The use of an acoustic technique to assess wood decay in laboratory soil-bed tests

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Abstract This study assesses the changes in elastic behaviour (i.e. modulus of elasticity – MOE) and mass loss of different hardwood and softwood species exposed to decay in laboratory soil-bed tests. Elasticity moduli were determined using conventional static methods as well as a dynamic method based on flexural vibration. The results obtained show a high correlation between dynamic and static bending measurements for all the timber species tested at different stages of fungal decay. Furthermore, the non-destructive MOE assessment proved to be a good tool for the early detection of wood decay.

Introduction
Methods generally applied to assess wood decay (e.g. mass loss detection, visual examination), although relatively simple to perform, are often destructive and not sufficiently sensitive to detect early stages of fungal decay. Strength testing has been reported to be a reliable test means to evaluate fungal attack of timber (Hardie 1980). Procedures for determining timber strength are relatively laborious and require stand-testing facilities; however, they provide quantitative and objective results. Assessment of the modulus of elasticity (MOE) is of particular interest for the evaluation of wood decay due to the non-destructive nature of this measurement.

Existing methods for determining MOE can be divided into two main groups, namely, static and dynamic test methods. Static techniques are conventionally used and described in most standards for MOE determination (e.g., EN 408 (1995) and DIN 52 186 (1978)). Dynamic methods, on the other hand, are based on resonant vibration excitation or ultrasonic pulse excitation of the test body (Görlacher 1984; Gray 1986). Although less frequently used, dynamic methods provide some advantages compared to static methods. Vibration techniques enable on-site measurements, they do not require laboratory stand equipment and they make possible a considerable reduction in testing time and labour costs.

Vibration methods were originally developed for the determination of the elastic constant (i.e., the Young’s module, shear modules and Poisson’s ratios) of

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isotropic materials. This methodology can also be used for purposes other than the global characterisation of the elastic behaviour of a material; e.g., for testing glue bonds in laminated lumber (Jayne 1955; Wang and Jwo 1985); determining moisture gradients in solid wood (Vermaas 1996); evaluating insect damages in construction wood (Lemaster et al. 1997); and assessing the quality of timber, lumber and wood-based panels (Dong et al. 1994; Schad et al. 1995; Walters and Westbrook 1970). Vibration techniques have also been applied for research purposes as a means to estimate the MOE of non-attacked wood (Görlacher 1984; Perstorper 1994). Little is known, however, about the applicability of this technique in the assessment of wood decay.

This study was set up to evaluate the potentials of non-destructive MOE methods for assessing wood decay in natural durability testing. For this purpose, both, the static and the dynamic MOE approach were employed. Bending measurements were compared with the mass loss data of attacked wood, the latter being the most conventional approach in wood decay assessment.

**Materials and methods**

**Wood species**

Untreated heartwood samples from four hardwood species differing in their susceptibility to fungal attack were chosen, namely: poplar (*Populus* spp.) (durability class – DC 5), elm (*Ulmus* spp.) (DC 4), keruing (*Dipterocarpus alatus*) (DC 3), teak (*Tectona grandis*) (DC1). Beech (*Fagus sylvatica*) (DC 5) specimens were included as a reference. The tested softwood species included spruce (*Picea abies*) (DC 4), larch (*Larix decidua*) (DC 3–4). Specimens from Scots pine (*Pinus sylvestris*) sapwood (DC 5) were used as reference material. The natural durability classification is according to European Standards (EN 350 1993).

**Laboratory soil-bed tests**

Wood decay was assessed in non-sterile soil-bed tests based on the European pre-standard ENV 807 (1993) under controlled environmental conditions promoting fungal attack (T = 26–28 °C; relative humidity = 70–80%). Plastic containers (360 × 550 × 190 (height) mm³) were supplied with different soil layers (bottom to top): 20 mm of gravel, 20 mm of river sand and 150 mm of loam-based horticultural soil composition. Soil moisture and soil temperature were monitored on-line using probes connected to a computer system. Experimental details of the laboratory soil test used are described in earlier work (Machek et al. 1997a).

Sixty specimens (10 × 5 × 100 mm³) per wood species were used. Specimens were placed vertically in the soil with 20 mm of their length protruding above the soil surface. Replicates were selected to be free of visual defects and to have approximately the same mass. The stakes were left to be moisture equilibrated at ambient conditions before exposition to soil.

**Monitoring**

Wood decay was assessed by determining the mass losses as well as the losses of both static and dynamic modulus of elasticity (MOE) at different stages of wood decay, most commonly after 6, 12, 18, 26 and 34 weeks of exposure. After each exposure period, a replicate set of 10 stakes was withdrawn from the soil-bed randomly. Stakes were cleaned from any adherent mycelium and soil. Prior to strength measurement, the stakes were saturated with water. For this purpose, stakes were placed in a vacuum vessel for approx. 60 h.