INSPECTION OF INTERNAL DEFECTS IN CONCRETE STRUCTURES BY SCANNING IMAGE ANALYSIS

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ABSTRACT

This paper describes one of visual inspection devices that developed with small borehole and to be named as Stick Scanner (SS) for internal concrete structure by using scanning technique. The advantage of SS is making the possibility for effective and secure working with a good precision to obtain plural information from one inspection mark such as crack width, crack depth, carbonation depth, corrosion etc in rapid way (about 30 minutes for one inspection mark). The use of small inspection borehole also gives a faster restoration and no significance damage effect towards the integrity of existing structures. The measurement and assessment process are conducted by analyzing of captured image in photograph stage.

Keywords: internal defect, scanning image, visual inspection, small-scale destruction, plural information

INTRODUCTION

Concrete is the most common material used in construction world because of its workability, durability, and relatively low in cost. However, concrete dependent upon elapsed time same as with all materials will be deteriorated due to various reasons. In Japan, there is an indication that structure maintenance for 50 years old construction is rapidly increasing in the last decade. For that reason, an assessment condition of structure member becomes an important aspect to determine a repair plan of aged structural system and establish the durability. The purpose of inspection is to grasp the performance of a structure and collect information necessary for carrying out maintenance. Inspection shall be carried out by suitable methods to discover deterioration, damage, or initial defects and to maintain the performance of the structure above the required level. In the cases when any defect or damage is found, immediate measures shall be taken (JSCE, 2001).

Continuous concrete structure soundness assessment should provide data from the internal of structures for understanding structural performances and predicting the remaining service life. For that reason, an assessment condition of structure member becomes an important aspect to determine a repair plan of aging structural system and establish the durability (Kawano, et. al, 2001). It is generally accepted that the estimation of structure condition and moreover for the estimation of the future structure degradation are based on the information collected by inspection and testing (Faber & Sorensen, 2002).

Breul, et al. (2008), developed diagnosis and assessment tools for existing structures that capable to estimate on-site concrete segregation using image analysis. This method relies on the use of endoscope and of automatic image processing that allows particle extraction from 0.1 to 10mm. Before image capturing, an improvement of the boring surface is carried out so as to simplify the subsequent of image processing. Image capturing is performed with a rigid endoscope with diameter of 8mm throughout the borehole. The captured image is covering a small area due to the size of sensor head.

Another method for assisting the inspection like core drilled will gather an existing concrete condition, and investigate the internal defects, such as carbonation depth, chloride ion diffusion, cracking, void, and corrosion. By this method, relatively big device is required and became difficult to determine the number of inspection mark related with cost and work problems. In addition, there is a partial damage or danger to cut off a steel reinforcing bar in core drilling process.

To solve the problems, an alternative method such as narrow path drilled hole will be applied with small breaking test to inspect carbonation depth or chloride ion diffusion of internal structure members after several years, because it is not effective to conduct only one inspection item in one mark of measurement (Zacoeb, et al., 2007). This paper presents the basic principles of inspection technology that developed by using a stick scanner to capture concrete surface image from inspection borehole, whereas the assessment is confirmed by imaging analysis in photograph stage.

OUTLINE AND SPECIFICATION

The stick scanner that developed for capturing internal concrete surface image from small inspection borehole is shown in **Figure 1** and the specification of device is shown in **Table 1**. The internal surface image is captured by inserting the stick scanner aperture mouth into inspection borehole and rotating in clockwise manual movement with one hand to capture all internal surface of inspection hole. The stick scanner is connected to a tablet PC through an USB port.

