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MECHANISM OF EXPLOSIVE CAVITY FILLING BY STRUCTURE-FORMING MATERIAL

Vertical cavity formation near the free surface with its simultaneous filling by structure-forming material is considered. Possibilities and features using oscillatory occurrences near an explosion site to control the vertical filling material transportation process during its primary enlargement are researched.

Рассматривается образование вертикальной полости вблизи свободной поверхности с одновременным ее заполнением структурирующим материалом. Изучаются возможности и особенности использования колебательных явлений вблизи очага взрыва для управления процессом транспортирования материала заполнителя в полость в период ее первого расширения.

Розглядається утворення вертикальної порожнини поблизу вільної поверхні з одночасним її заповненням матеріалом, що структурує. Вивчаються можливості і особливості використання коливальних явищ поблизу вогнища вибуху для управління процесом транспортування матеріалу заповнювача в порожнину в період її першого розширення.

Introduction. Formation of a vertical cavity by an elongated charge in a detrimental soil with its simultaneous or subsequent infill with a structure-forming material is essentially complicated by pulsating processes during the crack formation as well as by inability of structurally deformed detrimental soil in cavity walls to oppose a rarefaction wave action during the inverse pulsation process [1, 2]. In this connection, possibilities and features of the processes of simultaneous or consecutive infill of a vertical explosive crack with the solution are investigated.

The traditional way of infill of a gaseous cavity consists in mud placement in the opening (crack) formed by explosion through the embedment from a surface with the help of forces of gravitation only. However, in structurally soft floor which lose its connectivity under the influence of deformation processes irreversibly and because of fragility and instability of a compacted layer on the boundary with a gaseous cavity, life time of an opening is much less than time necessary for grouting. Hence, other solutions which could time these two processes need to be found.

In some cases, in order to get a steady cavity in soft floor it is enough to dabble soil around the hole before detonation, or it would be even better to spacefill the hole with a fastening mud where the elongated charge should take place. If system of piles, sandy drains [3, 4] or curtain walls are formed in soft floor as a result of explosion, it is enough to slow down back motion of walls of a cavity for some time - till the moment when the filling material would be pulled down in a cavity from a surface under gravity or under the influence of other forces. This method could be used in case with a formation of a vertical curtain (“wall in soil” type) when the mud of a water-resistant material [5] is moved in the crack formed by detonating of system of parallel vertical charges, for example.

As the cavity development begins on the contact of the upper end of a charge with a sandy stratum and explosive gases have no loose from a cavity, it is possible to enable the prevalence of pulsation along the axis of a cavity from the surface of the environments separation. This process may be enabled by a shockwave, as well, which is reflected from the boundary of separation of two beds (when it is a rarefaction wave).

For the approximate calculations it is possible to be oriented on the mass rate in a shockwave during the detonation process in a sandy ground:

$$u_2 = u_3 = 4{,}72\left(\frac{R}{\sqrt[3]{Q}}\right)^{-2,,06}, \text{ m/s.}$$

According to the resulted data in actual practice during the construction of the shield recess of a face part of elongated charge Q, which repeats the action of a concentrated charge (an index of operating of detonation $n = 2$) will be with $C_{П}$=1,0 kg/m approximately 0,2 m. Then the value of mass rate will equal

$$u_2 = 4{,}72 \cdot Q^{2/3} / R^2 = 118 \text{ m/s.}$$

As the vertical direction of soil mass parts movement over a charge and accordingly a sealer coincides with a direction of operating of force of terrestrial gravitation, we will make calculations by analogy with a body free fall.

If travelling speed of a falling body is $v = \sqrt{2gh}$ where g is gravitational acceleration, or in our case – initial acceleration under the influence of a rarefaction wave, h is depth of fall (we will take 5,0 m for our calculations) then apparent acceleration of initial mass rate $v = 118$ m/s is:

$$g = \frac{u^2}{10} = 1400 m/s^2.$$

From the relation $h = 0{,}5gt^2$ we will calculate a possible mud fall time:

$$t = \sqrt{\frac{2h}{g}} = 0{,}085 s = 85 ms.$$

The calculated time of a mud falling into a cavity under the influence of a rarefaction wave that leads to «collapse» of gas cavities is comparable to the time of cavity expansion.

