Study on concrete surface damage using hyper-spectral remote sensing

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Abstract: In this research, the concrete with paint film was classified using hyper-spectral remote sensing. First, spectral characteristics of concrete and concrete with some kinds of paint films were investigated with a spectrometer. Second, using reflectance and first order derivative, spectral characteristics of the normal concrete and the concrete with paint film were classified. By using hyper-spectral remote sensing, not only extraction of crack but also inspection of paint film distribution is possible.

Keywords: hyper-spectral remote sensing, concrete, damage, paint film

1. Introduction

Recently, much attention has been paid to concrete damage and maintenance of concrete structures, because of the fact that damages are found in most concrete structures. The inspection for concrete maintenance is mainly carried out by the visual inspection or the hammering test but these methods have some shortcomings, such as great differences among the engineers, being qualitative instead of quantitative, and needing much effort and time. To overcome recently, non-destructive inspection by using laser or digital camera is sometimes used as an alternative, which has enabled detection of various damages. However, non-destructive inspection on the damage of paint film, which is used to delay carbonation and salt damage is not performed. Moreover, if paint film is colorless, it is difficult to detect damages on the paint film by using laser or digital camera. On the other hand, with the remote sensing, hyper-spectral sensor has been developed, which can continuously measure spectrum of an object with wavelength resolution below 10nm in a wavelength region of visible, near infrared and short wave infrared (400-2500nm). This research aims at developing methodologies to extract cracks and inspect paint film distribution as an initial research. Firstly, spectral characteristics of concrete, paint film and concrete with paint film were investigated using hyper-spectral sensor. Secondly, using the first order derivative, spectral characteristics of the concrete with some kinds of paint film were classified.

2. Hyper-spectral measurement

1) Experiment

The spectrum of the normal concrete and the concrete with some kinds of paint film were measured with a spectrometer (GER-2600, GER) with a spectral range from 400nm to 2500nm and with a spectral resolution below 10nm, because it is difficult to classify same color of paint films by the visual inspection and using a normal camera. In this research, colorless urethane resin, white urethane resin and white acrylic resin were used. Measurement distance was 5cm above object. The angle of incidence was 45 degrees. Moreover, an object was routed every 90 degrees to decrease effect of roughness of surface, when an object was measured. The spectral characteristic of an object was calculated by these data.

2) Spectral characteristics

Using these paint films, the difference of spectral characteristic in the normal concrete and the concrete with paint film and in the concrete with same color and different kinds of paint film were measured. The formula of spectral reflectance is described in equation (1). Figure 1-4 shows reflectance of spectral for the normal concrete and the concrete with colorless urethane resin, white urethane resin and white acrylic resin respectively.

$$R_{\lambda_i} = \frac{Rad_{o\lambda_i}}{Rad_{w\lambda_i}} \times 100$$

(1)

where R_{λ_i} is reflectance of an object at λ_i wavelength, $Rad_{o\lambda_i}$ is radiance of an object, and $Rad_{w\lambda_i}$ is radiance luminosity of white board($BaSO_4$).

