominal sensitivity 1.02 mV/(m/s^2)] were installed on the floor with hot melt glue, and the signals from the impact hammer and accelerometers were recorded by a dynamic data analyzer (Brüel & Kjær, LAN-XI 3050) within the frequency range of 100 Hz. BK Connect (Brüel & Kjær) vibration engineering software was used to conduct the modal analysis. The location of accelerometers and test setup is illustrated in Figure 7.

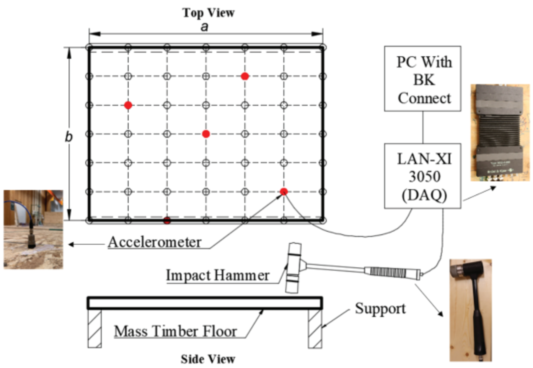

Figure 7: *Schematic drawing of modal test setup with selected accelerometer locations*

3.3.2 Vibration performance tests

After the modal test, a floor vibration performance test was conducted in each group for their acceleration levels under normal human walking. The walking test was performed by a 75 kg evaluator following several walking paths with a gait around 2 Hz. For each floor, four accelerometers were mounted on the left and right midspan (Am-1 and Am-2), and on top and bottom of the floor center (Ac-1 and Ac-2) respectively. The acceleration responses were recorded at various locations that were believed to exhibit the highest possible vibration magnitude and recorded by BK Connect Software. The time-domain acceleration data of the whole walking path was post-processed based on ISO 2631 [19].

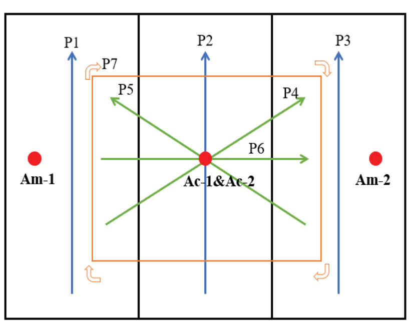

Figure 8: *Human walking paths on the tested floors*

Deflection test was conducted according to ISO 18324 [20] by applying a 1kN point load (a 100 kg concrete block) at the center of the floor, the deflection of the floor was measured by one dial indicator with an accuracy of 0.01 mm at the midspan under the loading point.

Figure 9: *Deflection test (Left: Applied 1 kN concentrated load on the floor, Right: Data collection)*

Subjective evaluations were conducted for the acceptance level of the floors according to ISO 21136 [21], categorizing the floors into levels 1 to 5, i.e. 1 = definitely unacceptable, 2 = unacceptable; 3 = marginal, 4 = acceptable, 5 = definitely acceptable. A survey with 20 evaluators was conducted on each floor. The evaluator first walked on the floor, then stood and sat stationary at the center while a 75kg walker walked on the floor, as shown in Figure 10. Each evaluator completed a questionnaire provided in ISO 21136 to report his/her perception and acceptance regarding vibration levels, all the ratings for each floor were averaged and reported as its final rating.

Figure 10: *Subjective evaluation of tested floors*

4 RESULTS AND DISCUSSION

4.1 DYNAMIC PROPERTIES

Modal tests were performed on the floor panels with different supports. The first three natural frequencies as well as the damping ratios were obtained and presented in Table 4, the corresponding mode shapes with rigid supports and beam supports of NLT and CLT are shown in Figure 11 and 12.

Table 4: *Measured dynamic properties of the floor specimens*

Floor	Supports	f_1 (Hz)	f_2 (Hz)	f_3 (Hz)	Damping (%)
DLT	Rigid	14.88	15.88	19.50	3.6
	B1	11.13	16.25	17.64	3.5
	B2	12.05	16.05	17.97	2.8
NLT	Rigid	14.38	14.88	18.13	4.8
	B1	11.13	16.88	18.08	2.7
	B2	12.13	16.62	20.33	2.9
CLT	Rigid	17.25	18.63	21.98	3.1
	B1	10.63	17.00	21.00	3.7
	B2	12.15	19.75	21.00	3.4

