Spatial variability in longitudinal elastic modulus of clear timber

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1 Introduction

Different factors such as age, location of timber within the tree, structural imperfections, load history such as wind and snow etc. can affect the material properties of timber taken from the same species, and grown in the same geographical location and local growth conditions. Consequently, there is a high variability in the mechanical properties [1-2]. This variability is both spatial and random, and is sometimes referred to as 'random spatial variability' [3].
Four groups of specimens of different lengths were prepared and their quasi-static behavior was experimentally investigated under tensile loading. In addition to the global displacement monitoring, the local deformations along the length of each specimen were measured. The effect of the mesostructure of the clear timber on the local elastic modulus was examined. The spatial variability of the elastic modulus was experimentally characterized. Also, Statistics concerning the elastic modulus for different lengths were derived and compared.

2 Experimental investigation

Clear Norway spruce wood was used for the specimens' preparation in this study. All specimens were conditioned to 12% moisture content and were tested at the laboratory temperature of 22±3 C°. The nominal lengths of the specimens were 2, 8, 32 and 128 mm with a square cross section of 2×2 mm^2. The total number of specimens for each length was ca. 40. Sample specimens are shown in Fig. 1a.

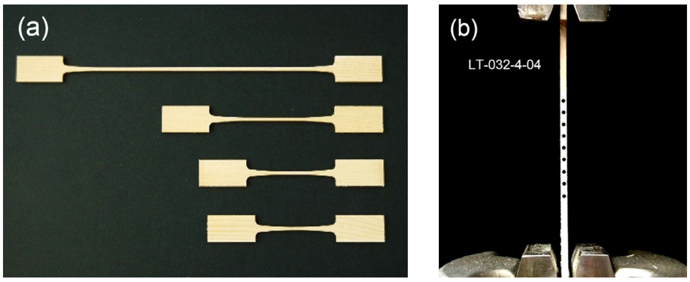

Fig. 1 a) Fabricated specimens b) Specimen with target dots

All experiments were carried out on a 25-kN MTS Landmark servo-hydraulic testing machine. Prior to the tests, small black target dots of 1.3-mm diameter were applied on the specimens' surfaces (Fig. 1b). The axial coordinates of the dots were recorded at a frequency of 5 Hz by the camera throughout loading using a videoextensometry system.

3 Results

Typical examples of the correlation between the local elastic modulus and the local mesostructure of spruce wood are given in Fig. 2a, considering two specimens of 128-mm

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length. In specimen LT-128-4-06 (LT is longitudinal tensile, 128 is length, 4 is cross section and 06 is specimen number), it can be seen that, initially, there is an obvious fiber misalignment that gradually diminishes so that the fiber becomes parallel to the nominal axis of the specimen. Subsequently, the fiber starts to deviate from the nominal axis again. Correspondingly, the local elastic modulus generally first increases and then decreases. In specimen LT-128-4-07, there is an obvious fiber waviness over the first few millimeters of the length, which is why the local elastic modulus suddenly increases from 8.0 GPa to 13.0 GPa. In Fig. 2b, spatial variability of all specimens of 18mm length are shown, and three indicative curves are highlighted. It can be seen that the variability in some specimens is low along their lengths and the local elastic modulus oscillates around the effective elastic modulus of the specimen. On the other hand, some specimens exhibit more significant changes in their local modulus. In Figs. 3a and b, statistics of the effective modulus whole nominal length of four groups of specimens are shown. The mean value does not change significantly with length, but the reduction in the COV is very significant.

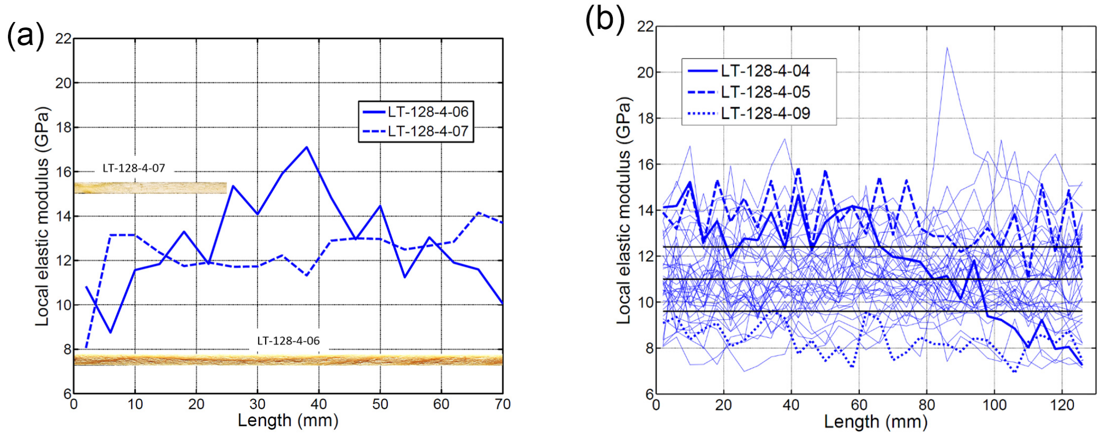

Fig. 2 a) Correspondence between mesostructure of spruce and variability of local elastic modulus b) Variation of local elastic modulus along length of 128-mm specimens

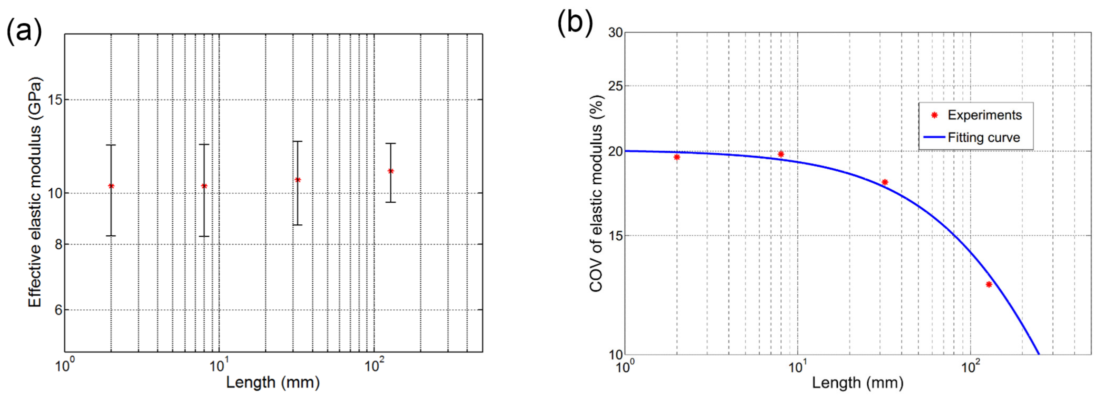

Fig. 3 a) Mean values of effective elastic moduli and b) COV of effective elastic moduli as function of specimen length.

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