Analysis of the Main Factors Affecting Static Blasting Effect

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Abstract

As an important supplement and development of blasting, static blasting is widely applied in concrete buildings crushing, stone mining and cutting, rock excavation and other engineering. From the external factors that affect the static blasting, this paper analyzes the relationship between static blasting effect and water-cement ratio, reaction time, external environment temperature, blast hole diameter, hole depth, material properties, filling density.

Keywords

Static blasting; influencing factors; static cracking agent (SCA)

1. Introduction

For a long time, explosive blasting has been used as the main method of building demolition, rock mining and cutting [1]. Explosive blasting mainly uses thousands of to tens of thousands of MPa pressure produced in the 10^{-5}-10^{-6} second to instantly destroy the objects to be blast. Blasting process will produce vibration, air shock wave, flying rock, noise, toxic gases and dust, etc., and will cause major damage and threats to the surrounding environment and security. Thus, a blasting method-static blasting whose destructive power can be easily controlled and impact on the environment is small came into being in this case.

Static blasting uses SCA to slowly load the object to be crushed until it is cracked and broken. SCA used in static blasting, also known as silent cracking agent, static splitting agent, static crushing agent, non-explosive cracking agent, etc. [2], is a kind of highly expansive powder gel material. After mixing with water into a paste, is filled to the broken holes. Under the action of hydration volume expansion, SCA can produce expansion stress of 30-100MPa, which will make the brittle object to be crushed burst to produce crushing effect.

Compared with traditional explosive blasting, static blasting has the advantages of less pollution, low cost, safety and reliability, non-destructive precision cutting, etc. [3]. Therefore, this new cracking technology has been popularized and applied in many countries. At the same time, the research on the theory and application of SCA continues to be enriched.

Based on the existing static blasting theories, this paper mainly analyzes the external factors affecting the static blasting to provide a reference for engineering practice.

2. Analysis of the main factors

2.1 Water-cement ratio [4]

Water-cement ratio is the ratio of the amount of water and SCA. Fig. 1 shows that under the same conditions, when the water-cement ratio is 0.32, the maximum expansion pressure produced by the ordinary type SCA is approximately 50Mpa; when the water-cement ratio is 0.36, the maximum expansion pressure is about 42MPa; when the water-cement ratio is 0.38, the maximum expansion pressure is about 30Mpa, which indicates that the expansion pressure generated by SCA decreases with the increase of water cement ratio. In engineering practice, water-cement ratio can be neither too large nor too small. If the water-cement ratio is too large, the expansion pressure generated by SCA is not ideal; if the water-cement ratio is too small, slurry liquidity is bad and explosive is difficult to charge. Based on past experience in engineering, optimum water-cement ratio is 0.20-0.38.

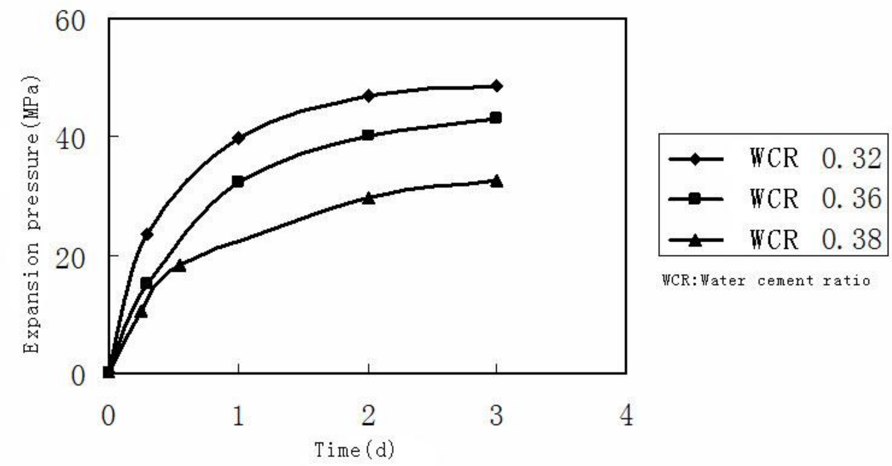


Fig. 1 Expansion pressure-time curve of ordinary SCA under different water cement ratio (SCA-II, hole diameter 40mm)

