Physico- Mathematical Modeling and Experimental Study of Cracks in Concrete Obtained by Exposure to a Pulsed High Voltage Discharge

Long Che
Nanjing University of Sci. & Tech
No.200,Xiaolingwei street,Xuanwu District, Nanjing, Jiangsu Provinc
Nanjing, China
564799167@qq.com

Hongda Li
Shenyang Ligong University
No.6,Nanping Middle Road, Hunnan New Distict, Shenyang, Liaoning Provinc, China
Shenyang, China
308544490@qq.com

Sergei Sosnovskiy
Tomsk state university
Ministry of Science and Higher Education of the Russian Federation
36 Lenin Ave., 634050,
Tomsk, Russia
ssa777@mail.ru

Alexander Lukanin
Tomsk state university of architecture and building
Ministry of Science and Higher Education of the Russian Federation
2, Salt Sq., 634003,
Tomsk, Russia
loukanin@list.ru

Alexander Tskhe
Tomsk state university of architecture and building
Ministry of Science and Higher Education of the Russian Federation
2, Salt Sq., 634003, Tomsk, Russia
pktb23@mail.ru

Anna Tskhe
Tomsk polytechnic university
Ministry of Science and Higher Education of the Russian Federation
30 Lenin Ave., 634050, Tomsk, Russia
anny0393@mail.ru

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Introduction

- Concrete is the most widely used material in civil construction facilities, defense engineering, and etc.
- The main breaking modes of concrete are mechanical breaking, ejection shock wave breaking, high pressure water jet breaking, and etc.

Experimental Setup

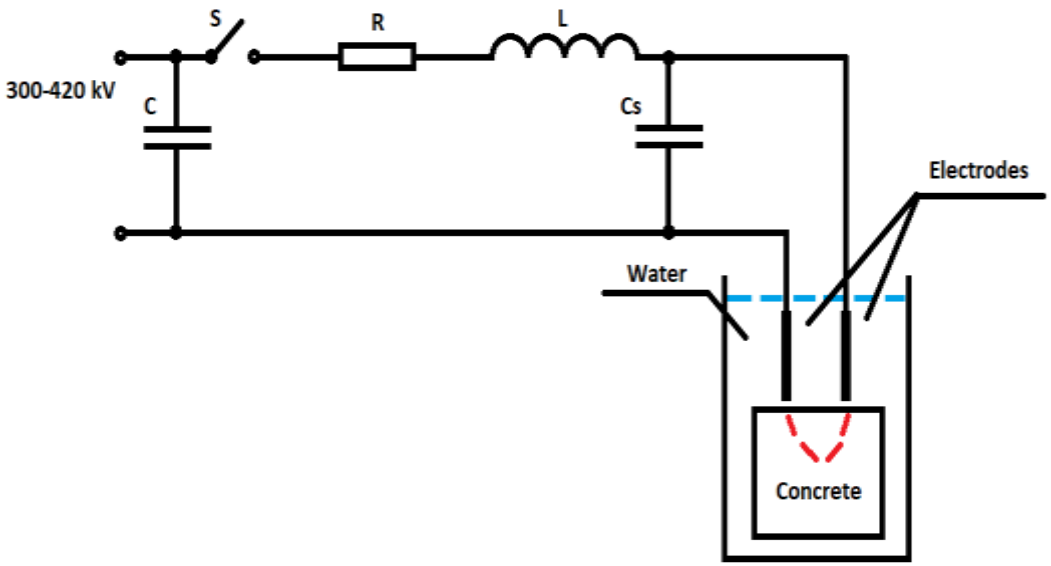

Fig. 1. *Diagram of experiment system for high voltage pulse discharge crushing concrete generator*

The experimental system is mainly composed of high voltage power supply, capacitors, discharge switches, breakdown chamber, discharge electrodes, water, concrete target and oscilloscope (Tektronix).

