Floor Stiffness
- How much bounce is too much?

This article is intended for both legal and technical readers.

Key points:

* Suspended timber or steel floors may comply with design standards and yet provide an unacceptably bouncy floor.
* A large number of factors affect performance and designers seeking good performance may need to specify framing of considerably greater stiffness than the minimum.
* Standard performance criteria for domestic floor performance are generally liberal and not very helpful.
* Practical remedial solutions are discussed.

Introduction

A common cause of building occupant dissatisfaction is floors perceived to be springy or bouncy underfoot. This article explores why this occurs and appropriate remedial works. This is a restricted treatise concentrating upon footfall sensitivity in framed floors.

Design Requirements

Structural design standards for strength and stability are intended to ensure a structure has sufficient strength. They involve safety margins that are usually embedded in amplification factors applied to design loads and capacity reduction factors applied to structural capacities. These result in effective safety factors of about 50%. These factors are effectively mandatory via the use of Australian Standards required by the Building Code of Australia.

In the case of design for stiffness or springiness, no safety factors are required. This means that structures designed to minimum standards may not meet serviceability requirements. This situation is further diluted by the lack of useful standards, particularly for the sensitive case of springiness under foot.

Applicable Design Standards

In the common case of specifying timber floor joists, solid timber or manufactured product, little analysis is done and members are often simply chosen from a span table listing maximum spans for a design loading and application. The difficulty is that maximum spans provide minimum stiffness and often stiffness below serviceability requirements. The use of such tables without this understanding is a common source of springy floors.

In the case of engineer designed floor frames, calculations are often restricted to checking total deflections under total loads, not the sensitive footfall case. It is very difficult to accurate and meaningful analyse floor performance under foot as this involves accelerations and resonance as well as simple deflections. It is also typically complicated by the properties of surrounding elements such as floor coverings, flooring and joist supports.

Thus it is not uncommon to find a floor which complies with the required standards and even has supporting calculations but does not perform to expectations.

Floor Systems

Timber floor joists, be they solid or manufactured product, comprise the majority of long span domestic floors. Timber is inherently self damping and easy to fix to which makes it a practical choice for floor frames.

Steel floor joists and other supporting members are inherently resonant as steel is not self damping. Manufacturer' recommended spans attempt to take this into account. Some steel systems are primarily intended for low cost, commercial, or even temporary buildings and so can produce a floor which lacks the solidity expected for permanent residential use.

Lightweight steel floor frames are inherently resonant

Concrete and composite systems are not considered in in this article as they generally have sufficient mass not to be sensitive under footfall.

Factors That Affect Performance

Footfall sensitivity is a subjective test. Many factors affect the perception of inadequate stiffness including:

* Floor coverings; these affect load transfer and damping.
* Wall layout; this affects damping and stiffness.
* Room use; occupants have differing expectations in differing rooms.
* Cabinets; Can demonstrate and appear to amplify noise.
* Furnishings; affect damping.
* Expectations; this is the broadest category of all. People tend to expect a ground floor to be stiffer than an upper storey floor, higher quality houses are expected to feel more robust etc.
* Framing or fixings beneath the floor frame; may affect stiffness and damping.
* Resonance of supporting members, particularly steelwork.

Clearly these factors are numerous and many are subjective.

How Much Bounce is too Much?

As far as I am aware no rigorous system of measuring underfoot stiffness has been evolved that can be used as a reliable guide. The (former) Victorian Building Commission Guide to Standards and Tolerances nominates "floors that feel springy when walking" as a performance criteria. This is a much lower standard than heal drop which is a common subjective test. I recently reviewed a house where floors felt normal when walking in rubber souled shoes but bounced when walked upon in stocking feet. Obviously the mass and walking action of the occupants may also vary.

In building disputes, hopefully experts can agree upon the conclusions from a subjective test.

Common Mistakes

Common reasons for bouncy floors include:

* Selecting joists from tables at or near their maximum spans.
* Failing to understand that sensitive areas such as long span high use bare timber floors need to be substantially stiffer than tables suggests, not just 10 to 20% but typically at least 50%.
* Using a design intended for an upper level floor for a lower level floor.
* Failing to understand that when timber joists are supported by a long span steel beam extra stiffness is required.
* Inadequate blocking or strongbacks. Elements in the second direction - across the joists - help share load and improve stiffness. Workmanship is also important as such elements must be a tight fit to be fully effective.

Blocking or strongbacks can greatly improve stiffness

Remedial Solutions

If the building is complete, remedial works can be challenging, solutions include:

* Improvements of blocking to increase load sharing between joists.
* Battening and re-fixing the ceiling beneath, also to improve load sharing.
* Fixing stiffeners to sides of joists.
* Re-flooring or improving flooring fixings,
* Altering floor coverings.
* Altering cabinets or furnishings,
* Major structural works such as replacing joists.
* Adding bearers or stumps beneath bearers.

Most of these solutions are comparatively low cost and some do not require building works, however a marked lack of stiffness will typically require major works. One of the difficulties with many of the solutions above is that there is no accepted way to analyse them accurately for the footfall case. Thus it may be difficult to specify a solution with confidence. Trial and error approaches may be practical but not helpful in dispute resolution. To specify a solution with confidence that it will be fully effective, it may be necessary to take a conservative approach.

Conclusions

The subjective nature of the performance and lack of rigorous standards for design and construction will ensure this continues to be a contentious issue. Agreement by experts of the extent of the problem, early in the dispute resolution process is the first step in resolution.

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