Non-destructive testing of timber

Non-destructive testing of masonry

Construction issues

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the material strength properties. Actually, wood hardness involves components of other mechanical characteristics (strengths) and it is reversely proportional to the moisture content, see Table 1. Of course, hardness is further dependent on the surface orientation. It is higher on the cross-section face than on the longitudinal faces. This difference attains 40% in coniferous wood and 30% in deciduous species. There is no or little difference between radial and tangential faces, see Table 1 [6]. Radial hardness is higher than tangential (about 5-10 %) in deciduous trees with significant amount of wood rays, as e.g. in oak or beech [7].

Table 1 Comparison of static hardness values for selected wood at various moisture content [6].

	Wood hardness in MPa					
Wood species	**Cross-section**		**Radial face**		**Tangential face**	
	12%	30%	12%	30%	12%	30%
Larch	43,5	20,5	29,0	13,5	29,0	14,0
Pine	28,5	13,5	24,0	11,0	25,0	11,5
Spruce	26,0	12,0	18,0	8,5	18,5	8,5
Acacia	97,0	57,7	68,0	40,5	78,0	46,5
Ash w.	80,0	48,0	59,0	35,0	67,0	39,5
Oak	67,5	40,0	56,0	33,5	49,0	29,0
Beech	61,0	36,5	43,5	25,5	44,5	26,5
Hornbeam	90,5	54,0	77,0	45,5	78,5	47,0
Lime-tree	26,0	15,5	17,5	10,0	18,0	10,5

From the Table 1 it follows that the static hardness changes by about 3% in relation to a relevant moisture content change of about 1%.

With laboratory devices other hardness measurement techniques may be applied. For example, the classical Brinell hardness test or the Janke hardness test modification. They do not differ in principle from the Piazza method described above.

As it has been already mentioned, the static indentation technique has a potential for in situ measurements of local compressive strength. Moreover, such measurements may be carried out in different depths and a change of material properties along the timber profile may be followed.

3 Surface dynamic indentation

The dynamic indentation uses a slender steel rod or pin of a given diameter, which is driven into the wood by a dynamic force usually generated by releasing a compressed spring.

For practical measurements a set of commercially available PILODYN devices is used. This mechanical instrument has been developed in Switzerland and shoots a thin steel rod of 2.5 mm in diameter against the tested surface with a constant energy dependent on the stiffness of the spring of individual devices. There are typical devices with 6J, 12J and 18J stiffness, and one specific type 4JR offering repetition of shooting. Different spring stiffness is utilized for wood density or degradation level [8]. The PILODYN device enables to measure the depth of penetration of the driven rod into the wooden surface, (Figure 3). The typical range of measurement covers depth between 0 and 40 mm and the result is displayed on the scale of the device.

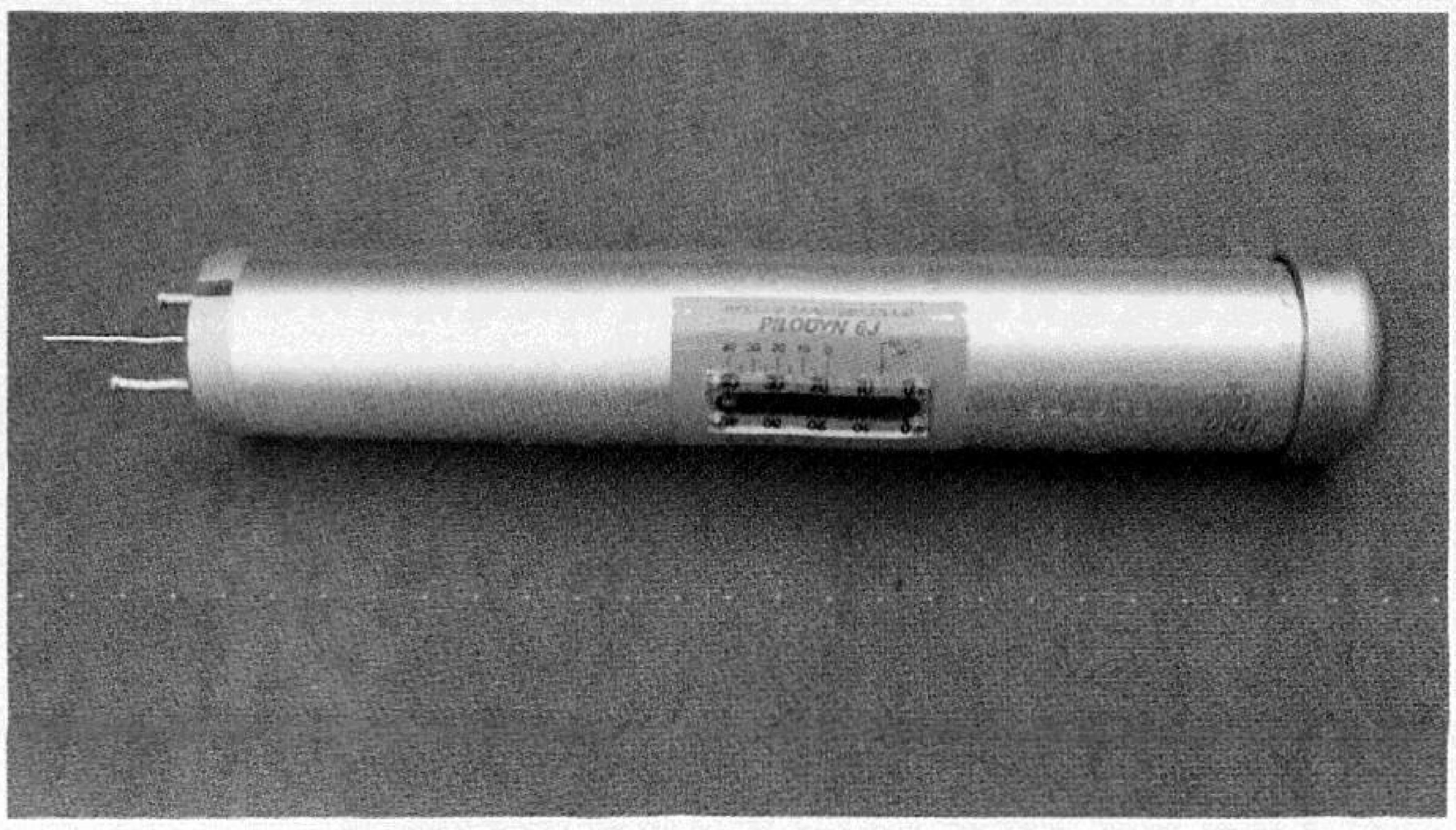

Figure 3 Dynamic indentor Pilodyn F6J Forest.

The depth of penetration correlates quite well with material density [9], [10]. The density is one of the key material characteristics of wood which is useful for prediction of other material characteristics as well as it is indispensable for interpretation of other physical measurements, e.g. the velocity of sound propagation. The measurement of density is quite precise. Correlation coefficient for dependence density on the depth of penetration varies between 0.74 and 0.92 according to Görlacher [9], in relation to number of measurements and species, which calls for calibration. Developed empirical relations are influenced mostly by moisture content [11], [12], [13]. For example, for spruce the following 5% regression formula (2) can be used [14]:

$$\rho_{12} = -0.027102\ t\,\rho_{12} + 0.727987 \tag{2}$$

$$t\,\rho_{12} = t\,\rho\,(1 - 0.007\,\Delta w) \tag{3}$$