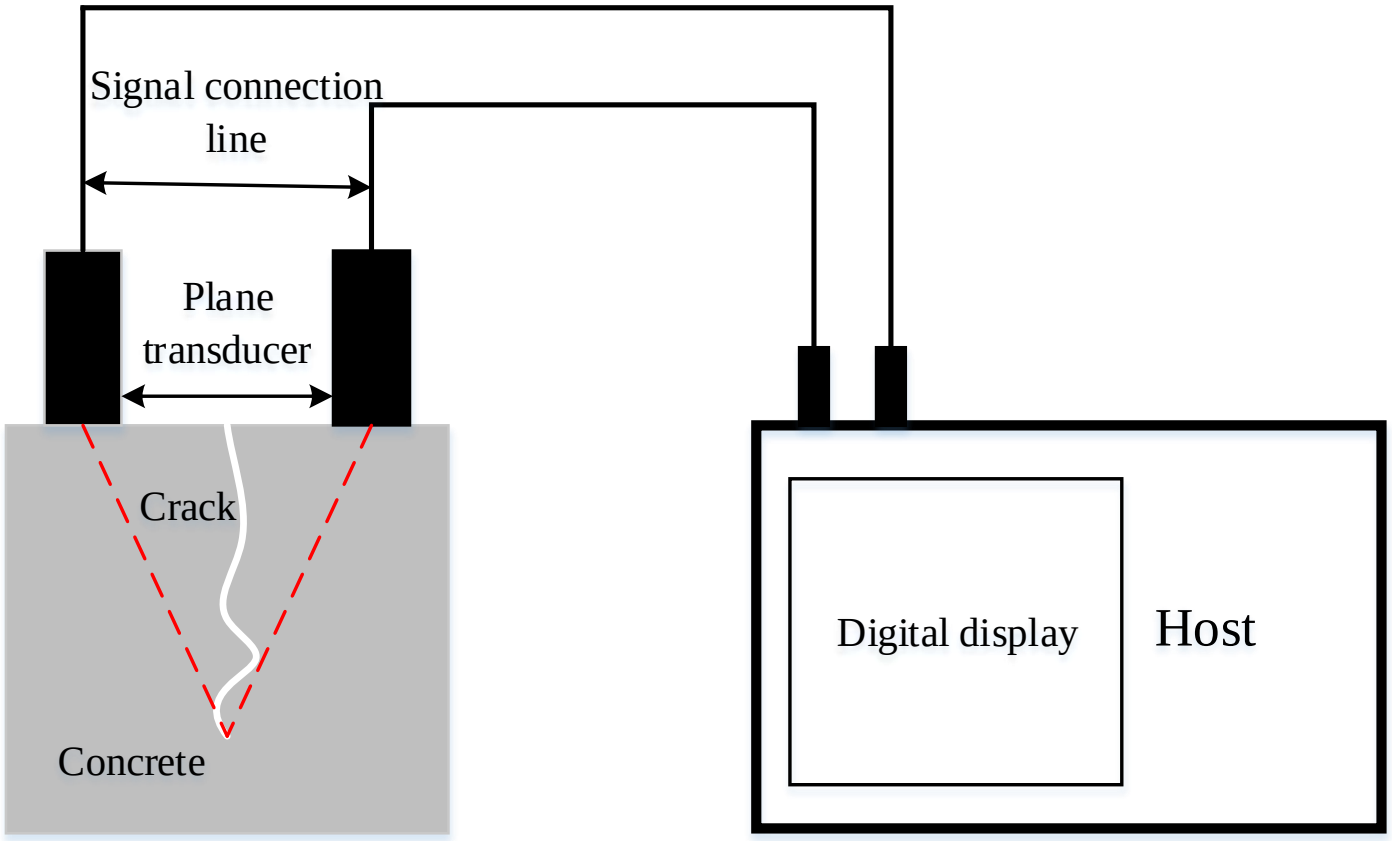

Fig. 2. *Diagrammatic sketch of experiment system of crack depth detection of concrete.*

