COMPUTATIONS OF EXPERIMENTS ON SEISMIC EXPLOSION WAVE IMPACT ON UNDERGROUND CONSTRUCTIONS USING STEP-BY-STEP PROCEDURE

E. V. Shuvalova, A. A. Krayukhin, E. I. Naumova, T. V. Rezvova, D. Yu. Dyanov, M. V. Ilyina, A. P. Tikhonova, T. E. Sinatova

FSUE «RFNC – VNIIEF», Sarov, Russia

Currently, the urgency of evaluating the level of seismic explosion wave impact on subsurface facilities is increasing. The peculiarity of such computations is the diversity of the studied processes both in terms of time and space. Such computations are complex and require a number of physical processes to be accounted for, while keeping high accuracy of their description. High accuracy can be also achieved by shock-capturing which covers maximum possible number of numerical simulation steps with minimum interference in the computing process.

The paper presents a computational procedure comprised of three steps, according to the time structure of processes of the considered experiments:

1-st step – computation of the initial stage of explosion development;

2-nd step – computation of seismic explosion wave generation and propagation;

3-rd step – computation of seismic explosion wave interaction with an underground facility.

The first step involves the computation of charge explosion with due regard for, if needed, heat propagation over the ground surface. The location of the charge relative to the soil surface can be different. The computation of the second and third steps requires the use of models for describing the soil behavior in a wide range of changes in its deformation characteristics. To perform shock-capturing, the combined soil model was proposed to be applied for near and far zones of shock wave propagation.

To solve the third-step problem, the counting technique of the coupled problems using the Lagrangian-Euler coupling FSI (Fluid Structure Interaction) was applied. The principle of the method is that for solving the problems on deformation of robust constructions and on propagation of disturbances in their environment, different computation methods are used, and the interfacial interaction is provided by using the coupling algorithm. The robust construction deformation is computed using the Lagrangian solver “Logos Prochnost” [1], and wave propagation in the environment is computed using the Euler approach of the LEGAK method [2].

The connection between the computation procedure steps is provided by the regridding program in the case of a change in the dimension of the problem or mathematical grid topology. As the wave propagates in the soil ground, the procedure of extending the mathematical domain in the shock-capturing process was applied. The dimension of the problems at each step depends on set-up characteristics.

The paper presents the numerical study of two experiments to evaluate seismic explosion wave impact on the underground tunnel [3] and on underground reinforced concrete structure [4]. The shock-capturing procedure was practiced on computations in order to describe the results of these experiments. The computation results are consistent with the experimental data in terms of the kind of concrete tunnel damage and reinforced concrete slab deformation.

References

1. Software package «Logos» [Electronic resource], URL: http://logos.vniief.ru/products/logos (in Russian).
2. **Bakhrakh, S. M.** LEGAK program system for computing unsteady flows of multicomponent continuous medium and principles of system implementation on multiprocessor distributed-memory computers [Text] / Bakhrakh S.M., Velichko S.V., Spiridonov V.F. et. al. // Problems of Atomic Science and Technology. Ser. “Mathematical modeling of physical processes”. – 2001. – Iss. 3. – P. 14–18. (in Russian).
3. **Mobaraki, B.** Numerical study of the depth and cross-sectional shape of tunnel under surface explosion [Text] / B. Mobaraki, M. Vaghefi // Tunnelling and Underground Space Technology. – 2015. – Vol. 47. – P. 114–122.
4. Modeling coupled blast/structure interaction with Zapotec, benchmark calculations for the Conventional Weapon Effects Backfill (CONWEB) tests [Text]: preprint. Sandia; Bessette G.C.; SAND2004-4096. Sandia, 2004.