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Experimental Measurements on a Concrete Destruction Volume for the Electric Explosion Model Verification

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Abstract. *Experimental results on a concrete samples explosion with electric discharge are presented here. A study purpose is to verify a developed mathematical model on electric blast in concrete. The obtained experimental data (as energy in a discharge circuit, a number and size of formed cracks) have been made possible to introduce additional adjustments on a mathematical model for electric explosion depended on an energy input mode, voltage value, pulse velocity, etc. The results on electric explosion of a concrete block are presented here when the discharge channel is simultaneously initiated in one blast-hole and initiated in two blast-holes. The work results are used on to verify the model of electric-discharge destruction for concrete as well as reinforced concrete products.*

Keywords: *concrete, destruction, electric discharge, channel, explosion, blast, voltage generator, impulse, voltage, electrodes.*

Introduction

Electric explosion in inhomogeneous media is a fundamental phenomenon in the electro physical processes in dielectrics and determines a materials behavior in strong electric fields. A research importance is related to promising electric discharge technologies as for materials crushing, cleaning from surface deposits and removing of surface layers, destroying oversized materials during mining, and reconstruction of facilities, tunnels construction, production of bored piles, etc. [1-4].

Despite numerous experimental and theoretical studies, a consistent theory describing all aspects of electric discharge destruction has not been created yet. Theoretical difficulties are caused both by a complexity of the analytical description for stochastically developing discharge channels and cracks, and as well as by a problem of same consideration on electrical and mechanical processes [5-8].

Besides, discharge channels and cracks form three-dimensional structures, a shape of which can significantly affect on a destruction process. Only certain aspects of this phenomenon are considered in experimental works. Therefore, there is not only a physical and mathematical model of these processes in its connection, but also in its unified phenomenological description.

Thus, a solution of the following issues is here important: a development of appropriate computational models which quantitatively describe a discharge phenomenon in materials under processing. A same important task is verification of these models on a basis of experimental studies as; mode selection, optimal parameters for a pulse power equipment and electrode systems for technology of electric discharge spalling and of concrete or reinforced concrete destruction. For this, the experimental studies have been carried out which will be used both as selected results and will be as a basis for the mathematical and computer models adjustment.

Description of materials and experiment methods

Model test equipment for electric-discharge spalling and concrete destruction has been applied in order to carry out experimental studies on a blast-hole electric explosion and to measure of generated cracks lengths. Experimental were carried out on the M300 type of concrete poured into a ground. The experiments were carried out on the basis of a partner of the Tomsk Polytechnic University [9].

A body sample is the monolithic concrete block of M300 concrete sized as 3000 × 1500 × 1200 mm. The concrete block was poured into a ground while a top of the block was placed at the ground level. There was a free 50 cm space between a ground level and one of a side face. An external image of the massif-body simulator is shown in Figure 1.

Study on stage-by-stage destruction from the monolithic concrete block by the electric discharge method was done as an initiation of the discharge channel in one blast-hole and in two blast-holes simultaneously. The blast-holes of 26 mm diameter were drilled vertically at a distance of (30-50) cm from each other, and at a distance of 20 to 50 cm from a free side of the monolithic concrete block. A blast-holes depth was from 50 to 80 centimeters. The generator started to operate at 12 kV, 13 kV and 14 kV of voltage with 1120 μF of a total generator capacity. Water or polyethylene has been served in a blast-hole as a transmission medium. Experimental has been carried out with not of 5 times less for each combination.

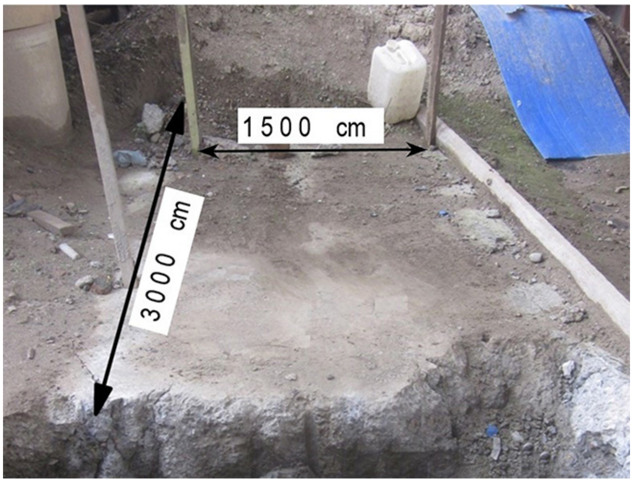

Figure 1 – Monolithic concrete block as a body simulator

Experiments with an initiation of the discharge channel in one blast-hole have been successively done for each blast-hole. The current and voltage pulse shape obtained in one measurement are given in Figure 2.

Based on those test oscillograms the diagrams for released energy in a discharge circuit at different voltages have been developed (Figure 3).

Figures 4 and 5 shows a monolith section with prepared blast-holes and cracks formed after a series of electric blasts.