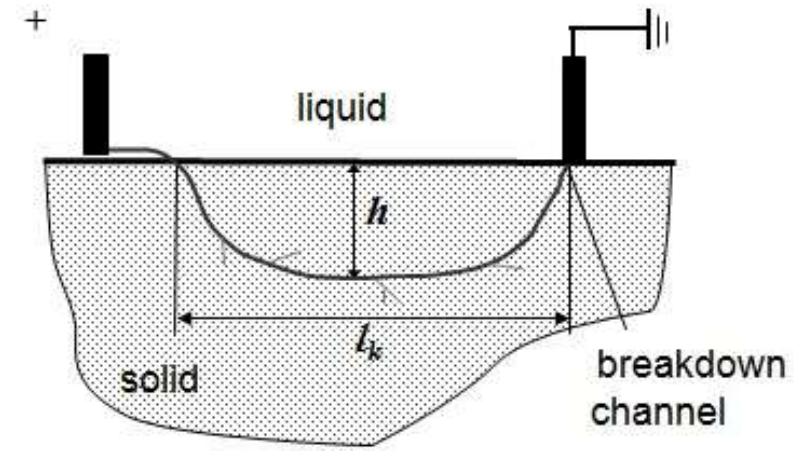

Fig. 3. *Electrode position and typical channel trajectory*

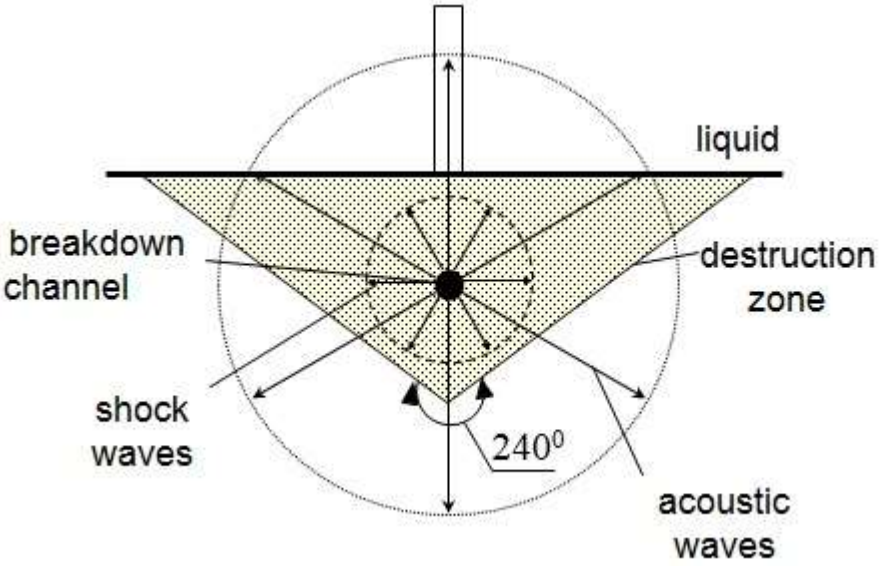

Fig. 4. *Cross section perpendicular to the channel*