To check of the results, modelling physical studies are conducted. The method experiments envisaged the detonation of an elongated charge 70 mm length and 4 mm in diameter in dry sandy ground at recess of its upper end within 0 … 70 mm from the surface of a soil massive (fig. 1).

To control the movements of a ground surface, a metal disc of 26 mm in diameter was placed over the charge (fig. 2). It centre coincided with a charge axis. Then, coaxial with a charge on a ground surface, the cylindrical transparent container 104 mm in diameter was placed fastened on a basis of a larger horizontal disk which intended for prevention of breakthrough of explosive gases into the atmosphere during detonating of a charge and scattering of sand from a face part of an explosion chamber. The container was filled with dry sand necessary for creation of tightening over a charge and to infill the cavity, formed during detonation.

Fig. 1. Modelling elongated charge

Fig. 2. Metal disk over the charge

During the experiment three parameter were fixed: magnitude of recess of the upper end of the charge under a source surface of a soil massive, magnitude of subsidence of sand in the container after detonating, and a depth of immersion in soil of the metal disk which had to confirm the presence and scale of the effect of the ground vertical fall acceleration from high layers in the cavity during the pulsating movements in the cavity and the surrounding massive. Results of the studies are on fig. 3 - 4.

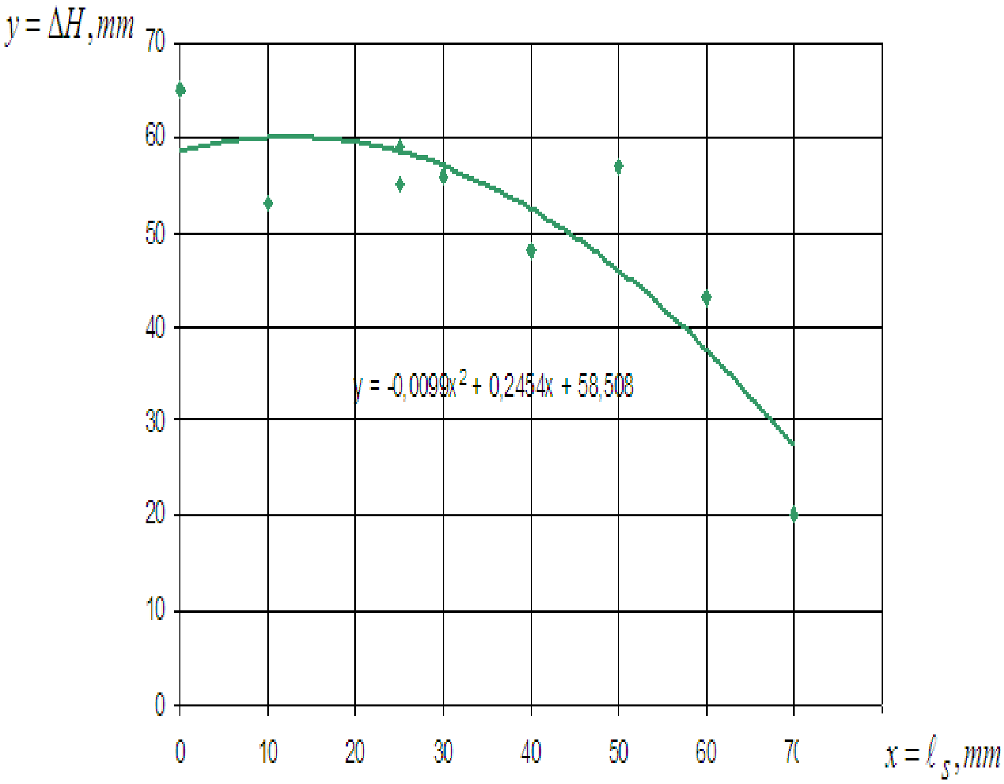

Fig. 3. Dependence of magnitude of sand level lowering in the container after detonation on the tightening size

