A NEW TIME INTEGRATION SCHEME FOR SHOCK PROPAGATION IN SATURATED SOIL

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In the Netherlands, a study is underway to determine the possible consequences of allowing vessels carrying hazardous materials to use underground tunnels. A direct consequence of such an act is the increase in likelihood of a BLEVE or gas explosion in a tunnel to occur. BLEVE is a boiling liquid expanding vapour explosion which results as a consequence of violent rupture of a pressure vessel containing a liquefied gas. Such kind of explosions might exert serious damage to the tunnel structure, inducing a ground shock loading in the surrounding region.

The impulsive loading due to such explosions is of a high frequency nature, and as such numerical modeling of the effect on the surrounding region might require enormous computational power. Nevertheless, several attempts have been reported for modeling the behavior of soil under such a loading condition. In these works the focus was on the development of constitutive models for describing soil behavior under blast loading. Little attention was given to the numerical procedure used to solve the involved system of equations efficiently.

This paper presents a time integration scheme capable of simulating blast loading of relatively high frequency wave propagation in porous media using coarse meshes.
In order to avoid the use of fine meshes, the partition of unity method for the discretization of the time domain was utilized. The developed scheme is referred to as the partition of time unity (PTU). The PTU is a polynomial enhancement procedure which is capable of simulating discontinuities or high gradient fields within a element. The developed time integration scheme is unconditionally stable and has controllable numerical dissipation in the high frequency range. The time scheme has been implemented and combined with Biot's theory of wave propagation in two-phase media. Numerical examples have demonstrated that the proposed time scheme is, in addition to being accurate and stable, highly effective for coarse meshes. This makes the developed scheme suitable for large scale finite element analysis.

Outlines of the new time integration method and the BIOT theory will be presented in the paper. The features of the method are illustrated in numerical examples. Comparison with other time integration methods and with single phase soil models are given. Finally the induced ground shock due to an explosion in a tunnel is presented to illustrate the engineering applicability of the developed technique.