2.2 Reaction time

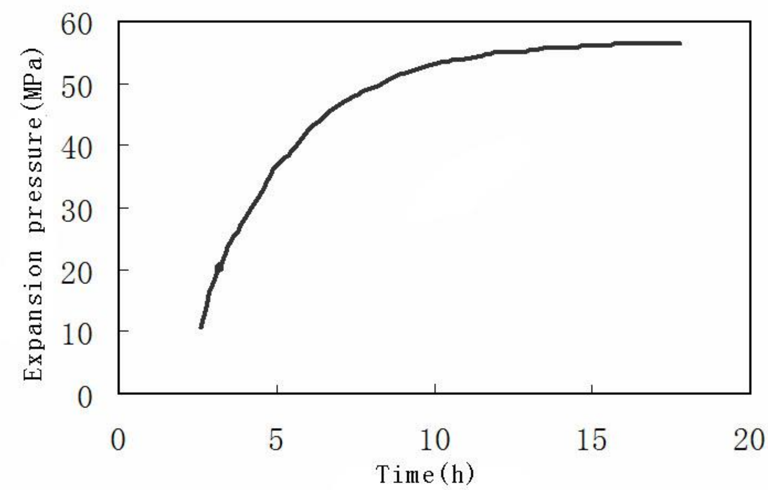


Fig. 2(a) Expansion pressure-time curve of ordinary SCA

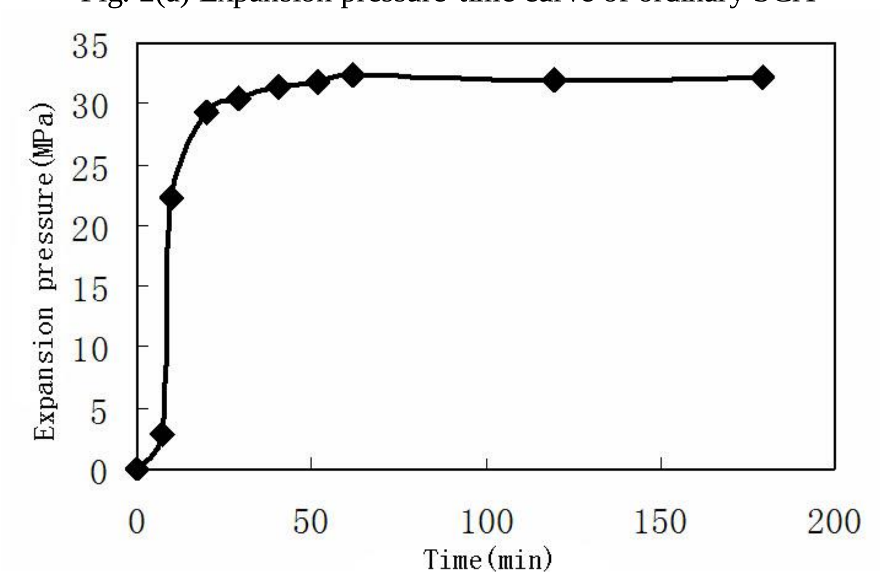


Fig. 2(b) Expansion pressure-time curve of fast-acting SCA

Fig. 2 shows, the expansion pressure -time curve change trends of ordinary type SCA and fast-acting type SCA are roughly the same. During the initial stage of reaction, the curve slope is big, which indicates the expansion pressure increases rapidly; as reaction continues, the curve slope becomes small, indicating that the expansion pressure increase rate decreases. However, compared to the fast-acting SCA, the maximum expansion pressure generated by ordinary type SCA hydration reaction is great, and the time required for the reaction is long, reaching 15- 20h. The expansion pressure of the fast-acting SCA rapidly grows half an hour after the reaction starts, and can reach maximum within 0.5-1.0 hour. When the expansion pressure generated by SCA reaches a critical value of cracking, the objects begins to crack.

