A study on fiber laser-based concrete surface removal technique for the development of decontamination tool

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1. Introduction

Laser scabbling technology can be useful tool for decontaminating the surface of concrete structure. Particularly, the scabbling tool using fiber laser [1] has merits of the remote controllability and the less generation of secondary waste. From the perspective of laser scabbling principle, a high powered laser beam irradiated onto the porous concrete surface rapidly evaporates the moisture inside the concrete, and then the water vapor pressure in the pores are rapidly increased at pores inside the concrete. An explosion at pores is induced in which the surface is peeled off.

The scabbling efficiency is greatly influenced by the laser beam intensity incident on concrete surface. In turn, the intensity depends on the diameter of laser beam irradiated onto concrete surface. The distance between the concrete surface and the scabbling head is a variable that affect the laser beam size on concrete surface. In practical application of laser scabbling tool in the decontamination site of concrete building, it is difficult to maintain the constant distance at the corner of the building wall because of the narrower structure.

In this study, we made a concrete blocks in a shape that was bent at a right angle to simulate the corner of a wall. A 5kW fiber laser was used to induce explosive spalling on concrete surface.

2. Methods and Results

2.1 Experimental setup

The Figure 1 shows experimental setup for laser scabbling. Fiber laser capable of emitting 5kW maximum laser power (IPG YLS-5000, λ=1070 nm) was used to peel off the concrete surface. The beam traveling through the optical fiber cable (core dia.: 200 μm) is sent into the optical head without loss of power. The beam focused by two optics of the collimator (f = 160 mm) and focal lens (f = 300 mm) was emitted toward concrete surface as continuously diverging. The compressible air gas was also continuously exhausted from the nozzle in the optical head. The compressible air blow out the laser-produced debris flying toward the optical head. It is aim for preventing contamination and damage of optics from the debris with high momentum. The optical head was combined with the X-Y-Z stage equipment. The optical head was remotely moved by the computer program through remotely controlling the X-Y-Z stage equipment.

Concrete specimen was manufactured using ASTM Type I Ordinary Portland Cement, fly ash, (OPC), blast furnace slag, limestone coarse aggregates, sand fine aggregates, and water. The compressive strength of cured concrete is greatly influenced by the water/binder ratio in the ready mixed concrete [2]. The water/binder ratio was set to be 0.34 in this experiment. The low water/binder ratio is to produce the high-strength concrete.

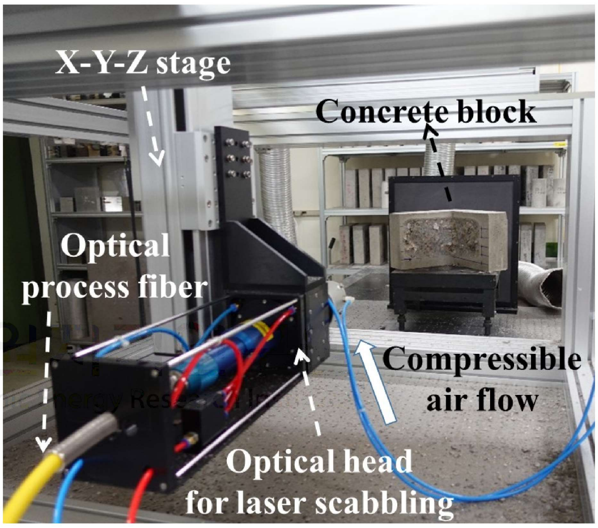

Fig. 1. Experimental setup for laser scabbling.

2.2 Results and Discussion

Figure 2(a) shows the scene where the scabbling is in progress. The stand-off distance from nozzle tip to concrete surface was changed from 750mm to 900mm in the scabbling process. It is originated from the geometrical structure of the specimen bent at right angle. The laser beam emitting from optical head travels the length of 300 mm from left to right on the concrete surface. And then, the laser beam moves the width of 30mm from top to bottom. The laser beam again travels a distance of 300 mm toward left side. The movement of the optical head made 2.0 repetitions in this way. Figure 2(b) shows a concrete specimen after the scabbling has been completed. The small sparks shown in Fig. 2(b) represent the concrete debris falling off the concrete surface. The prominent melting parts were observed in the right side of concrete specimen at short stand-off distance. The laser intensity, which presents the laser energy applied to the concrete surface, increases as the stand-off distance decreases. The concrete surface interacted with excessive laser energy causes melting on its surface.

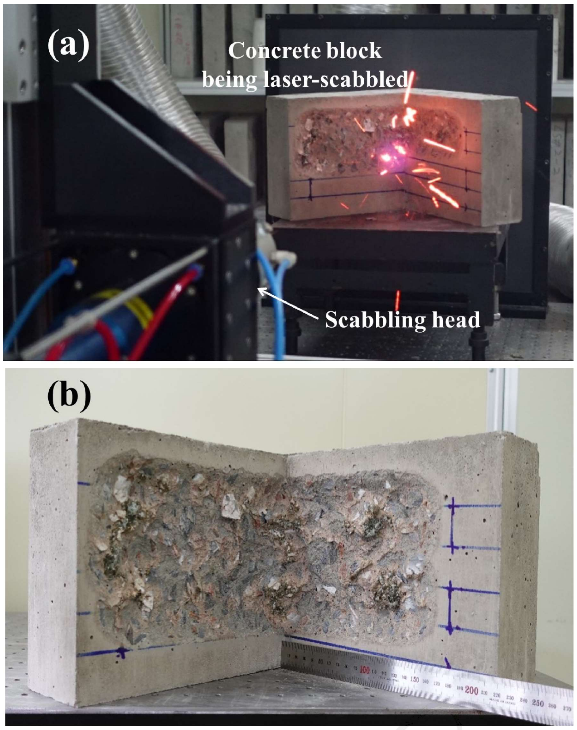

Fig. 2. (a) laser-scabbling scene, (b) laser-scabbled concrete block

3. Conclusions

We have carried out a laser scabbling experiment on the concrete block bent at a right angle. It is to check whether laser scabbling is possible at the edge of the concrete wall. It was confirmed that laser scabbling was possible at the edge of the concrete wall.

REFERENCES

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