The State of Abrasive Waterjet Technologies for construction in Korea

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ABSTRACT: With the passage of time, various new technologies are developed and applied in civil engineering, especially in the field of construction. In recent years, among the newly applied technologies, waterjets have begun to be used on various construction sites. A waterjet is a system that generates a high pressure water stream, and they are common employed in the chemical industry, oil refining business and resource production. Waterjet technology has been applied for cutting, cleaning and demolition. This environmentally friendly technology can be applied for rock cutting in tunneling as it generates no mechanical stress, is highly versatile, with low vibration and low noise. Two types of waterjet systems are used in industry: the abrasive waterjet system (AWJ) and the abrasive suspension jet system (ASJ). In the last 10 years these waterjet systems had been studied and developed for application to construction. However, the correlation between studies has not been clarified, and is also insufficient for practical applications. Before waterjets can be practically applied in construction, a body of research on the technology needs to be established. Therefore, in this study, the practical application of waterjets for construction in Korea is introduced, and different types of waterjet systems are compared based on their performance. Finally, an appropriate waterjet system for construction is suggested based on the characteristics from those comparisons. These results can be used as basic information for applying waterjets in construction.

1 INTRODUCTION.

Waterjets have been used in various industries for the purpose of cleaning, processing rocks, metals, plastics, pipelines, and surface exfoliation (Summers 1995). Waterjet technology has the advantage of not causing additional stress and heat during material removal. It is environmental-friendly because it requires only water and abrasives. Due to these advantages, the application field is gradually expanding. Recently, abrasive-injected waterjet have been studied and applied as a crushing technology, wherein the impact pressure can be increased by injecting abrasives. Abrasive water jets cimprise three phases-water, air and abrasives (fig. 1), while pure water jets comprise two phase-liquid and air,. Abrasive waterjets are high in cutting efficiency due to the abrasive being accelerated by high-speed water flow (Momber 2004) Continuous striking of the accelerated abrasive causes microscopic cracks and destroys brittle materials such as rocks (Evans et al. 1978; Zeng and Kim 1996).

2 GEOTECHNICAL APPLICATION OF WATERJET.

Waterjet technology is being applied and further developed in various construction fields such as concrete demolitions, structure maintenance, rock excavation, pipe cleaning, treatment of contaminated soil and materials cutting (fig. 2). In particular, various researchers and engineers are engaged in studies related to ground penetration, rock fracture and excavation (table 1).

2 .1 *Excavation*

Waterjet can be used in rock excavation for tunneling, and it can be used as an auxiliary method for tunneling. A representative method of waterjet-assisted tunneling is in reducing the effect of stress waves. Principle studies on blocking the propagation path of vibration during blasting have been conducted. Artificial discontinuity zones such as barrier holes and trenching were opened to reduce blast-induced vibrations. Vibration reduction using different types of waterjet cutting and rock excavation applicability to civil engineering was studied from various perspectives. Drilling in granite, which is a representative rock in Korea, by using a abrasive suspension jet (ASJ) was carried out, and performance was evaluated (Kim 2012). In particular, the effects of waterjet variables (water pressure, traverse speed, abrasive feed rate and standoff distance) on rock cutting were experimentally analyzed and optimization of the water jet system was attempted (Oh and Cho 2014). Waterjets are also used to install submarine cables and pipelines without disturbing the marine environment. Waterjet arm excavators were developed for seabed excavation and liquefaction (Na et al 2015). It has also been attempted to apply waterjet for vertical excavation and disk-type space formation for large mat foundation (Park et al. 2003).