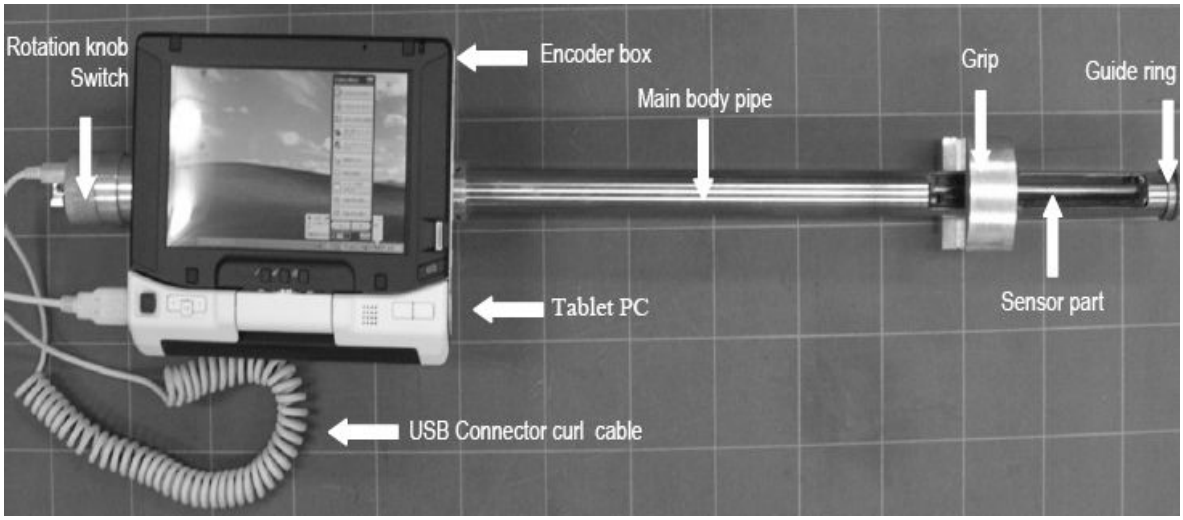

Figure 1 The stick scanner

Table 1 Specification of stick scanner

Main Body	Material Total length Insertion length Total mass	: Stainless steel round pipe : 650mm : 350mm (extent up to 1000mm by installing the extension of steel pipe) : 1040gr (tablet PC excluded)
Sensor	Type Length Reading size Resolution Focus depth	: Contact Image Sensor (CIS) : 120mm : 105 x 356mm : 600dpi (dot per inch) : 1mm
Curl Cable	Length	: 700mm (connector included)
Mobile Instrument	OS PC CPU Memory	: Windows®/2000/ME/XP : AT compatible machine equipped with USB port : Pentium(R) - 266MHz or higher : 64MB (minimum)

CHARACTERISTIC OF IMAGE

The gap between object and the contact image sensor in this scanner is consistent in two dimensional (insertion and rotation direction). It means an image pixel always becomes the same size with scanner reading resolution. Scale calibration became unnecessary with this scanner. The captured image from inside borehole in maximum reading size of 105 x 356mm for one time scanning is contains approximately of 21,190,476 pixels or more than 20 megapixels that can be obtained at maximum quality of 600dpi.

This image is enabled to confirm fine aggregate or cracking condition bigger than 0.005 mm. Scale calibration that to be needed by various measurements with a digital camera is become unnecessary with this device, included in copying process. Arbitrary distance between two points on captured image can be easily measured from the calculation of the pixels number.

This device can perform accumulation display of image as well as pixel size being constant precisely because there is no image distortion. If the insertion length is more than maximum reading size of sensor, it will require for extra scanning by inserted the sensor part of SS deeper into the inspection borehole. The common parts of image are shown in **Figure 2** and both images are partially overlapping become one image on PC with composition method.