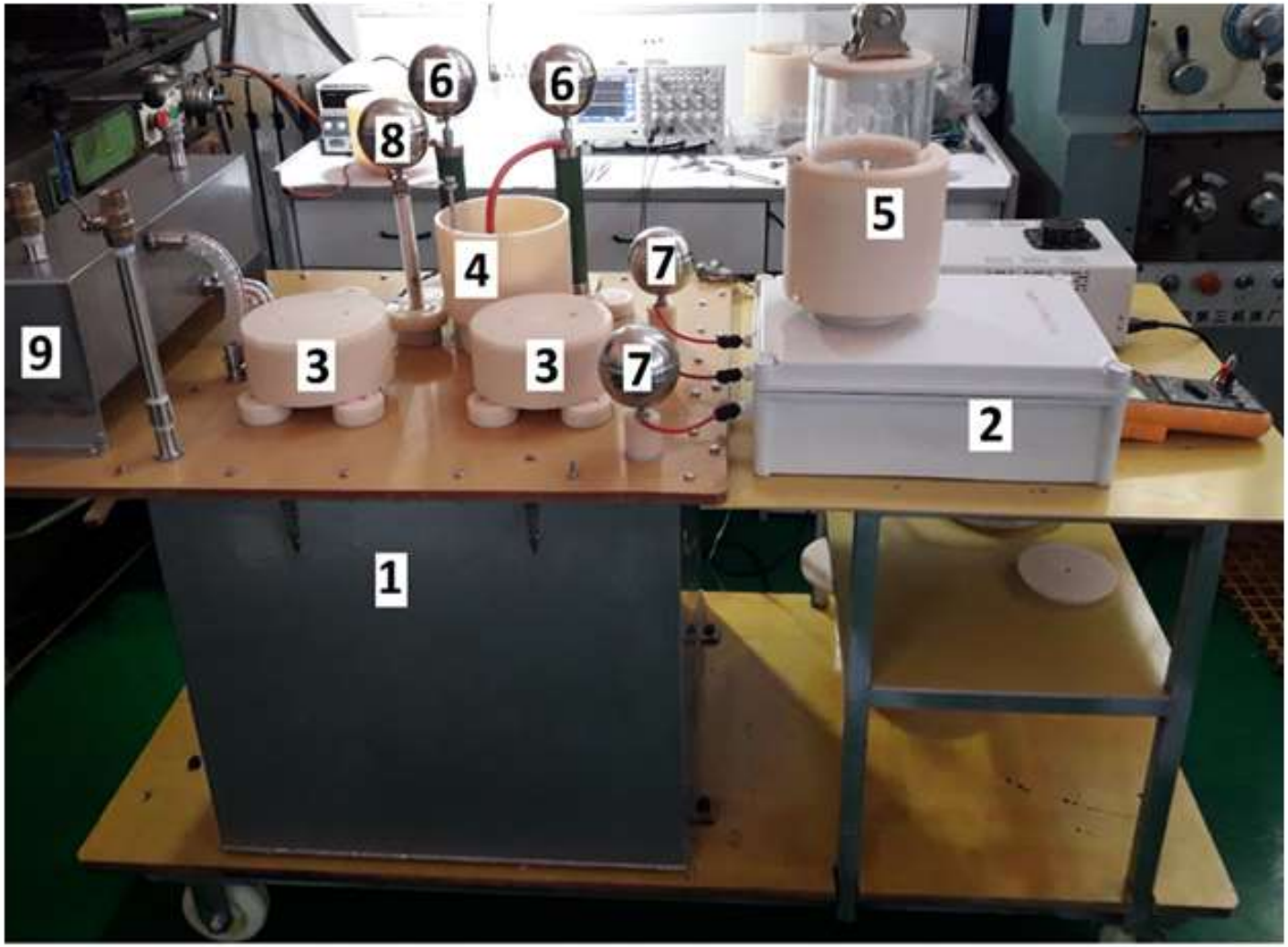

Fig. 5. *Photo of laboratory setup*

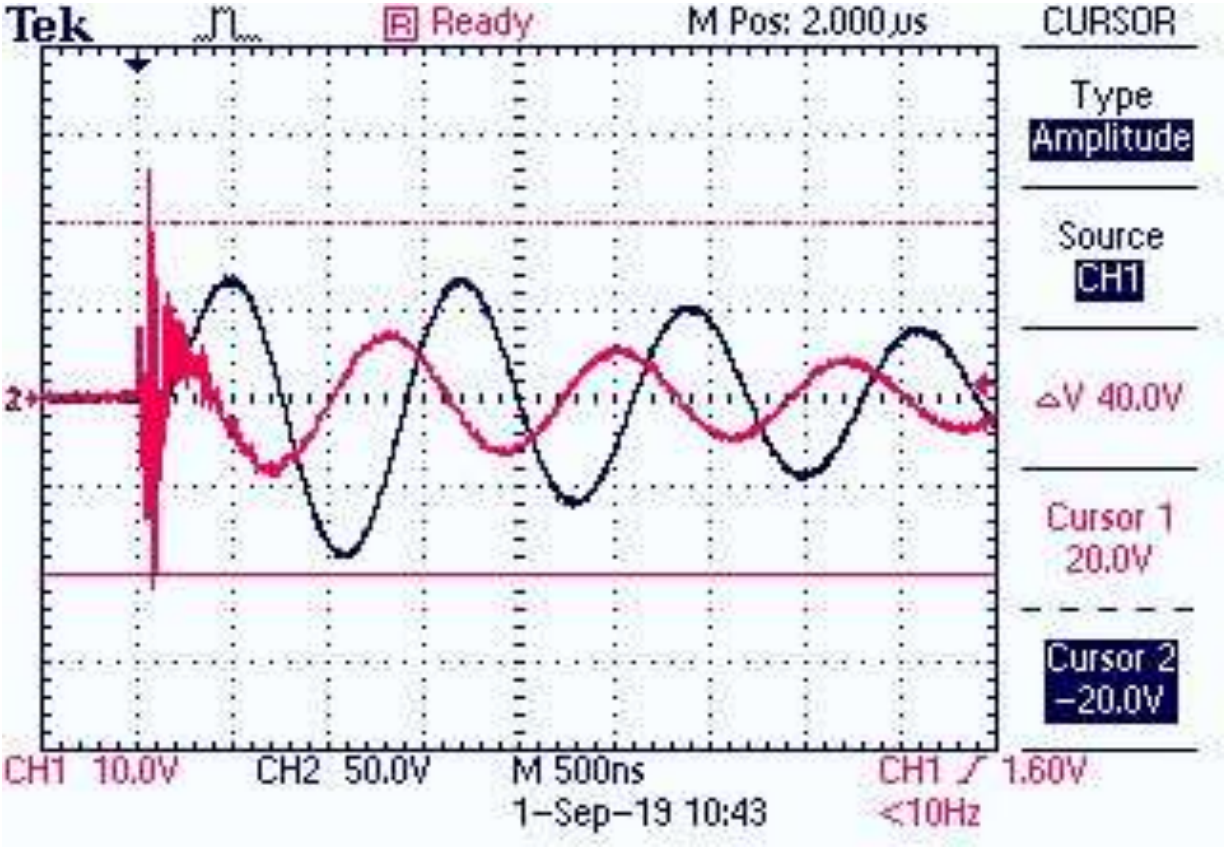

Fig. 6. *Examples of breakdown of samples of copper-bearing rock*

Fig. 7. *Individual square concrete samples in the experiment.*

Size 10 cm*10 cm*10 cm;

40 square samples in total in the experiment.

