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A generalized model for stability of trees under impact conditions

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Stability of trees to external actions involve the combined effects of stem and tree root systems. A block impacting on the stem or an applied force pulling the stem can cause a tree instability involving stem bending or failure and tree root rotation. So different contributions are involved in the stability of the system.
The rockfalls are common natural phenomena that can be unpredictable in terms of frequency and magnitude characteristics, and this makes difficult the estimate of potential hazard and risk for human lives and activities. In mountain areas a natural form of protection from rockfalls is provided by forest growing. The difficulties in the assessment of the real capability of this natural barrier by means of models is an open problem. Nevertheless, a large amount of experimental data are now available which provides support for the development of advanced theoretical framework and corresponding models.
The aim of this contribution consists in presenting a model developed to predict the behavior of trees during a block impact. This model describes the tree stem by means of a linear elastic beam system consisting of two beams connected in series and with an equivalent geometry. The tree root system is described via an equivalent foundation, whose behavior is modelled through an elasto-plastic macro-element model.
In order to calibrate the model parameters, simulations reproducing a series of winching tests, are performed. These numerical simulations confirm the capability of the model to predict the mechanical behavior of the stem-root system in terms of displacement vs force curves.
Finally, numerical simulations of the impact of a boulder with a tree stem are carried out. These simulations, done under dynamic regime and with the model parameters obtained from the previous set of simulations, confirm the capability of the model to reproduce the effects on the stem-roots system generated by impulsive loads.