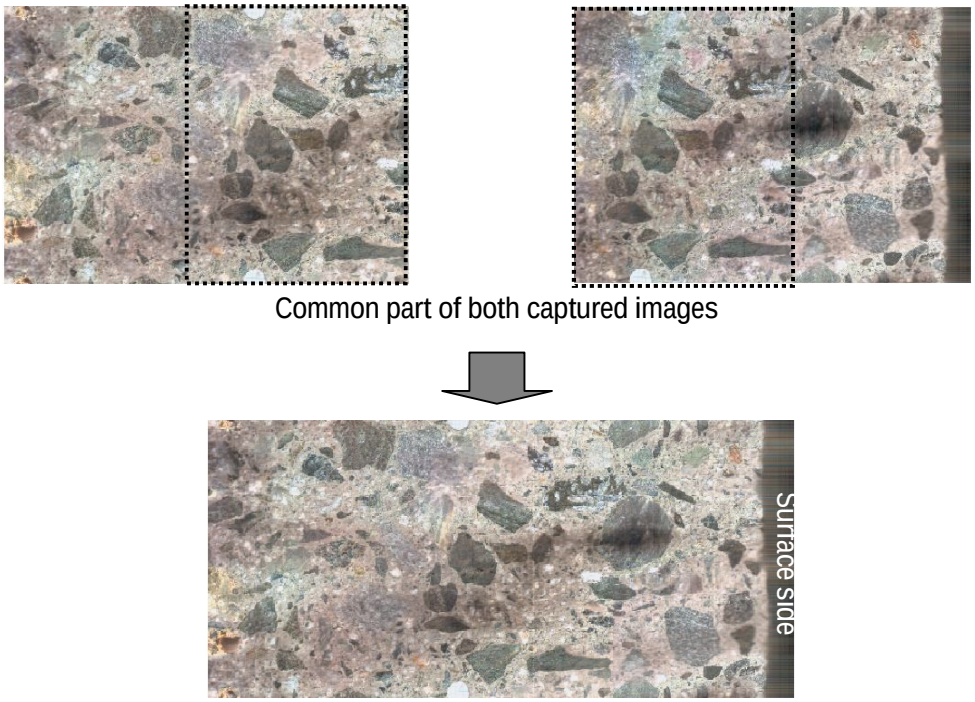

Figure 2 Method of image composition

This digital image characteristic is also enabled to conduct a various analyses. For example, extraction of coarse aggregate (aggregate more than 5mm in size) by using image extraction to process the captured image with the result as shown in **Figure 3** is enabled to calculate the rate of coarse aggregate area and homogeneity of concrete. In other words, it is possible to evaluate the segregation degree of concrete by extracting the captured inside surface image.

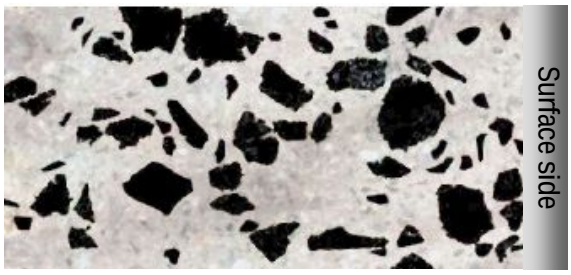

Figure 3 Method of image extraction

INSPECTION PROCEDURE

Reinforcing bar investigation is performed in the first stage by a rebar locator to determine a drilling location and avoid a reinforcing bar cutting accident. Inspection of internal defect such as cracking or void is possible by scanning image after having sprayed with phenolphthalein solution for carbonation depth measurement in dry or wet core drilling process. While for chloride ion diffusion, it must be performed in dry process and sprayed with nitrate silver solution ($AgNO_3$). The measurement is possible by calculating a number of pixels in the scanning image part with color changes after having sprayed with the solution. The scanning process is conducted after dry conditioning of inspection borehole. Inspection procedure with this scanner, from reinforcing bar investigation to the segment restoration for various investigations with this stick scanner is shown in **Figure 4**.