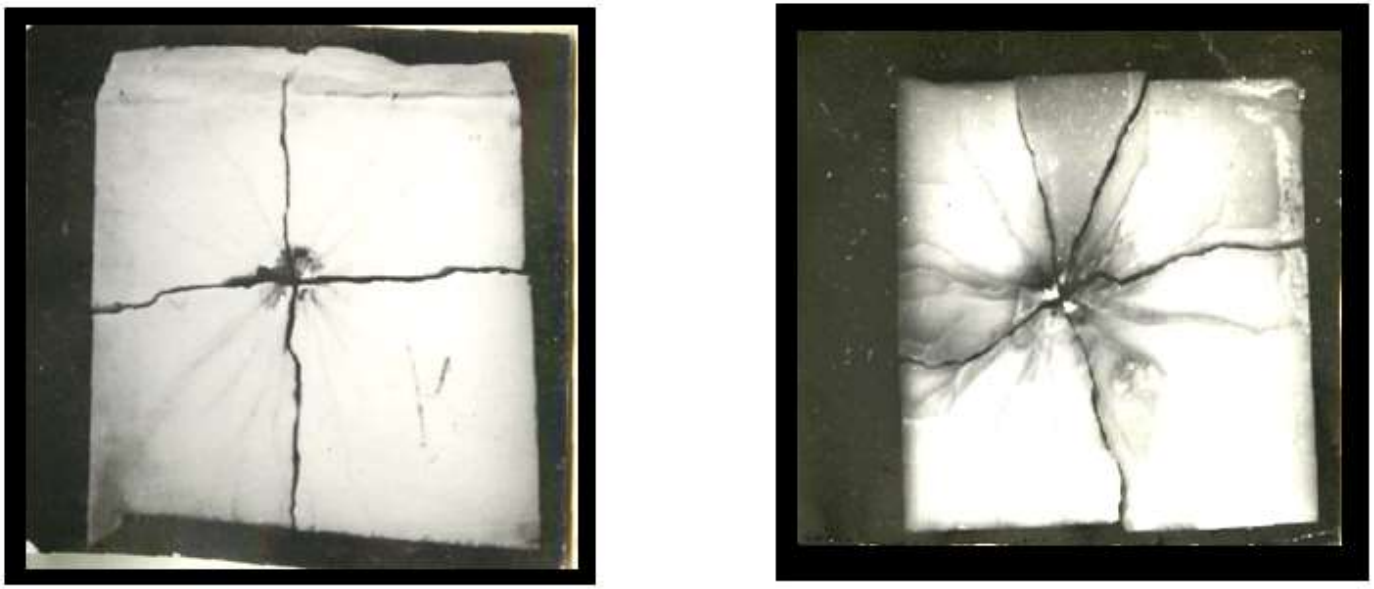

Fig. 8. *The nature of destruction during electrical breakdown of cement samples*

Initial data:

- plasma temperature range: 300–10000 K;
- concentration Al_2O_3: 50%;
- concentration Fe_2O_3: 4%;
- concentration SiO_2: 6%;
- concentration CaO: 40%;
- pressure: 10000 MPa.

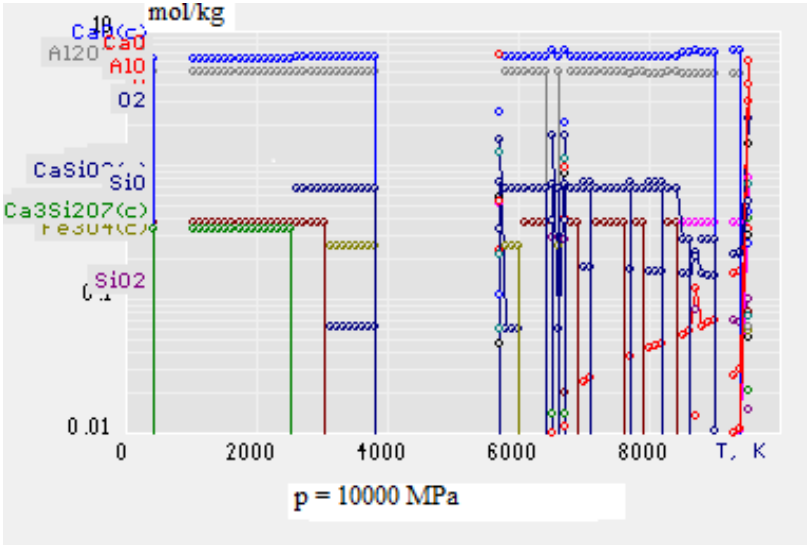

Fig. 9. *Phase composition in the Al_2O_3 - Fe_2O_{3-} - SiO_2 - CaO system under plasma conditions.*