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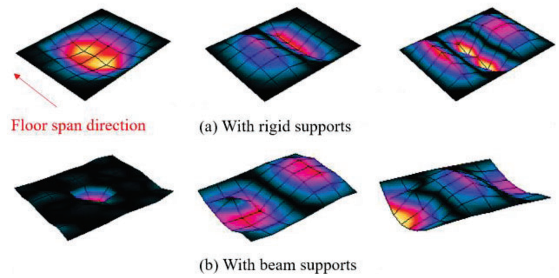

***Figure 11:** Corresponding first three mode shapes of NLT floors*

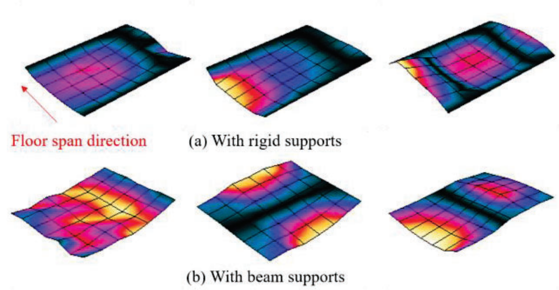

***Figure 12:** Corresponding first three mode shapes of CLT floors*

The dynamic properties of the supporting beams were measured prior to their connection with the floor panels. The fundamental natural frequency of beams B1 and B2 was found to be 28.32 Hz and 32.57 Hz respectively, when connected with columns. Table 4 showed that the fundamental natural frequency (f_1) of DLT, NLT, and CLT floor systems decreased over 20% as they were supported from rigid supports to glulam beams, while f_1 increased as the beam stiffness was increased. The damping ratios of each floor system remained relatively unchanged as the support conditions changed, with an average value of 3% to 4%.

Since the composition and material properties of DLT and NLT plates are relatively similar, they had the same mode shapes in the modal test. The corresponding mode shapes of NLT floors are the same under different support conditions, which are the first three bending mode along the longitudinal direction. The CLT also had the first three bending mode shape with rigid supports. Due to the flexibility of supporting beams, the first mode shape of CLT floor is governed by the supporting beams which is the bending mode along the beam direction.

4.2 VIBRATION SERVICEABILITY PERFORMANCE ACCESSMENT

The vibration performance parameters were determined by the experimental tests, subjective evaluations for each floor were also conducted, the results for each floor systems are shown in Table 5-7.

***Table 5:** Summary of DLT Floor's vibration performance parameters*

Support	Supporting beams' span (m)	f_1 (Hz)	d_{1kN} (mm)	Rating
Rigid	/	14.88	0.72	3.5
B1	6	11.13	0.74	2.9
	3	13.88	0.67	3.0
	2	14.75	0.66	3.5
B2	6	12.05	0.71	3.0
	3	13.62	0.63	3.5
	2	13.82	0.62	3.5

***Table 6:** Summary of NLT Floor's vibration performance parameters*

Support	Supporting beams' span (m)	f_1 (Hz)	d_{1kN} (mm)	Rating
Rigid	/	14.38	0.73	3.5
B1	6	11.13	0.77	2.8
	3	14.00	0.70	3.0
	2	14.25	0.62	3.5
B2	6	12.13	0.80	3.0
	3	13.73	0.71	3.5
	2	14.25	0.73	3.5

***Table 7:** Summary of CLT Floor's vibration performance parameters*

Support	Supporting beams' span (m)	f_1 (Hz)	d_{1kN} (mm)	Rating
Rigid	/	17.25	0.15	5.0
B1	6	10.63	0.17	2.9
	3	14.50	0.12	3.5
	2	16.13	0.11	4.0
B2	6	12.15	0.16	4.0
	3	14.92	0.13	4.5
	2	15.67	0.10	5.0

Changing the supports from rigid to supporting beams has a significant influence on the floor's fundamental natural frequencies, while the static deflection increased slightly due to the flexibility of beams. From the occupants' perspective, the NLT and DLT were acceptable for most of them when using the rigid wall supports, but they performed worse with the supporting beam 1 with an average rating lower than 3, which means not acceptable. Even the beam thickness was largely increased from 494 mm to 608 mm, the occupants still gave a marginal rating towards the floor vibration performance. CLT floors with the rigid simple supports can achieve a rating of 5, which is totally acceptable for the evaluators, while the performance changed significantly to not acceptable when connected with B1, and improved slightly with B2.

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To address the influence of supporting beams' stiffness to the vibration performance of the whole floor, the multi-supports were installed under the supporting beams to shorten their effective span. The test results showed that the installation of multi-supports under the beams reduced the floor deflection slightly, and increased the fundamental natural frequencies gradually close to the floors with rigid supports, leading to improved floor vibration performance for the occupants.