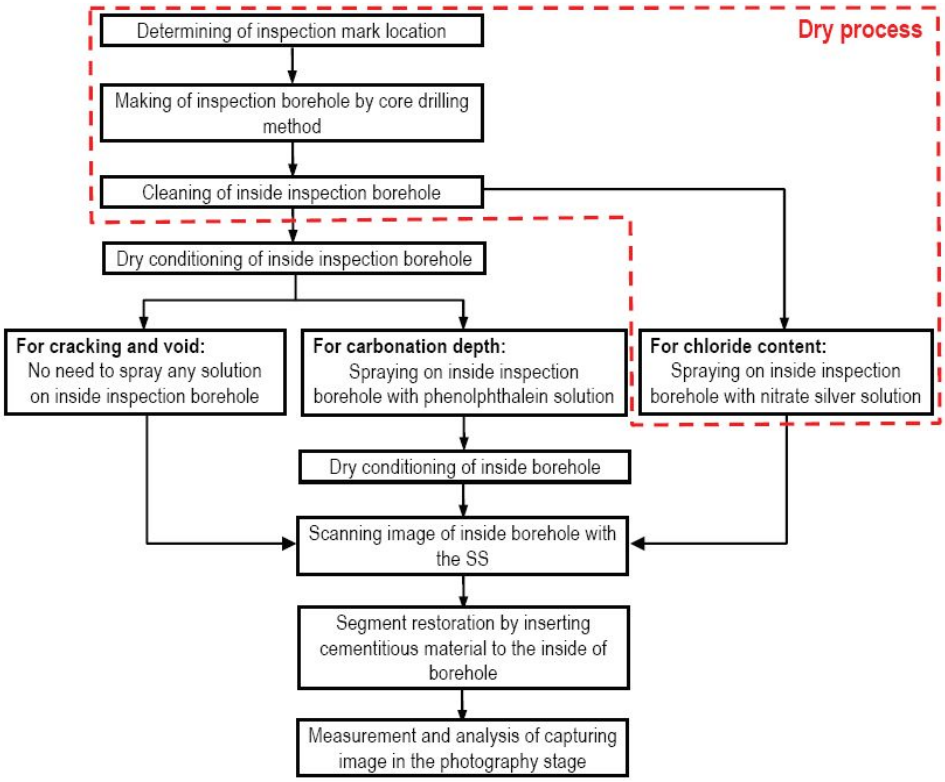

Figure 4 Flow chart of inspection

The measurement, such as crack width or carbonation depth that appeared in scanning image is confirmed easily by counting the number of pixels. This digital image characteristic is also enabled to conduct a various analyses. For scanning image sample result is shown in **Figure 5** that contains information about internal concrete defects, such as carbonation depth, crack condition and alkali silica gel.

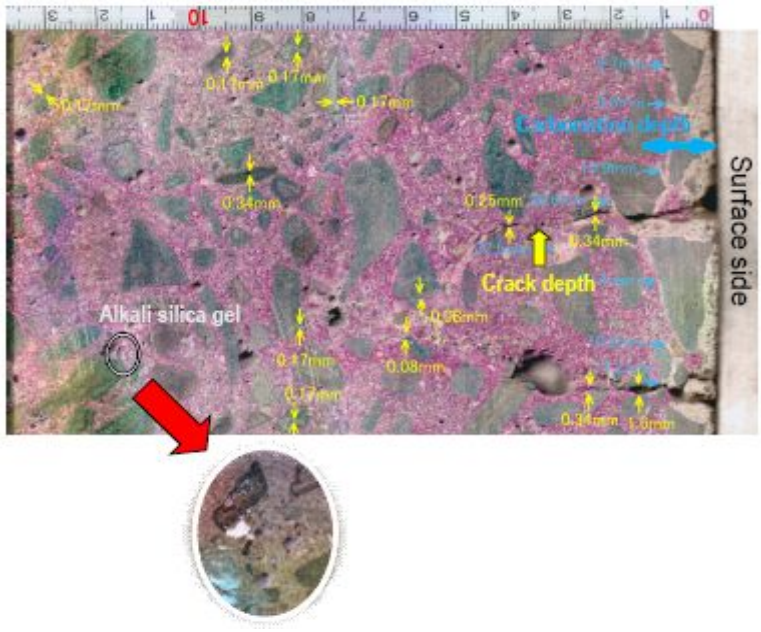

Figure 5 Sample of final image analysis

CONCLUSION

Internal inspection of concrete structure that conducted by this stick scanner is effective to obtain plural information from one inspection mark. By using a small inspection borehole diameter of 24.5mm, it will faster for concrete segment restoration and no giving any significant effect towards structure performance. The capturing image with maximum quality more than 20Megapixels is enabling for analysis the condition of internal concrete that will be beneficial for assessing and determining the maintenance plan.

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REFERENCES

Japan Society of Civil Engineers, *Standard Specifications for Concrete Structures "Maintenance"*, JSCE Guidelines for Concrete No. 4, 2001.

Kawano, H., Watanabe, H., & Koga, H., Nationwide Survey on Soundness of Concrete Structures, *Proceedings of the 2nd International Conference on Engineering Materials*, California, U.S., August 15-17, 2001, pp. 93-100.

Faber, M.H., & Sorensen, J.D., Indicators for Inspection and Maintenance Planning of Concrete Structures, *Structural Safety*, Vol. 24, 2002, pp. 377-396.

Breul, P., Geoffray, J.M., & Haddani, Y., On-Site Concrete Segregation Estimation using Image Analysis, *Journal of Advanced Concrete Technology*, Vol. 6, No. 1, 2008, pp. 1-10.

Zacoeb, A., Ishibashi, K., Ito, Y., Miyamoto, N., & Sogabe, M., Development of Advanced Inspection Device for Internal Concrete Structures, *Proceedings of the 1st International Conference of European Asian Civil Engineering Forum*, Tangerang, Indonesia, September 26-27, 200, pp. D32-D38.