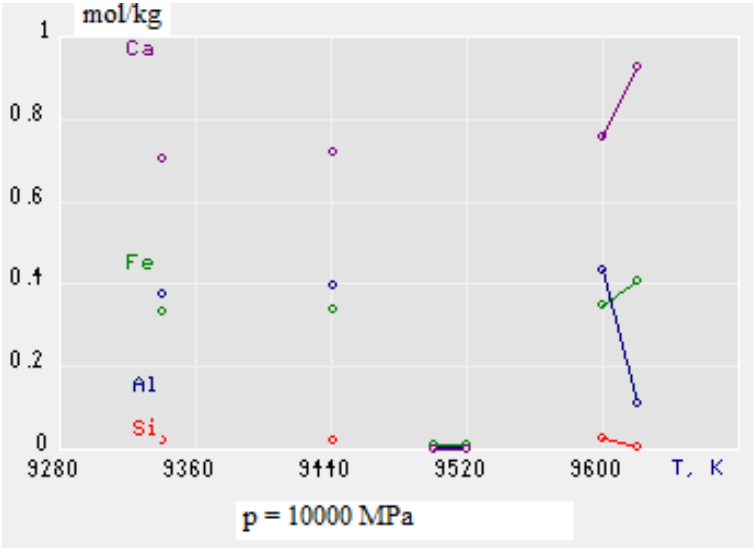

Fig.10. *Phase composition in the Al_2O_3 - Fe_2O_{3-} - SiO_2 - CaO system under plasma conditions.*

Phases Al (0.1-0.4 mol/kg) in the temperature range 9600 - 9800 K.
Phases Fe (0.28-0.4 mol/kg) in the temperature range 9600 - 9800 K.
Phases Si (0.01-0.02 mol/kg) in the temperature range 9600 - 9800 K.
Phases Ca (0.7 - 0.95 mol/kg) in the temperature range 9600 - 9800 K.

