

Laser decontamination of high-strength concrete using a high-power fiber laser



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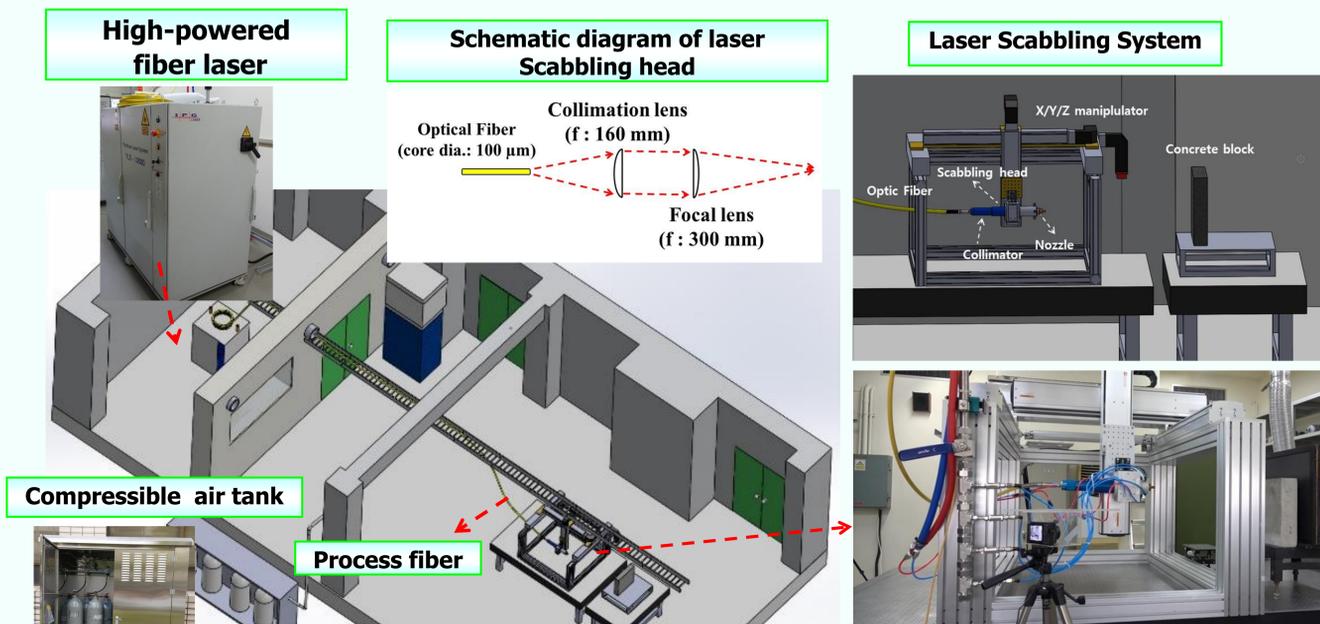
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Introduction

- Laser scabbling technology combined with a high power fiber laser can be a suitable decontamination tool at nuclear decommissioning site due to ease remote controllability.
- Concrete intrinsically contain water and a large number of pores. When a high-powered laser beam is irradiated onto concrete surface, water in the laser-heated local area were quickly converted into vapor. It lead to rapid increase of vapor pressure at pores, resulting in explosive spalling on concrete surface.
- High-strength concrete has a greater tendency to spall than normal-strength concrete when exposed to a high-powered laser beam. It is because high-strength concrete have a smaller size of pores and less porosity than normal-strength concrete. The pore structure of high-strength concrete When exposed to a heating source, the pore structure of high-strength concrete is easy to induce explosive spalling on concrete surface.
- In this study, we performed laser scabbling experiment using 10kW fiber laser(IPG Photonics, YLS-10000, $\lambda=1070$ nm) on high-strength concrete (60 Mpa) .

Experimental Setup



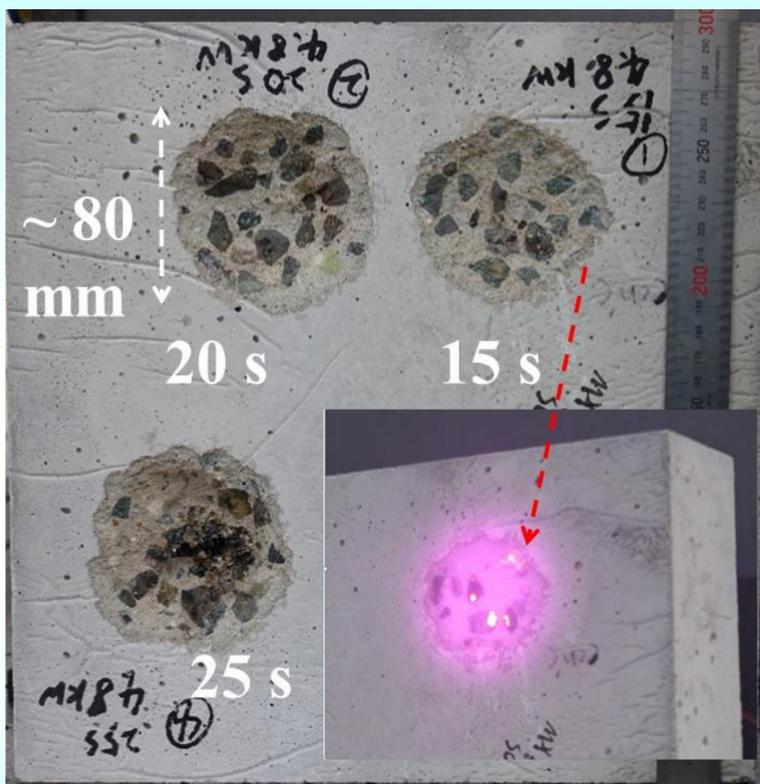
Mix proportions of ready-mixed concrete

Concrete compressive strength	Water/Binder (W/B)	S/a (s/a, %)	Water (kg/m ³)	Cement (kg/m ³)	Fine aggregate (kg/m ³)	Crushed coarse aggregate (kg/m ³)	Admixture (kg/m ³)
60MPa	0.35	33.3	194.8	556.7	556.7	1,113.4	12.8

※ Concrete compressive strength used in the scabbling experiment: **60 MPa**

Result and Discussion

Irradiation of stationary laser beam onto high-strength concrete block



Experiment parameter & Result (1)

Laser Power: 4.8kW
 Stand-off distance: 950 mm
 Exposure time of stationary laser beam: 15s, 20s, 25s
 Result: Some vitrification on concrete surface for exposure time of 25s

Irradiation of moving laser beam onto high-strength concrete block



Experiment parameter & Result (2)

Laser Power: 4.8kW
 Stand-off distance: 950 mm
 Moving laser beam speed: 300 mm/min
 Result
 - Spalling rates: 62.5 cm³/min
 - Averaged value of scabbled depth: 4.3mm
 - The spalling rates and scabbled depth were calculated using information on the difference in concrete weight before and after laser scabbling, laser-scabbled surface area, concrete density, and laser exposure time. The spalling rates and scabbled depth were 62.5 cm³/min and 4.3 mm, respectively.

Conclusion

We observed that it is possible to peel off the surface part of high strength concrete using high-powered laser beam. Vitrification phenomenon was occurred according to the exposure time at fixed laser power density (100 W/cm²) irradiated onto concrete surface. The proper selection of laser interaction time is necessary to avoid the vitrification on concrete surface.