The results of this study were compared to the performance and design criterion outlined in CSA 086-19, as shown in Figure 13 and 14. When evaluating the results using the performance criterion, a good correlation was observed between the data points and the subjective evaluation results, with a value greater than 15.3 indicating an acceptable level of floor vibration performance. However, the CLT floors in the study had a greater thickness, leading to smaller deflections compared to the DLT and NLT floor systems, but with similar fundamental natural frequencies. This resulted in an $f/d^{0.39}$ value that exceeded the limit, despite subjective evaluations that did not always align with the predictions.

The design criterion was developed using data from three CLT floors with rigid supports, the calculated design parameters (calculated using equation (4) and (13)) and the subjective evaluation results in this study did not correlate well with the curve provided in the design criterion. This suggests that the vibration-controlled span equation may not be suitable for real-world design applications for mass timber floors supported by beams.

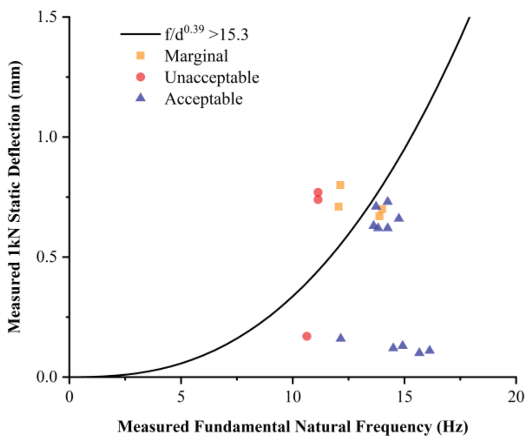

Figure 13: *Comparison between measured result and their subjective rating by performance criterion*

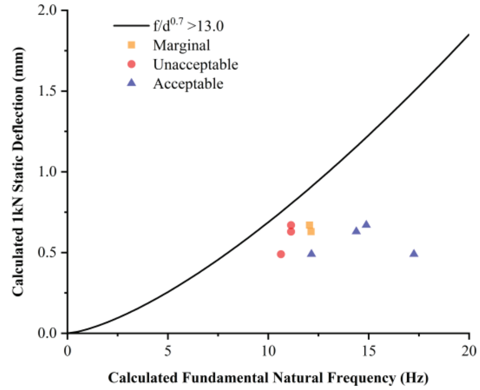

Figure 14: *Comparison between calculated result and their subjective rating by design criterion*

The peak and root-mean-square acceleration under human walking on floors were collected and the maximum value from all the walking paths is shown in Table 8. An example of captured acceleration waveform of CLT floor with B2 under human walking is shown in Figure 15, each peak represents a step on the floor. A transient response of the floor under human walking excitations can be observed, the frequency weighted data is also shown.
The peak acceleration can be greatly affected by the walker, walking path, boundary conditions, and any random disturbance from a single foot pulse excitation, which also showed great differentiation among each group in this study. Despite utilizing the same walking paths and excitation source in every test, the results still showed variation among the groups and all values were found to be higher than the tolerance value as specified by ISO 10137 even after the application of the multiplying factors. The results obtained from the RMS measurement do not align well with the subjective ratings obtained from the evaluators. This highlights the need for further investigation if RMS acceleration levels are to be used as an indicator of floor vibration performance.

Table 8: *Measured maximum frequency-weighted accelerations (m/s²)*

Floor	Supports	$a_{w,rms}$	$a_{w,peak}$
DLT	Rigid	0.323	5.720
	B1	0.255	2.320
	B2	0.181	0.800
NLT	Rigid	0.375	5.330
	B1	0.077	0.670
	B2	0.111	0.510
CLT	Rigid	0.038	0.259
	B1	0.025	0.119
	B2	0.190	0.639

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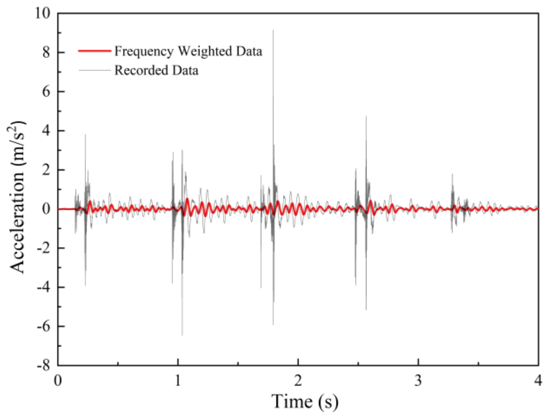

Figure 15: *Time history acceleration data of CLT floor under human walking excitation*

The beam B1 was designed by FPInnovation's beam stiffness equation, however, though the beams' bending stiffness meet the requirement, from the vibration performance tests and the subjective evaluations, all three mass timber floors performed much worse when they were constructed with B1 supporting beams, where the fundamental natural frequencies decreased significantly and the static deflection increased, and the ratings reduced from acceptable to not acceptable. Even with the supporting beam B2, which has twice the stiffness of B1, the floor's vibration performance was still impacted. Since this equation was developed by a few beam test data in the laboratory, further investigation is needed to verify and complete this method.

