INFORMATION SHEET
STRUCTURAL DESIGN

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FLOOR DYNAMICS
VIBRATION

The information provided below has been taken from the New Zealand Timber Design Guide 2007, published by the Timber Industry Federation and edited by Professor A H Buchanan. To purchase a copy of the Timber Design Guide, visit www.nztif.co.nz

A key design consideration for timber joist floors is that of vibration. Some people are bothered by floor vibrations caused by other people walking nearby, or from mechanical causes. Satisfactory performance is difficult to assess because different people have different thresholds of perception or tolerance. The three main factors that influence perception of movement are:

- vibration frequency
- damping in the floor system
- acceleration of the movement

The first two items are important for heavy floors. For light floors, including most timber floors, frequency and acceleration are more important. Floors will vibrate at a natural frequency as a result of footfall, or impact from a dropped object. Control of the natural frequency to acceptable limits, by careful design, will improve performance. Floor vibrations are nearly always the result of joist vibration rather than vibration in the floor sheathing material itself.

Natural sheathing frequencies of around 3 Hz can lead to resonance with walking traffic. Frequencies in the range 5 Hz to 8 Hz coincide with resonant frequencies in human organs. These can be very uncomfortable and should be avoided.

If the first mode natural frequency of the floor is calculated to be less than 8 Hz using the following formula, it is quite likely that vibration will be annoying and a stiffer floor system will be required:

$$\text{Frequency (Hz)} = (\pi / 2L^2) \times \sqrt{(EI / m)}$$

where

L = floor span (m)

m = mass per unit length of the floor (kg/mm), including live load

E = modulus of elasticity of the floor (kg.mm / s2 mm2)

I = area moment of inertia of the floor about its neutral axis (mm4)

To increase frequencies, designers can reduce spans, or increase stiffness and reduce mass. However, reducing mass also increases the accelerations of the motion, and in light timber floors this can lead to more felt vibrations.

Designers need to balance span, stiffness and mass for an acceptable solution. In general, systems with fundamental natural vibration frequencies greater than 12 Hz and accelerations less than 0.375 m/s2 perform adequately. Vibrations can be reduced by increasing joist size, or by increasing two-way floor action with joist blocking, transverse beams or stiffer flooring material. Simple methods of calculating vibration response are becoming available (see further reading).

The Canadian Wood Council has produced a graph relating span to deflection under a 1 kN static point load for solid timber and proprietary joists spanning up to 10 metres. The relationship is:

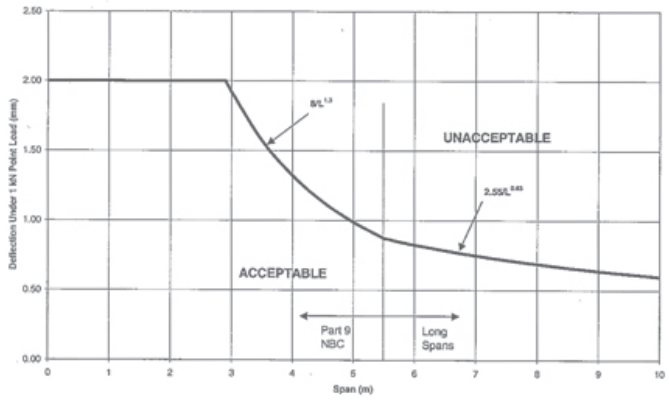

Figure 3-2 **Canadian relationship between span and acceptable deflection under 1 kN point load**

Potentially unacceptable liveliness can arise when there is no partitioning present either above or below the floor over its full span. If designers are uncertain about the likely vibration performance of a floor they should increase the joist size or reduce the spacing. Solid blocking between the joists has been shown to improve the dynamic behaviour of a floor to a lesser extent.

Source: Multi-storey Building Manual, Compiled by Graeme Beattie, BRANZ.