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Timber structures — Vibration performance criteria for timber floors

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html

This document was prepared by Technical Committee ISO/TC 165, *Timber structures.*

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Introduction

Timber floors are known to be prone to producing high level of vibration caused by human activities due to the light-weight nature of these systems. Given that human tolerance to floor vibration is rather subjective and could be influenced by a number of vibration response parameters, such as frequency content, peak vibration level (e.g. displacement, velocity and acceleration), mean vibration level and damping, there has not been any general agreement among researchers and code writers on the human acceptability criteria for design against objectionable floor vibration. With the advent of engineered timber floor products, it is necessary to provide generic guidelines on the establishment of human acceptability criteria for specific floor construction product. With the appropriate calculation procedures for response parameters, such human acceptability criteria can then be used by designers to predict floor vibration performance at the design stage. Such human acceptability criteria can also be used to evaluate floor vibration performance in the field or laboratory testing according to the test procedures given in ISO 18324.[1] To differentiate between these two types of human acceptability criteria, in this report, the criterion uses the measured parameters is called “Performance criterion”, and that uses the calculated parameters is called “Design criterion”.

Given that human tolerance levels to floor vibration may vary between countries due to cultural differences, floor construction products, and construction practices, it is felt that floor vibration performance criterion developed in one region may not be directly applicable to the others. Consequently it is the view of the ISO/TC 165 that a more fruitful approach is to provide guideline methods to individual countries and regions to develop their own human acceptability criterion. This is the main purpose of this document.

The methods reviewed in this document are intended to be used for establishing human acceptability criteria using the parameters that have been found to correlate well with human acceptability of timber floor systems. Generally a study is required that includes measurement or calculation of these parameters and a human subjective evaluation rating of the vibration performance of a number of floor systems in the field or in the laboratory, and subsequent statistical analyses to determine the best human acceptability criterion function. The proposed methods have been published in numerous research reports and peer-reviewed papers based on significant research efforts over the last four decades. They also have been validated by measurements and feedbacks on numerous field timber floors.

The potential floor vibration response parameters include fundamental natural frequency, static deflection under a concentrated load, peak-velocity, peak-acceleration, and root-mean-square acceleration. These parameters can be measured in the laboratory or in the field, and also can be calculated.

A comprehensive procedure is provided to establish human acceptability criteria using the measured or calculated response parameters and the subjective evaluation rating through advanced statistical analysis of a large database of timber floors. If the categorical variables of the subjective rating have more than two performance levels, a “Discriminant analysis” shall be used, while a “Logistic regression” can be used for the case of two performance levels. A simplified procedure is also provided for establishing human acceptability criteria using a relatively small database.

Annex A provides an example of questionnaire that was used in laboratory studies in Canada. Annex B demonstrates the application of the comprehensive procedure to establish a performance criterion for timber floors used in Canada (human acceptability criterion using measured criterion parameters). Annex C shows the application of the simplified procedure to establish a design criterion (human acceptability criterion using calculated parameters,) and the calculation formulae for the criterion parameters for cross laminated timber (CLT) floors used in Canada. Annex D presents the design criteria and the calculation formulae for the criterion parameters in EuroCode 5 (EC5).[5] Annex E presents the design criteria and the calculation formulae for the criterion parameters proposed by Hamm et al[8].

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Timber structures — Vibration performance criteria for timber floors

1 Scope

This document provides a review of key floor vibration design criteria (human acceptability criterion using calculated parameters) developed in research studies on timber floor around the world over the last 30 years. Associated design methods are provided in the Annexes. The methods proposed in this report are intended to be used for establishing human acceptability criteria for timber floor vibrations induced by walking activities.

The proposed methods are applicable to the following timber floors: lightweight floors made of timber joists and thin wood panel subfloor, heavy timber floors made of heavy timber beams with a thick timber deck, and mass timber slab floors such as cross laminated timber (CLT), nail laminated timber (NLT) and glued laminated timber.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

4 Background

A substantial amount of research efforts has been undertaken to develop human acceptability criterion for timber floor vibration control. Table 1 summarizes the most influential human acceptability criteria using calculated parameters, which is simply called “Design criteria”. Table 1 also summarizes the method used to develop the criterion, and the pros and cons of the criterion.

The Canadian National Building Code (NBC) presents provisions to control lumber joist floor vibration through limiting the floor deflection under a 1 kN load, see Table 1.[2] The NBC design criterion was developed based on research efforts by FPInnovations scientists between 1970s and 1990s.[3] Across Canada survey was conducted in 1970s. The survey included field testing and interview of the occupants using a comprehensive questionnaire. The questionnaire was developed in conjunction with statisticians and psychologist. A conversational approach was used so that the interview did not alert the occupants to the suspicion that the floor performance was likely to be of interest in the survey. The questionnaire included the following factors:

— previous experience of the evaluator on performance of floor,

— mechanical vibration of the floor by his/her own sensing and caused by others’ walking action,

— noise generated by the floor movement,

— visual effect caused by floor vibration.

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