4.3 VERIFICATION OF SYSTEM FREQUENCY PREDICTION EQUATIONS

Dunkerley's method and Kollar's method were used to calculate the system frequency with the given material properties. The results were compared with the test result, shown in Figure 16:

Table 9: *Calculated f_1 of simple-supported floors and beams*

	Calculated f1 (Hz)
DLT	14.87
NLT	15.31
CLT	17.25
B1	32.24
B2	40.42

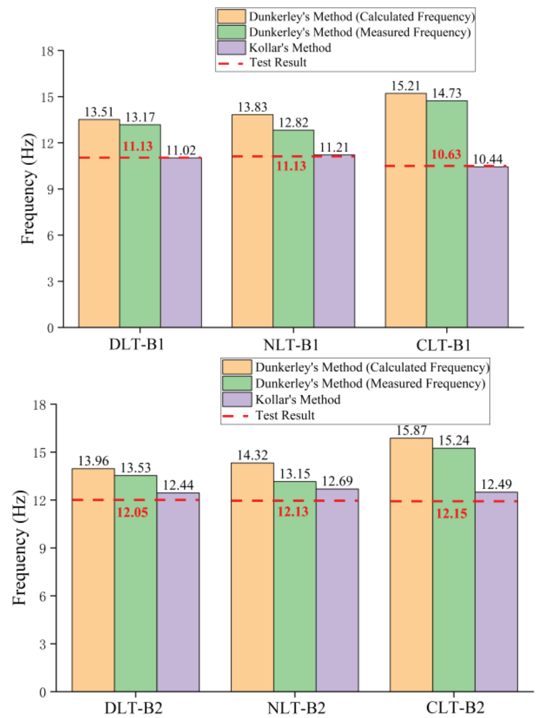

Figure 16: *Comparison of Dunkerley's method and Kollar's method to experimental test result of floor fundamental frequency*

It can be observed from the two figures that the estimated fundamental natural frequencies by Dunkerley's method are overestimate the floor system frequency. Even using the measured value from floors and beams under simple-supported conditions, the estimated value is still higher than the test result with an error of over 10% to 40%. However, the Kollar's method can predict the system' frequency precisely with an average error within 5% in each group.

5 CONCLUSIONS

In this study, modal test, vibration response test and subjective evaluation were conducted on three types of mass timber floors (NLT, DLT and CLT) under various support conditions. The measured dynamic properties of those floor systems were compared among each group and evaluated by the current commonly-used design criteria. The accuracy of prediction equations for beam-supported floor's frequency was also examined. From the study these conclusions can be drawn:

1. The stiffness of the support has a significant effect on the dynamic properties and vibration performance of the mass timber slab floors. When the rigid wall support is replaced with beam supports, the system's fundamental natural frequency is reduced and the subjective feeling becomes much worse. By increasing the thickness of the beam or adding multiple supports under the supporting beams, the frequency gradually returns to a level similar to that of the rigid support and the subjective perception improves.

2. The performance criterion outlined in CSA O86 generally exhibit a high level of correlation with experimental results, demonstrated potential for accurately predicting the vibration performance of beam-supported mass timber floors. However, for the design of such floors, the vibration-controlled span equation and the beam stiffness equation proposed by FPInnovation are both insufficient. The acceleration criterion outlined in ISO 10137 reveals notable discrepancies across all groups, with results consistently surpassing established limits.
3. The Dunkerley's equation overestimate the fundamental frequency of mass timber floor system by up to 40%. While the method proposed by Kollar had an average error within 5%, which demonstrates remarkable potential for practical use.

Future studies aim to extensively explore the feasibility of accurately predicting the dynamic parameters of beam-supported slabs through numerical modeling. The research also seeks to synthesize and develop a practical vibration design method for beam-supported mass timber slabs, based on a comprehensive analysis of current laboratory data and data collected from multiple on-site buildings.

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