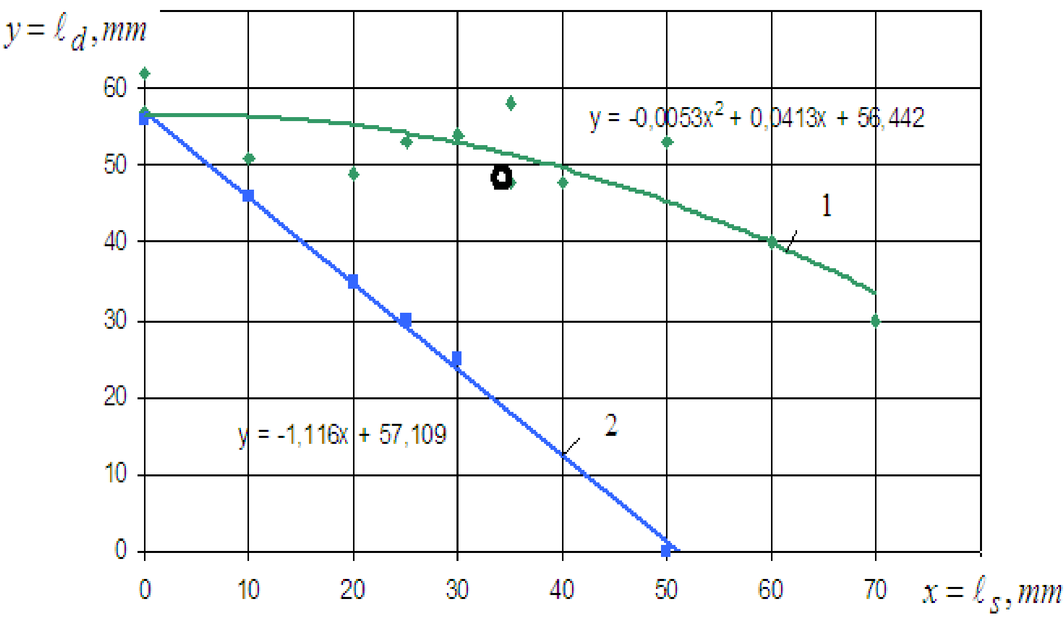

Fig. 4. Dependence of depth of a disk on the tightening size: 1 - in a daylight area; 2 - in the upper end of the charge.

Conclusion. The analysis of the given dependances (fig. 3–4) allows to arrive at the following conclusions:

- the recess of the vertical charge 70 mm ($l_s = 0$) long without vertical deepening, i.e. the placement of the contact end on a surface the magnitude of the disk submergence after detonating was comparable to the length of a charge and was approximately 60 mm;

- according to experimental conditions the possibility of sand blowout in the cavity top is almost excluded that is why the cavity infill occured mainly on account of sand from the container that is confirmed by the disk submergence. Only in the bottom face part of the charge at 60 mm level and lower the cavity is spacefilled by its own soil under the influence of a pulsation (radial and axial).

- at a later stage, when the spacing interval increase between the disk and the upper end of the charge, the progressing of dependences $\Delta H(l_s)$ and $l_m(l_s)$ is identical, i.e. the magnitude of sand level lowering in the container is compared to the disk submergence in a cavity and these magnitudes reach zero point at depth of the tightening about 82 mm or more than $20d_з$ of the charge;

- hence, at such a recess the cavity is spacefilled with the ground located under the metal monitor disk. Soil which is pulled down from the container with value ls does not reach the cavity and only confirms the deepening of the abovecavity block into the cavity with the force $\approx$ 50 mm. We arrive to the conclusion that in experimental conditions the most acceptable alternative to perform the combined technology is the placement of the upper end of the charge on the contact with the filler placed into the container;

- additional conformation of the vertical pulsations importance for the cavity infill process is an experiment dotted on the dependence 1 (fig. 2) which is circuled. This experiment is conducted in the same conditions but sand can not deepen from the container. For this purpose sand in the container was separateed from the basic massive at the level of its basis by a special bar. In this case at $l_s = 35mm$ the magnitude of the disk deepening practically did not differ from the same magnitude in the experiment where sand could fall down from the container. It means that soil in the container is not the main source of the pulsating process, and only supplies material for complete or partial infill of the cavity.

- the main conclusion from the carried experiments is the fact that time advance of the block movement over the charge towards the explosion chamber under the influence of vertically directional pulsations in comparison with horizontal movements of a massive.

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