Lateral Deformation of Solidifying Concrete under Uniaxial Loading

Yokohama National University, Graduate Program, Student Member of JSCE, Petr ŠTEMBERK
Yokohama National University, Faculty of Engineering, Member of JSCE, Tatsuya TSUBAKI

1. Introduction

At present there is no special testing method for measuring the lateral deformation of solidifying concrete. Contact methods which are used for hardened concrete are unsuitable for solidifying concrete due to either incapability of attaching measuring apparatus to the surface or the lack of adhesion in case of embedded strain gauges. The use of a laser sensor also is not easy to be applied since the longitudinal deformation of solidifying concrete is rather large, which requires some mobile attachment of the laser sensor so that it can follow the targeted spot with progressing longitudinal deformation. An optical method where the image is captured with a high resolution CCD camera is relatively easy and nowadays also inexpensive. Capturing an image solves the part of acquiring test data on lateral deformation, however, conversion of the image data to lateral deformation measurement requires some attention.

2. Testing method

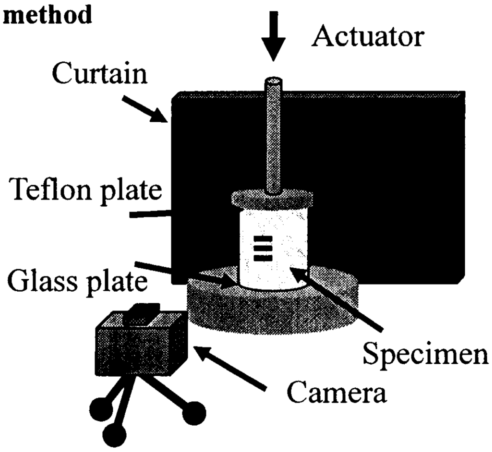

Fig. 1 Test configuration

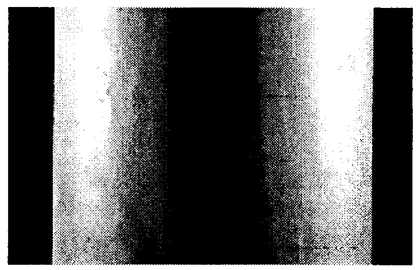

Fig. 2 Captured image of a specimen

A CCD camera with resolution 3040x2016 pixels was used. In order to pronounce the edge of a specimen a dark curtain was installed behind the test set and a specimen was illuminated on both sides with two spotlights, **Fig. 1**. The focus of the camera was set in advance and kept constant. The shutter of the camera was correlated in terms of time with a PC collected data on longitudinal displacement (LVDT, stroke 200mm) and loading force (load cell). The loading force was imposed by an electric actuator with an online fuzzy controller. An example of a captured image is shown in **Fig. 2**.

3. Image processing

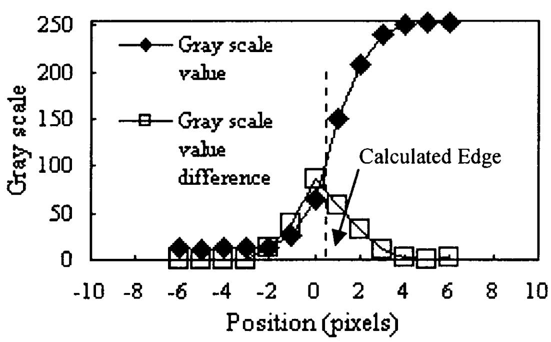

Fig. 3 Digitized edge of a specimen

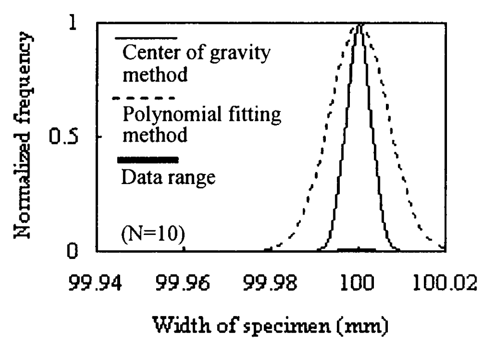

Fig. 4 Comparison between two methods

Keywords: solidifying concrete, image processing, lateral deformation
Contact: 〒240-8501 Hodogaya-ku, Yokohama, Yokohama National University, Faculty of Engineering FAX: 045-331-1707

