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Simulation of Concrete Wall Subjected to Airblast by Developing an Elastoplastic Spring Model in Modelica Modelling Language

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Abstract : To meet the civilizations future needs for safe living and low environmental footprint, the engineers designing the complex systems of tomorrow will need efficient ways to model and optimize these systems for their intended purpose. For example, a civil defence shelter and its subsystem components needs to withstand, e.g. airblast and ground shock from decided design level explosion which detonates with a certain distance from the structure. In addition, the complex civil defence shelter needs to have functioning air filter systems to protect from toxic gases and provide clean air, clean water, heat, and electricity needs to also be available through shock and vibration safe fixtures and connections. Similar complex building systems can be found in any concentrated living or office area. In this paper, the authors use a multidomain modelling language called Modelica to model a concrete wall as a single degree of freedom (SDOF) system with elastoplastic properties with the implemented option of plastic hardening. The elastoplastic model was developed and implemented in the open source tool OpenModelica. The simulation model was tested on the case with a transient equivalent reflected pressure time history representing an airblast from 100 kg TNT detonating 15 meters from the wall. The concrete wall is approximately regarded as a concrete strip of 1.0 m width. This load represents a realistic threat on any building in a city like area. The OpenModelica model results were compared with an Excel implementation of a SDOF model with an elastic-plastic spring using simple fixed timestep central difference solver. The structural displacement results agreed very well with each other when it comes to plastic displacement magnitude, elastic oscillation displacement, and response times.

Keywords : airblast from explosives, elastoplastic spring model, Modelica modelling language, SDOF, structural response of concrete structure
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