2.3 External environment temperature [4]

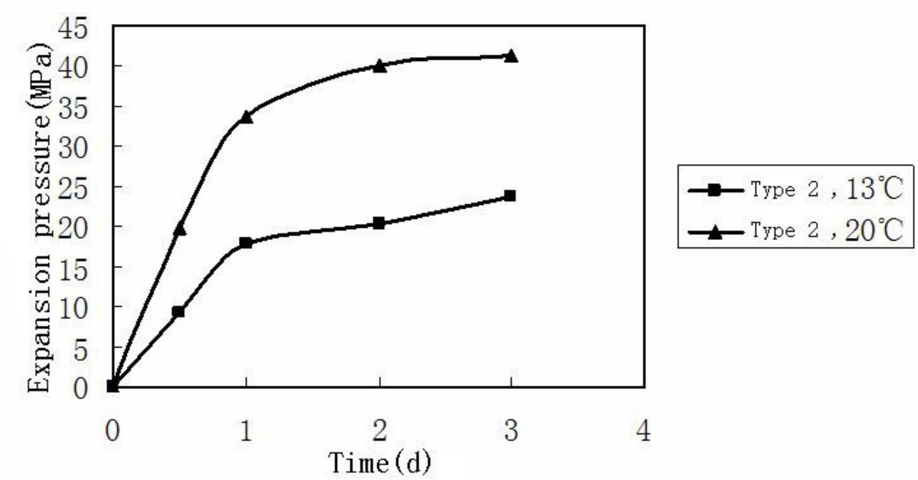


Fig. 3(a) Expansion pressure-time curve of ordinary SCA at different temperatures

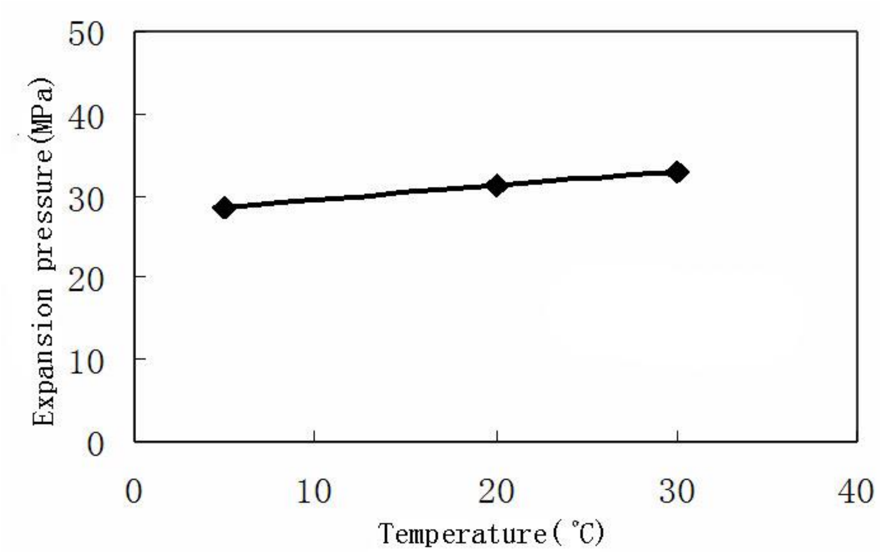


Fig. 3(b) Expansion pressure-temperature curve of fast-acting SCA

Fig. 3(a) shows that under the same conditions, when the outside temperature is 13 ℃, the maximum expansion pressure produced by the ordinary type SCA is about 20Mpa; when the outside temperature is 20 ℃, the maximum expansion pressure reaches 40MPa, which indicates that under the same conditions, the higher the temperature, the faster the hydration reaction of the ordinary type SCA is, and the greater the maximum expansion pressure is.

Fig. 3(b) shows that the curve is relatively flat, which indicates that for the fast-acting SCA, the outside temperature is not the main factor affecting its maximum expansion pressure.