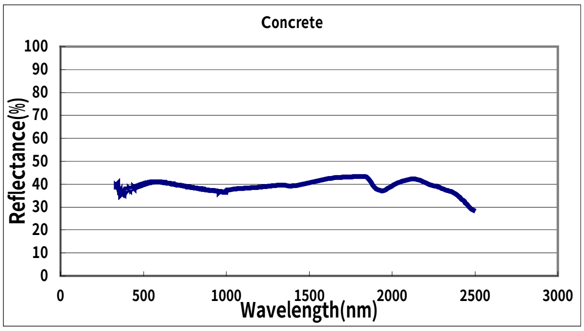

Fig1. Spectrum of the normal concrete resin

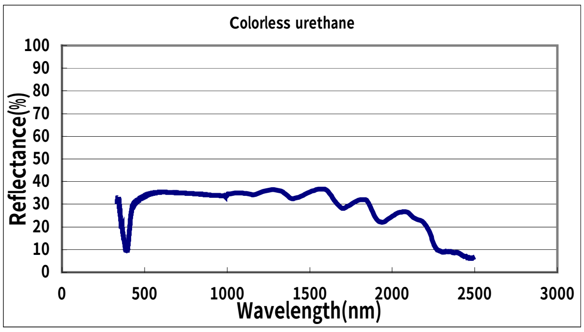

Fig 2. Spectrum of the concrete painted colorless urethane resin

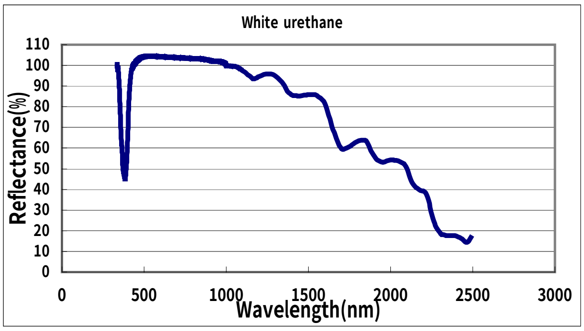

Fig 3. Spectrum of the concrete painted white urethane resin

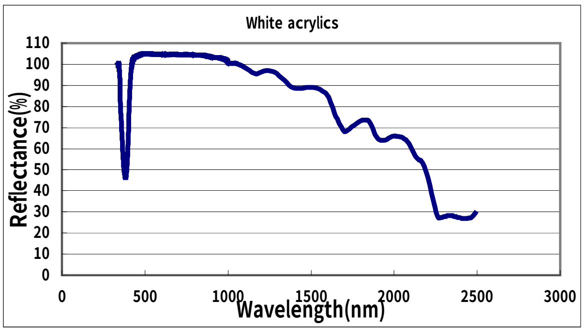

Fig 4. Spectrum of the concrete painted white acrylic resin

Reflectance of the concrete with some kinds of paint film differs from that of the normal concrete. Compared with the normal concrete, the concrete with paint films have more absorption peaks. There are new absorption peaks around 1200nm, 1400nm and 1700nm. It can be considered that these peaks are the influences by resin, which is contained in the constituent parts of paint film. On the other hand, reflectance of the concrete with white urethane resin resembles that of the concrete with white acrylic resin. In particular, the reflectance trends are similar up to 1000nm. Since a visible region is from 400nm to 700nm, it is difficult to classify these paint films by the visual inspection and using a normal camera. It can be considered that this is due to the influences by pigment. Moreover, it is difficult to classify these paint films from reflectance since reflectance after 1000nm of the concrete with white urethane resin resembles that of white acrylic resin.

3) First order derivative

Reflectance of the concrete with white urethane resin resembles that of the concrete with white acrylic resin. It is difficult to classify these paint films by using reflectance. Thus, the first order derivative reflectance of the concrete with these paint films was used in order to classify these paint films. The formula of the first order derivative reflectance is described in equation (2). Using the first order derivative reflectance, the change and shapes of spectrum can be represented. Figure 5 shows first order derivative of the concrete with white urethane resin and white acrylic resin. Normal line shows white urethane resin, while dashed line shows white acrylic resin.

$$\frac{dR_{\lambda_i}}{d\lambda} = \frac{R_{\lambda_{i+1}} - R_{\lambda_i}}{\lambda_{i+1} - \lambda_i} \qquad (2)$$

where λ_i is wavelength in band i, and $\frac{dR_{\lambda_i}}{d\lambda}$ is first order derivative reflectance.

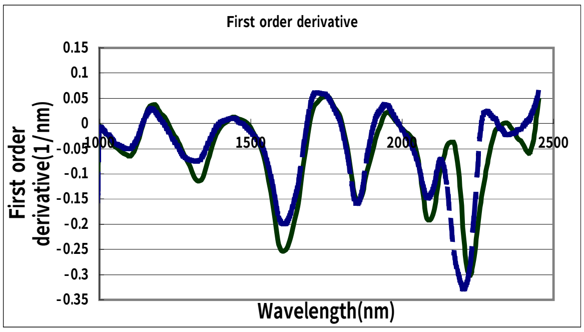

Fig 5. First order derivative in reflectance of the concrete with white urethane resin and white acrylic resin

At the wavelengths where the first order derivative changes from minus value to plus, such as around 1100nm, 1300nm and 1600nm, the spectrum has absorption peaks. Compared with first order derivative, slopes of the concrete with each paint film differ. Therefore, using the first order derivative in reflectance, characteristics of some kinds of paint film can be classified.

4. Conclusions

In this research, spectrum characteristics of the concrete with some kinds of paint film were measured with hyper-spectral meter. As a result, the kinds of paint films can be classified using the first order derivative. Hyper-spectral meter can measure the concrete surface as one certain point measurement. However, hyper-spectral meter cannot measure whole concrete surface. It is necessary to monitor concrete damage to detect spatial distribution of concrete damage. For obtaining this result, hyper-spectral imager is one of effective instruments to measure concrete surface, which is now under development. This methodology can be applied with the portable hyper-spectral imager for not only inspection of paint film distribution but extraction of damage in the future work.

References

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