Results

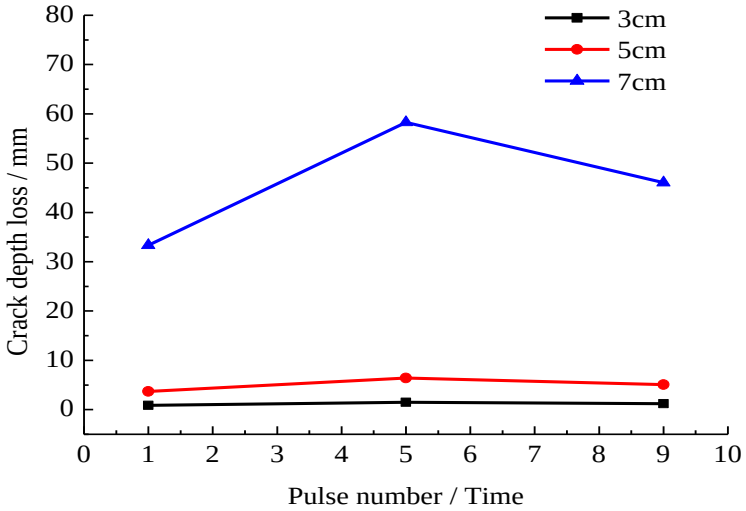

Fig.11. *Variation curves of the crack depth loss under different pulse number*

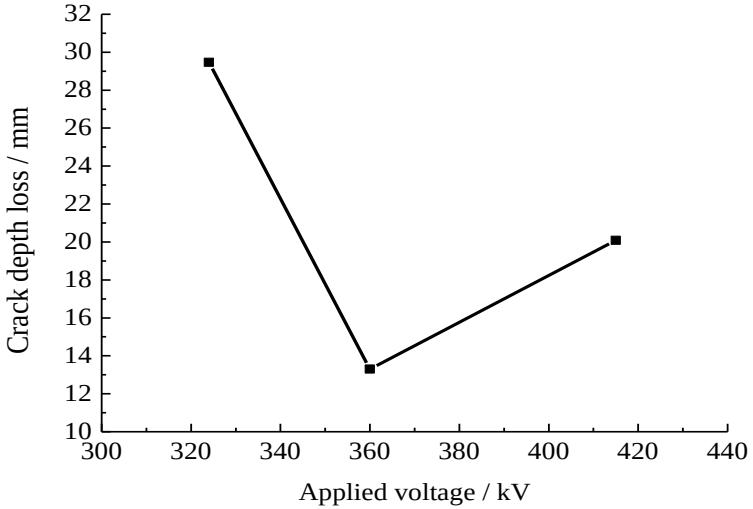

Fig. 12. *Applied voltage*

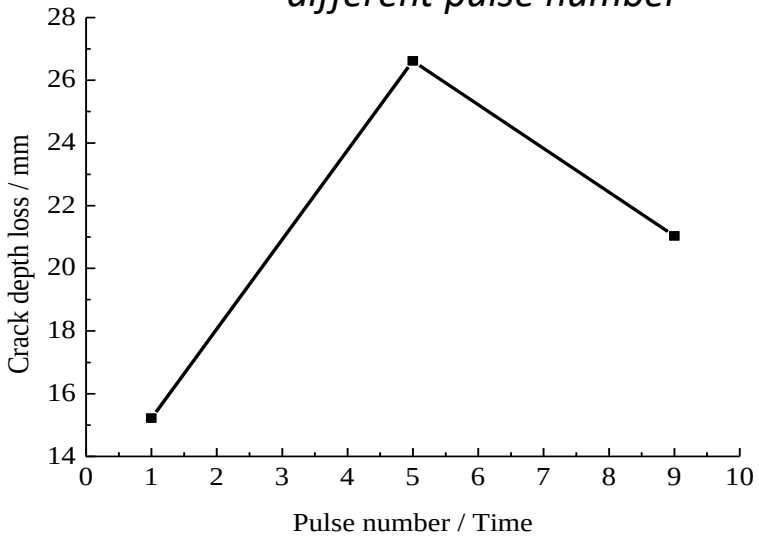

Fig.13. *Pulse number*

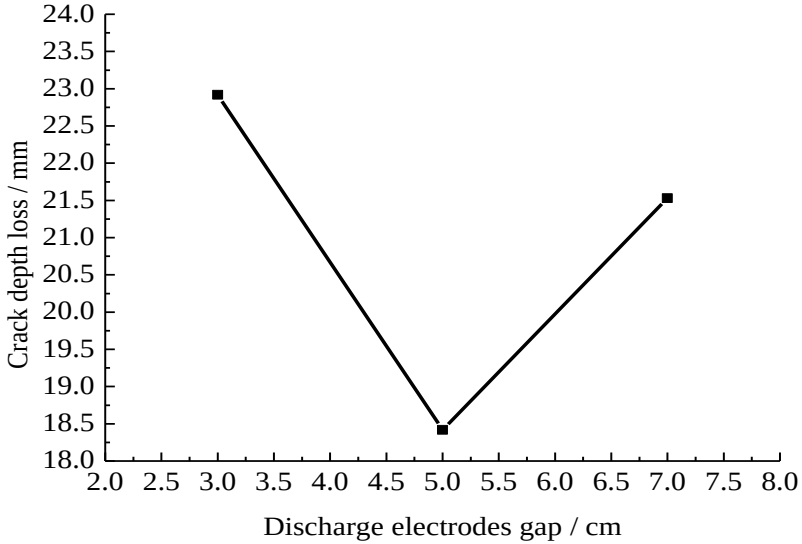

Fig. 14. *Discharge electrodes gapr.*

Results

- For the applied voltage factor, the crack depth loss of concrete crushed by high voltage pulse discharge is the greatest at 324kV (A_1).
- For the pulse number factor, the crack depth loss of concrete crushed by high voltage pulse discharge is the greatest at five times (B_2).
- For the discharge electrodes gap, the crack depth loss of concrete crushed by high voltage pulse discharge is the greatest at 3cm (C_1).
- Combining the above conclusions, the crack depth loss of crushing concrete under the combination of factors $A_1B_2C_1$ will be the largest.

Conclusion

- The applied voltage and the pulse number have an obvious effect on the crack depth loss of concrete broken by high voltage pulse discharge.
- 10 indoor experiments of high voltage pulse discharge breaking concrete and measurement of crack depth loss of concrete on three factors such as applied voltage, pulse number and discharge electrodes gap were carried out at three levels.
- When the applied voltage is 500 kV and the pulse number is 10, the crack depth loss of concrete can be broken by high voltage pulse discharge that is the largest.

Thanks for your attention!