2.4 Blast hole diameter [4]

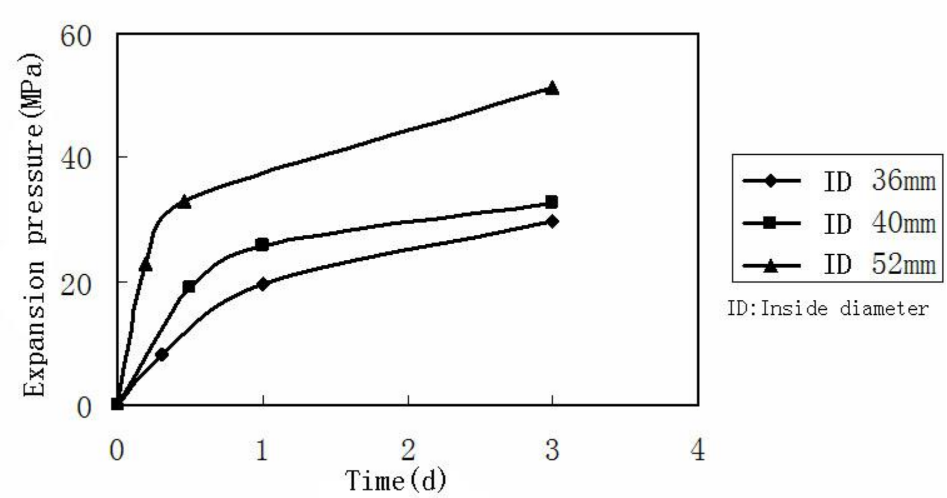
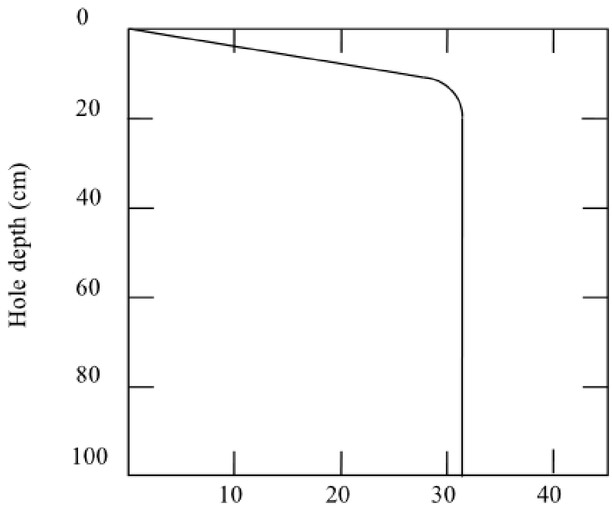


Fig. 4 Expansion pressure-time curve of ordinary SCA under different hole diameter

Fig. 4 shows, under the same conditions, when the inside diameter is 36mm, the maximum expansion pressure generated by ordinary SCA is about 25Mpa; when the inside diameter is 40mm, the maximum expansion pressure is about 30MPa; when the inside diameter is 53mm, the maximum expansion pressure is about 50Mpa, which indicates that the maximum expansion pressure produced by SCA increases as the diameter increases. The main reason is that the increased diameter results in an increase in the quantity of SCA loaded in per unit length. The heat released during the hydration reaction will accumulate and increase. Temperature increases will further promote the hydration reaction, eventually causing expansion pressure to increase. But excessively large diameter will make the heat of hydration accumulate quickly. When the heat cannot be released to the outside in time, spraying will happen very easily, with a certain risk. Thus, the diameter shall not be more than 60mm.

2.5 Blast hole depth



Expansion pressure（*Mpa*）(Hole diameter 50mm,Curing temperature20℃）

Fig. 5 Expansion pressure-hole depth curve of fast-acting SCA

Fig. 5 shows the expansion pressure produced by fast-acting SCA at the blast hole opening is 0; when the hole depth is 0-200mm, the value of the maximum expansion pressure shows linear increase relation with the hole depth; when the depth is below 200mm, the expansion pressure reaches the maximum, which indicates that the larger the hole depth, the greater the expansion pressure generated by SCA is. The main reason is that at the blast hole opening, SCA's expansion constraining force is very small, causing the expansion pressure at the blast hole opening to be small; with the increasing depth, SCA's expansion constraining force increases gradually, and the corresponding expansion pressure increases.

Therefore, in engineering practice, the inclined hole can be used to increase the depth of the hole and enhance the crushing effect of SCA.

2.6 Material properties

SCA is suitable to be applied to crushing of brittle objects such as stone and concrete [5-7], since the theoretical maximum expansion pressure of SCA can reach 100MPa, while the tensile strength of the ordinary rock is about 5-10MPa, and the tensile strength of concrete is about 1.5- 3MPa [8].

2.7 Filling density

Uniform and solid SCA during loading of explosive is more advantageous to reaction. If the gap between the slurry is large, the heat generated by the reaction may cause the slurry in front of the hole to spray, which affects the crushing effect; if the SCA slurry is filled tightly, spraying will become less likely and better crushing effect will be produced.

3. Conclusion

The key to improving the static crushing effect is to increase the expansion pressure. Therefore, only considering the influence of many factors on the expansion pressure can SCA be better applied to engineering practice.

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