Viscoelastic layer model for assessing the mechanical properties and viability of articular cartilage using rebound indentation test

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The so-called rebound indentation test for time-dependent materials is considered following a recent paper by C.P. Brown, R.W. Crawford, and A. Oloyede (An alternative mechanical parameter for assessing the viability of articular cartilage. *Proc. Inst. Mech. Eng.*, Part H **223** (2009), 53–62.). The test is assumed to be composed of two stages. In the first stage, called the indentation phase, the sample is subject to loading at a constant speed v_0 to n_1 per cent strain. That is the indenter displacement is assumed to be specified according to the law

$$w^{(1)}(t) = v_0 t, \quad 0 \le t < t_1. \tag{1}$$

Further, we assume that at n_1 per cent strain the load is immediately removed and the second stage, called the recovery phase, lasts for a theoretically indefinite time. In the recovery phase, we have

$$P^{(2)}(t) = 0, \quad t \ge t_1. \tag{2}$$

We underline that in the first stage, the function $w^{(1)}(t)$ is specified by Eq.(1), while $P^{(1)}(t)$ is unknown. In the second stage, on the contrary, the displacement function $w^{(2)}(t)$ is unknown, whereas the contact loading $P^{(2)}(t)$ is specified by Eq.(2).

The rebound indentation test for a cylindrical at-ended indenter was theoretically investigated by I. Argatov and G. Mishuris (Flat-ended rebound indentation test for assessing viability of articular cartilage: Application of the viscoelastic layer model. arXiv:1102.2054v1). In the present study, the generalized rebound indentation test with an arbitrary monotonic indentation history $w^{(1)}(t)$, $0 \le t < t_1$, is considered. In the framework of viscoelastic layer model, the governing integral equation of the associated linear contact problem for a flat-ended arbitrary indenter is formulated, and a closed-form solution for the rebound displacement function $w^{(2)}(t)$ for $t \ge t_1$ is obtain. Explicit formulas are derived for a viscoelastic layer following a standard linear viscoelastic solid model.