The efficiency test of a rock excavator
by use of a multistage edge excavation method

Kawamura Rintaro, Shigematsu Takahisa
s201053@sd.kure-nct.ac.jp
Department of Civil Engineering Course,
Kure National College of Technology

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1. Introduction

The purpose of this study was to develop a rock excavator attached to the backhoe by use of a multistage edge excavation method. Earlier studies have proposed that the edge excavation method is efficient compared to the plane excavation method. The former method uses the free edge of the specimen in a bit, while the latter method uses the plane of the specimen in a bit. We did experiments with the model excavator to find out efficiency and force acting on the rock excavator.

2. Experimental apparatus and method

Fig. 1 shows the model excavator. This excavator is composed of 2 point attack bits, a fish tail, and 4 roller cutter bits of 2 stages. A load cell provided at the top of the excavator was measured by the thrust $F_z$, torque $T$, and digging depth $z$. Additionally, we calculated penetration speed $V$ and specific energy $E_s$. A specimen (mortar, W/C 50%, 40N/mm$^2$ uniaxial compressive strength) was fixed on a turntable rotating at 2 r.p.m. A model excavator was in all 3 stages, we set 3 types of thrust at each stage. The first stage was set the thrust 7.5, 8.5, and 10.0kN. The second stage was set the thrust 20.0, 22.5, and 25.0kN. The third stage was set the thrust 30.0, 35.0, and 40.0kN.

3. Results and discussion

Fig. 2 shows relationships between thrust $F_z$ and torque $T$. Torque $T$ increased with increasing thrust $F_z$ at each stage. In addition, proportionate relationships between thrust $F_z$ and torque $T$ were observed when each dataset mixed together.
Fig. 3 shows relationships between thrust $F_z$ and penetration speed $V$ at each stage. Penetration speed $V$ increased with the increment of thrust $F_z$ at each stage. In addition, gradient of penetration speed $V$ tended to decreased with increasing number of stages. This is thought to be due to excavation area increased with the number of stages.

Fig. 4 shows specific energy $E_s$ at each stage. Specific energy $E_s$ is defined as the energy required for excavation divided by excavated volume. Therefore, small specific energy $E_s$ is efficient. The lowest specific energy $E_s$ was obtained at the first stage. This would be due to the reason why the point attack bits were placed in the center of the excavator; the torque $T$ was less than those at the other stages. On the other hand, the specific energy $E_s$ of the third stage was two times smaller than that of the second stage. This is because the excavated volume increased as the number of bits increased from 2 to 4 pieces. Therefore, it is assumed that the excavation efficiency is improved by increasing the number of stages.

4. Conclusion

We obtained the following results from these experiments,

(1) Torque $T$ and penetration speed $V$ tended to be proportional to thrust $F_z$.

(2) Efficiency of the model excavator was improved by increasing the number of stages.

5. Practical implications

The present results would be applied to the rock excavator in the field, as well. Therefore, it is possible to deduce torque and penetration speed of the rock excavator by measuring thrust. However, further experiments by increasing the number of stages are needed in order to clarify the relationship between efficiency and the stage numbers of the rock excavator.

References