A series of tests were performed with an initiation of the channel discharge in two blast-holes simultaneously. The experiments at the same time were carried out as an initiation of the discharge channel in two blast-holes. Blast-holes were drilled in pairs on a one line with a same depth (h), and a distance from the block edge to the blast-hole center (d) has been constantly increased. A step between the blast-holes lines was chosen as 25 cm, and a distance between the one line blast-holes is of 40 cm.

Discussion

Table presents the results of experimental studies of a blast-hole breaking from a monolithic concrete block when initiating of discharge channel takes place in two holes simultaneously.

Electric blast (explosion) in concrete at indicated energy values as shown in Table 3 causes in rare case of cracks developing of more than 25 cm length. This is mostly related to a time of energy release and a speed of shock wave propagation in concrete. At energy distribution time of 200 μs realized in

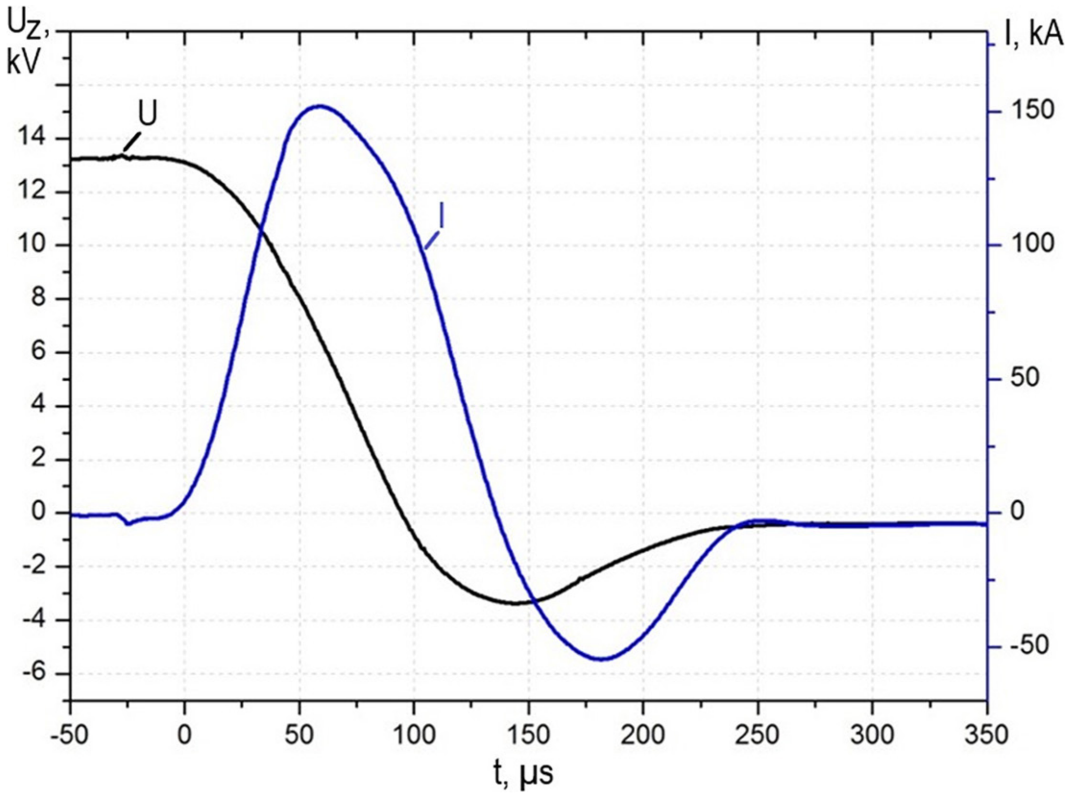

Figure 2 – Current and Voltage oscillogram

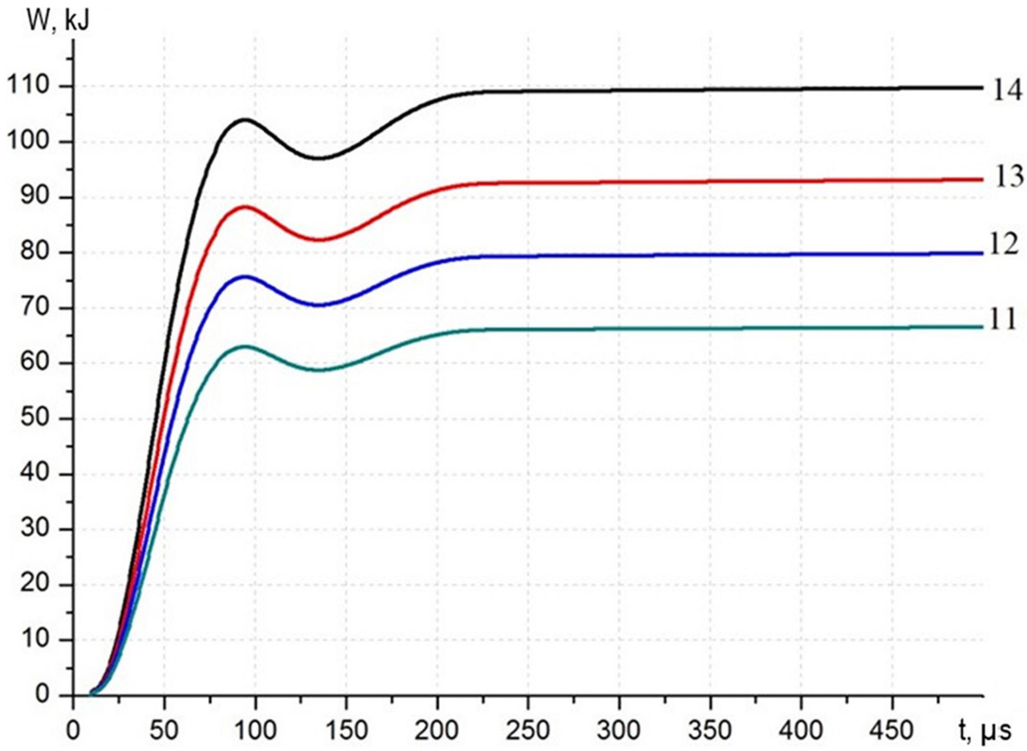

Figure 3 – Energy in discharge circuit

presented tests, a shockwave the order is (realized in real experiments), a shock wave in concrete manages to pass a distance of (50-55) cm order [10]. Therefore, when a distance to free surface increases by more than 30 cm, this does not already form a main crack.

Figure 4 – Blast-holes with installed cartridges

Figure 5 – Cracks between blast-holes after a series of electric blasts

Break off a monolithic concrete block		
W_b, kJ	d, cm	Result
67	25	2 main cracks from blast-holes to the block edge of 22 and 25 cm
67	50	cracking in a blast-holes area with cracking radius of 4-5 cm
67	75	cracking in a blast-holes area with cracking radius of 2-3 cm
80	25	main crack along a whole block width through the blast-holes centers, from the blast-holes centers expand as 2 cracks of 20 cm by length
80	50	main crack along a whole block width through the blast-holes centers with multi-cracks between the blast-holes
80	75	main crack between blast-holes, small cracks with 10 cm of length developed from a center
94	25	2 main cracks along a whole block width through the blast-holes centers 2, almost a whole massif fragment is broken off
94	50	main crack between the blast-holes, branches off as many small cracks
94	75	3 cracks in between blast-holes of 25, 30 and 28 centimeters

Conclusion