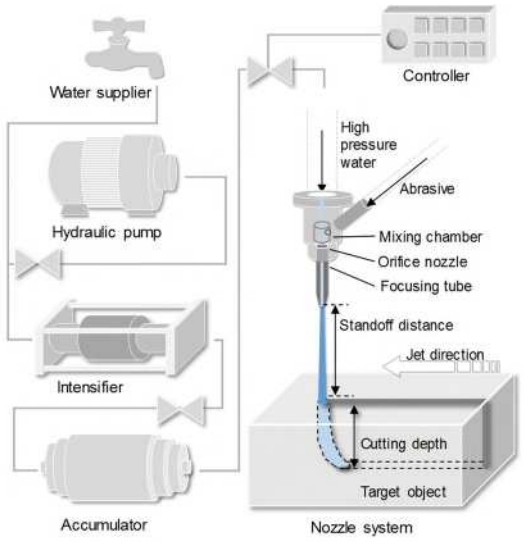

Fig. 1. Typical waterjet system

Table 1. Various waterjet applications for construction

Classification	Research content	Object	Reference
Excavation	Cutting on the rock for tunneling (ASJ)	Rock	Oh and Cho2014
	Drilling on the granite for tunneling (AWJ)	Rock	Kim 2006
	Waterjet application to vertical excavation and disk type space formation for mat foundation	Soil	Park et al 2003
	Trenching for submarine cables and pipelines	Sea bed soil	Na et al 2015
Maintenance	Mobile waterjet manipulator design for resurfacing asphalt and building demolition	Asphalt (Pavement) Reinforced concrete	Lee et al 2014
	Road stripe removing equipment design	Asphalt (Pavement)	Han et al 2006
	Waterjet impingement research for demolition of the old water duct using bit with waterjet	Steel	Roh et al 2008
Manufacturing	Adhesion force improvement for pavement and placing joint of concrete Treating	Asphalt (Pavement) Concrete	Kim et al 2007 Song et al 2008
	Stone manufacturing for quality down of stone surface	Rock	Kang 2003

Fig. 2. Waterjet applications

2 .2 *Maintenance*

Concrete cutting using mechanical rock drilling machine on structures generates cracks by impact, which may affect stability, and it is difficult to use in narrow spaces. On the other hand, when cutting a concrete using a waterjet, very low vibration and unnecessary stresses are caused. In the case of a mechanical breaking mechanism such as a hydraulic breaker, the steel structure installed inside is also damaged, which requires a long repair time. To solve these drawbacks, a water jet crushing mechanism can be utilized. Waterjet is also useful in asphalt paved surfaces. When damaged pavement or peeling of the road surface occurs, repair material such as polyurethane is generally used. However, for wide areas, repacking after local crushing of the damaged section may be ineffective. When waterjet is applied in a localized section of damaged asphalt, it is possible to remove the asphalt and concrete without damaging the steel structure and to decrease the repair time. Similar to asphalt surface processing, removal of road surface striping is possible. And is already commonly applied in the field. Waterjets can reduce labor dependencies and risks, while increasing efficiency (Han et al 2006). In a variety of waterjet applications in Korea, researchers have developed a manipulator with a waterjet for resurfacing asphalt and building demolitions (Lee et.al. 2014). In order to design the old water duct, the heat transfer characteristics of waterjet impingement were studied using 3D numerical analysis. In that study, a waterjet was used to cool the frictional heat of the bit and an optimal condition of waterjet impingement was proposed (Roh 2008).

2 .3 *Manufacturing*

The adhesion between the pavement layer and the concrete deck has the greatest influence on pavement quality in construction and repair of asphalt surfaces. When combined with a perfect attachment, it has excellent service life and high structural stability. Waterjets can be used in the surface treatment of concrete layer to aid attachment. This method shows high adhesion strength and less dust compared to existing shot blasting (Kim et al 2007, Song 2008). For surface micro-crack consolidation by rock surface processing, waterjets can also be applied. Compared with conventional methods, less noise and dust are generated (Kang 2003)

3 CONCLUSION.

In this study, the geotechnical application of waterjets in Korea is investigated. Waterjet technology has played a large role in several applications in civil engineering, either as a main method or as an auxiliary method. However, the technology is under development, and only few applications are investigated. With this survey and introduction, various studies for various geotechnical applications is expected

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