Three stripes were cut from the captured image. The monochromatic bitmap image comprising data in the form of a gray scale with 256 levels was converted to an array of digits for each pixel. In order to detect the edges of a specimen on the subpixel domain the center of the gravity of the area under the curve defined by gray scale value differences of neighboring pixels, **Fig. 3**, was calculated. The distance between the centers of gravity on both sides of the specimen defines the width of a specimen, A_0-B_0 in **Fig. 5**. However, because the distance of the camera from a specimen is of about the same order as the width of the specimen, some correction of the reading, *A-B* in **Fig. 5,** should be introduced. From elementary geometry applied to the problem shown in **Fig. 5**, where *r* is the radius of a specimen and *d* is the distance between the lenses of camera and the center of a specimen, the correction factor *c* can be derived, **Eq. 1.**

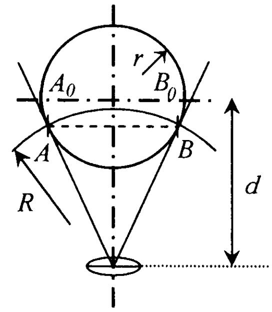

Fig. 5 Correction of measurement

$$c = r\left(\cos\left(\arcsin\frac{r}{d}\right) - 1\right) \qquad [1]$$

The center of gravity method was compared with the method proposed in [1] for measurement of steel beam deflection which is based on sixth order polynomial fitting. The comparison was done on a series of images captured on one unloaded specimen. The result shown in **Fig. 4** stands for a partial verification of the proposed testing method.

4. Experimental data

The experiment was conducted with specimens (diameter 100mm and height 200mm) for two types of mixes using rapid hardening portland cement (RHPC). The mix design is summarized in **Table 1**.

The compressive strength development is shown in **Fig. 6**. The Poisson's ratios as a function of a load level for respective mixes are shown in **Figs. 7** and **8**. Due to inconsistent readings of both the longitudinal and lateral deformations related to settling of the specimen at the beginning of loading the values of the Poisson's ratio before the load level of about 20% were excluded.

Table 1 Mix proportions

Type	Weight per unit volume (kg/m^3)			
	W	C	S	A
Type-1	168	271	767	1136
Type-2	181	490	598.5	1093

[Note] Target 28 day strength =30 MPa (Type-1)
60 MPa (Type-2)
Target slump = 8 cm
Target air content = 2 %

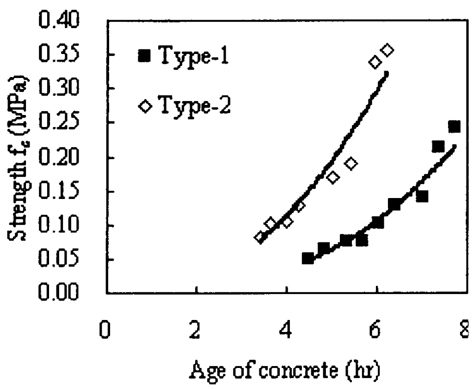

Fig. 6 Strength development

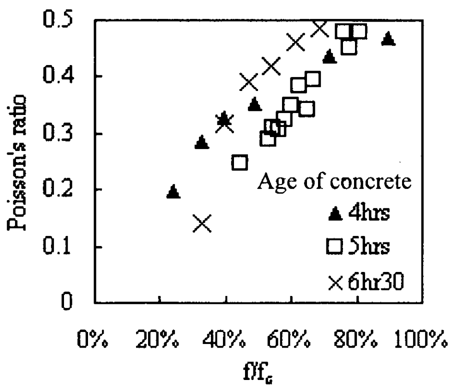

Fig. 7 Poisson's ratio (Type-1)

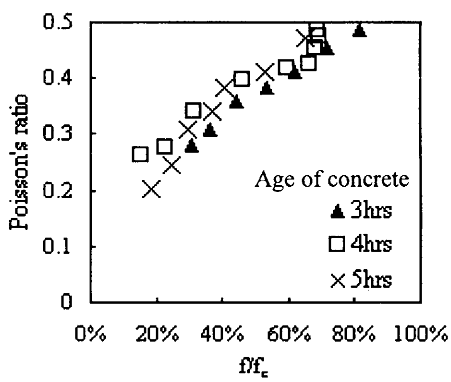

Fig. 8 Poisson's ratio (Type-2)

5. Conclusions

A testing method for measuring time-dependent lateral deformation of solidifying concrete was proposed. Two methods of image processing were compared. The Poisson's ratio of solidifying concrete for two mix designs of rapid hardening portland cement was investigated and the results were presented.

References

1. Fu, G. and Moosa, A. G.: An Optical Approach to Structural Displacement Measurement and Its Application, Journal of Engineering Mechanics, ASCE, Vol. 128, No. 5, 2002, pp. 511-520.