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Timber structures — Test methods — Floor vibration performance

Structures en bois — Méthodes d'essai — Comportement vibratoire des planchers

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

Technical Committee ISO/TC 165, Timber Structures, prepared ISO/DIS 18324.

Introduction

Dynamic properties of timber structures are of critical importance to designers since they govern how these structures respond to seismic, wind and in-service human-induced dynamic excitation. Seismic and wind can cause structural failure, while in-service human-induced motion generally causes serviceability problems related to human discomfort, this is also true to wind-induced building motion. Since occupants are constantly in contact with the floor system, vibration serviceability of floor systems is often of concern to designers of timber structures. Vibrational performance of a timber floor can be assessed using parameters such as natural frequencies, damping ratios, dynamic responses to an impulse (dynamic displacement, velocity, and acceleration), and static deflection under a concentrated load. These parameters have been found to correlate well with human perceptions. Among these parameters, natural frequencies, damping ratios, and static deflection under concentrated load are commonly used to evaluate timber floor vibrational performance. Design procedures have been developed, and in some cases implemented in design standards, for assessing vibration serviceability of timber floors. These design procedures usually include criteria for floor response parameters, such as those listed above, and mathematical procedures to calculate these parameters. As an alternative to calculation, it is also necessary to provide standardized procedures to measure these parameters experimentally. This is the prime motive for the development of this ISO test standard.

Natural frequencies and damping ratios of a test system can be measured using modal testing. ISO published a series of standards on the application of modal testing and analysis to determine natural frequencies, modal damping ratios, and other dynamic properties of an object. The theory of modal testing and analysis has been well documented by Ewins.[1] This Standard provides practical procedures that can be applied either in the laboratory or in the field to measure natural frequencies, modal damping ratios and static deflection under a concentrated load of a timber floor. It is assumed that users of the Standard possess the necessary equipment and fundamental knowledge to perform modal testing.

This standard does not address acceptance criteria for vibrational serviceability.

Timber structures — Test methods — Floor vibration performance

1 Scope

This International Standard specifies test procedures to measure natural frequencies, modal damping ratios and static deflection under a concentrated load of laboratory or field timber floors. These parameters have been found to correlate well with human perception to timber floor vibration response caused by human-induced excitation under normal use. It is intended that the test procedures can be applied in lieu of calculation to quantify some or all of the above parameters that are used to evaluate the vibrational serviceability of the test floor. The subsequent use of the measured parameters to evaluate vibrational serviceability is however outside the scope of this standard.

ISO published a series of standards on the application of modal testing and analysis to determine natural frequencies, modal damping ratios, and other dynamic properties of a structure. For the measurement of dynamic parameters such as natural frequencies and modal damping ratios, modal testing is proposed in this standard. It is assumed that the test operators possess the required equipment and fundamental knowledge to perform such a test. The theory of modal testing and analysis has been well documented by Ewins.[1]

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 7626-1, *Mechanical vibration and shock — Experimental determination of mechanical mobility — Part 1: Basic terms and definitions, and transducer specifications*

ISO 7626-2, *Vibration and shock – Experimental determination of mechanical mobility — Part 2: Measurements using single-point translation excitation with an attached vibration exciter*

ISO 7626-5, *Vibration and shock — Experimental determination of mechanical mobility — Part 5: Measurements using impact excitation with an exciter which is not attached to the structure*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
Coherence function
An indicator of the degree of linearity at each frequency component between the input and output signals, i.e. the noise level at each frequency component in the frequency response function (FRF) spectrum. The value of coherence function is one when there is no noise in the signal, and zero for pure noise in the measured signals

3.2
Damping
The parameter relating to the dissipation of energy, or more precisely, to the conversion of the mechanical energy associated with a vibration to a form that is unavailable to the vibration

3.3
Natural frequency
The frequency, associated with a vibration mode, at which a system naturally vibrates once it has been set into motion with a transient excitation

3.4
Frequency Response Function
The response function expressed in frequency domain and normalized to the input force. It is the summation of each mode in the modal space. It shows the response of a system to be a series of peaks. Each peak with identifiable centre-frequency is the natural frequency of the system vibrating as if it was a single degree-of-freedom system

3.5
Leakage
The effect on measured frequency due to truncating the infinite time response signal during Discrete Fourier Transform

3.6
Modal damping ratio
Damping ratio associated with a vibration mode

3.7
Modal testing
Measurement of the Frequency Response Function

3.8
Modal analysis
The process of determining the natural frequencies, modal damping ratios, and mode shapes of a structure (floor) for the vibration modes in the frequency range of interest from the Frequency Response Function

3.9
Mode shape
Pattern of movement (i.e. dynamic displacement, velocity, acceleration) of a structure (floor) for a vibration mode

3.10
Nodal point
Point of zero displacement on a vibrating system of a mode shape associated with a vibration mode

3.11
Vibration
The oscillation of a system about its equilibrium position

3.12
Vibration mode
The vibration behaviour of system or object that is characterized by its natural frequency, modal damping and mode shape. The free vibration of a continuous structure such as floor system contains a summation of an infinite number of vibration modes

