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Simplified Modeling of Post-Soil Interaction for Roadside Safety Barriers

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Abstract : The performance of road side safety barriers depends largely on the dynamic interactions between post and soil. These interactions play a key role in the response of barriers to crash testing. In the literature, soil-post interaction is modeled in crash test simulations using three approaches. Many researchers have initially used the finite element approach, in which the post is embedded in a continuum soil modelled by solid finite elements. This method represents a more comprehensive and detailed approach, employing a mesh-based continuum to model the soil's behavior and its interaction with the post. Although this method takes all soil properties into account, it is nevertheless very costly in terms of simulation time. In the second approach, all the points of the post located at a predefined depth are fixed. Although this approach reduces CPU computing time, it overestimates soil-post stiffness. The third approach involves modeling the post as a beam supported by a set of nonlinear springs in the horizontal directions. For support in the vertical direction, the posts were constrained at a node at ground level. This approach is less costly, but the literature does not provide a simple procedure to determine the constitutive law of the springs The aim of this study is to propose a simple and low-cost procedure to obtain the constitutive law of nonlinear springs that model the soil-post interaction. To achieve this objective, we will first present a procedure to obtain the constitutive law of nonlinear springs thanks to the simulation of a soil compression test. The test consists in compressing the soil contained in the tank by a rigid solid, up to a vertical displacement of 200 mm. The resultant force exerted by the ground on the rigid solid and its vertical displacement are extracted and, a force-displacement curve was determined. The proposed procedure for replacing the soil with springs must be tested against a reference model. The reference model consists of a wooden post embedded into the ground and impacted with an impactor. Two simplified models with springs are studied. In the first model, called Kh-Kv model, the springs are attached to the post in the horizontal and vertical directions. The second Kh model is the one described in the literature. The two simplified models are compared with the reference model according to several criteria: the displacement of a node located at the top of the post in vertical and horizontal directions; displacement of the post's center of rotation and impactor velocity. The results given by both simplified models are very close to the reference model results. It is noticeable that the Kh-Kv model is slightly better than the Kh model. Further, the former model is more interesting than the latter as it involves less arbitrary conditions. The simplified models also reduce the simulation time by a factor 4. The Kh-Kv model can therefore be used as a reliable tool to represent the soil-post interaction in a future research and development of road safety barriers.

Keywords : crash tests, nonlinear springs, soil-post interaction modeling, constitutive law
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