The results of experimental studies have been used in mathematical and computer models adjustment which make possible a simulating at all stages of electric explosion in various parameters of capacitive pulse generators, and for materials of different dielectric, acoustic, thermodynamic, and mechanical properties.

Based on this described model of electric-discharge spalling a numerical algorithm has been developed which makes possible to carry out computer simulation for an electric-explosive spalling in solid media.

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Электрлік жарылу моделін айқындау үшін бетонның бұзылу көлемін эксперименттік өлшеу

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***Аңдатпа.** Бұл мақалада бетон үлгілерін электр разрядымен жару тәжірибесінің нәтижелері келтірілген. Зерттеудің мақсаты-бетондағы электр жарылысының дамыған математикалық моделін тексеру. Алынған эксперименттік деректер (разрядтық тізбектегі энергия, пайда болған жарықтардың саны мен мөлшері) Электржетек режиміне, кернеу шамасына, импульс жылдамдығына және т.б. байланысты электр жарылысының математикалық моделіне қосымша түзетулер енгізуге мүмкіндік береді. Бір теспеде разряд каналын іске қосу және бір уақытта екі теспеде іске қосу кезінде бетон блогының электрлік жарылысының нәтижелері келтірілген. Нәтижелер бетон және темірбетон бұйымдарының электрлік разрядты бұзылу моделін тексеру үшін қолданылады.*

***Кілт сөздер:** бетон, сыну, электр разряды, канал, жарылыс, кернеу генераторы, импульс, кернеу, электродтар.*

Экспериментальные измерения объема разрушения бетона для верификации модели электровзрыва

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***Аннотация.** В настоящей статье приведены результаты эксперимента взрыва образцов бетона электрическим разрядом. Целью исследования является верификация разработанной математической модели электрического взрыва в бетоне. Полученные экспериментальные данные (энергия в разрядном контуре, количество и размер образовавшихся трещин) позволяют внести дополнительные корректировки математической модели электровзрыва в зависимости от режима энерговвода, величины напряжения, скорости импульса и т.п. Приведены результаты электрического взрыва бетонного блока при инициировании канала разряда в одном шпуре и одновременном инициировании в двух шпурах. Результаты использованы для верификации модели электроразрядного разрушения бетонных и железобетонных изделий.*

***Ключевые слова:** бетон, разрушение, электрический разряд, канал, взрыв, генератор напряжения, импульс, напряжение, электроды.*

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