4 Symbols and abbreviated terms

4.1 General notation

FFT Fast Fourier Transform

FRF Frequency Response Function

5 Measurement of natural frequencies and modal damping ratios

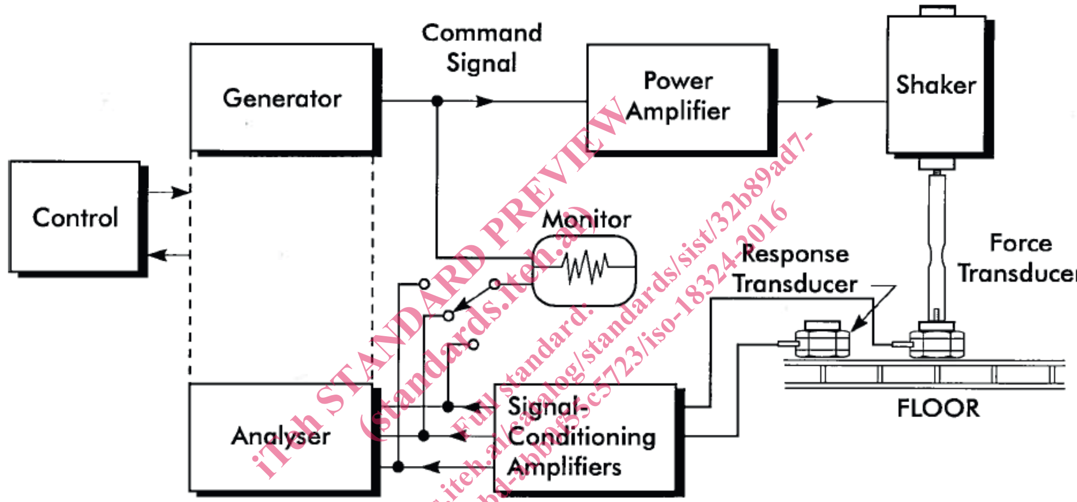
5.1 Scope

This clause specifies the general procedure of applying modal testing and analysis described in ISO 7626 to timber floors to determine their natural frequencies and damping ratios associated with the vibration modes. Specifically, this clause focuses on two techniques of exciting the out-of-plane vibration of a floor. One technique uses a shaker that is attached to the test floor, and the other uses an impact device that is not attached to the floor.

NOTE A general understanding of the theoretical basis of modal testing is expected in order to apply the procedures described in this clause. This understanding can be acquired by consulting relevant text e.g.[1]

5.2 Apparatus

The equipment required for modal testing shall consist of three major items: 1) an exciter for inducing vibration; 2) transducers for measuring the time history signal of excitation force and the vibration response; 3) a signal analyser for recording and analysing the time signals and extracting the desired information from the analysis results. Figure 1 illustrates the layout of a modal test system using a shaker as the exciter.



NOTE 1 This figure was a modification of the original figure in.[1]

Figure 1 — A layout of a modal test system using a shaker as the exciter

5.2.1 Exciter

An exciter shall be provided to initiate vibration in a structure. Generally, a satisfactory exciter for floor testing shall have the following capabilities:

a) Sufficient energy to induce floor vibration so that the modal testing measurements made over the entire frequency range of interest has an adequate signal-to-noise ratio without exciting a nonlinear response.

b) A suitable excitation waveform with frequency content that covers the frequency range of interest.

The exciter shall be either a shaker or an unattached impact device.

5.2.1.1 Attached exciter – Shaker

An attached shaker shall be an electro-dynamic, electro-hydraulic, or piezoelectric vibration exciter attached to the test floor. The shaker shall be attached to a selected location on the floor during testing to continuously apply the excitation to the floor.

5.2.1.2 Unattached exciter – Impact device

An instrumented hammer with a built-in force transducer or an impact device with a separate force transducer placed on a floor shall be used as the unattached exciter. The impact system shall have sufficient energy and contact surface to excite all the frequencies that are of interest. Specific requirements on the impact characteristics are given in 5.3.3.

5.2.2 Transducer and mounting

5.2.2.1 Transducer

For modal testing, both excitation and response signals are required. The transducer shall have sufficient sensitivity and capacity to cover the frequency range of interest, and low noise-to-signal ratio, and be insensitive to extraneous environmental effects, such as temperature, humidity, shock, rough field working conditions, etc. It shall also be sufficiently light that its presence on the test floor does not change the floor's dynamic characteristics. The vibration response shall be measured using accelerometers. A procedure to evaluate any possible influence of mass of transducer is given in 5.3.1.3.

5.2.2.2 Transducer mounting

For an instrumented hammer, the force transducer is built into the hammer. The technique of mounting a force transducer onto a shaker is specified in 5.3.2.1 along with the shaker mounting technique. The accelerometer shall be rigidly attached to the floor structure.

For floors with carpet overlaid on wood-based subfloor, a special mounting base that penetrates the carpet to the subfloor shall be used. The accelerometer shall be attached to the upper face of the base plate of the tripod. A tripod with a heavy metal base plate and pinned legs that can penetrate through the carpet to the subfloor has been found to work well.[2]

For timber floors with a floating flooring as finishing or a floating heavy topping, the accelerometer shall be attached to the underside of the floor.

5.2.3 Signal analyser

A signal analyser shall be used to process the time signals and shall use the fast fourier transform (FFT) method to convert the time domain signals into frequency domain. For signal analysers that also acquire the data, the equipment shall have at least two input channels for acquiring the excitation force signal and the floor response signal simultaneously. The sampling frequency shall be at least twice the highest frequency of interest in order to capture all the target natural frequencies of the test floor. As a minimum the outputs of the signal analyser shall include the Frequency Response Function (FRF) and Coherence Function.

5.3 Test procedures

5.3.1 General requirements and principles

The following principles shall be followed when performing the test procedure:

a) The locations for exciter and response measurement shall be selected in such a way that all the modal parameters of the modes of interest, such as natural frequencies, modal damping ratios, and mode shapes, can be obtained.

b) The modal parameters shall be extracted from a set of frequency response measurements between a fixed reference point on the floor and a number of roving points over the floor. The number of frequency response measurements shall be larger than or equal to the number of modes of interest.

The general procedure of modal testing shall consist of the following 5 steps:

a) Selection of excitation location (see 5.3.1.1);

