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Experiment on Long-Term Deformation of SRC Columns

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ABSTRACT

Long-term deformation of steel-reinforced concrete (SRC) column is different from that of reinforced concrete (RC) column due to the different moisture distribution. Wide-flange steel in SRC column obstructs diffusion and makes the long-term deformation resulted from drying slower. Previous researches show the long-term deformation of SRC columns analytically and experimentally, but additional experiment is necessary to investigate this phenomenon more precisely. Therefore, creep of SRC column specimens with various types of wide-flange steel are tested. Wide-flange steel is made of thin acrylic panel so that it can block the diffusion but does not have strength in order to exclusively demonstrate the long-term deformation of concrete regardless of reinforcement ratio. Experimental results show that the long-term deformation of SRC column develops slower than RC, and it is slower as the wide-flange steel hinders the diffusion more. According to the experimental result, it can be concluded that new prediction model for long-term deformation of SRC columns should be developed.

1. INTRODUCTION

Steel-reinforced concrete (SRC) columns are frequently used for high-rise buildings because of the increased load-bearing capacity of load and construction convenience. Prediction of column shortening in high-rise buildings is much more important than low-rise buildings because a small error can lead a huge danger. Previous researches show that the long-term deformation of SRC column is different from that of RC column due to the different moisture diffusion (An, et al., 2015) (Seol, et al., 2008). Experiments of various SRC columns are conducted to verify the effect of wide-flange steel on the long-term deformation of SRC columns. Thin acrylic panel is used for the wide-flange steel to simulate exclusively the effect of wide-flange steel on the moisture diffusion and long-term deformation. The experimental results show the characteristic of long-term deformation of SRC columns compared to reinforced concrete (RC) columns. Finally, some correction factors for the existing model

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equations are suggested to predict the long-term deformation of SRC columns in the field.

2. EXPERIMENTAL PROGRAM

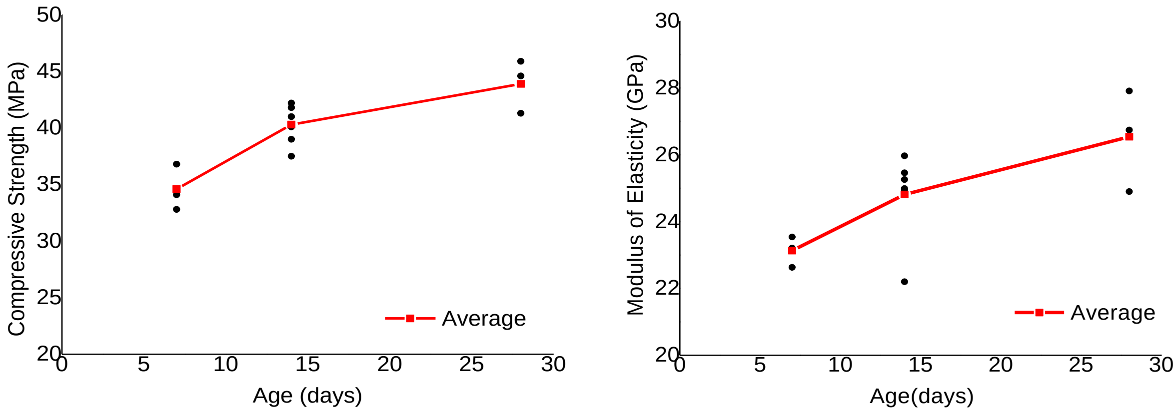
2.1 Materials

Concrete   Mix proportion of concrete is provided in Table 1.

Table 1 Mix proportion of concrete

w/c(%)	S/a(%)	Unit Weight (kg/m^3)				
		W	C	S	G	SP
45	43	170	378	754	1008	2.27

Compressive strength and elastic modulus of concrete are tested according to the standards, KS F 2403 and KS F 2405, with the cylindrical specimens of $\phi 100 \times 200$ mm and $\phi 150 \times 300$ mm. Mechanical properties of concrete used for SRC column specimens are as shown in Fig. 1.



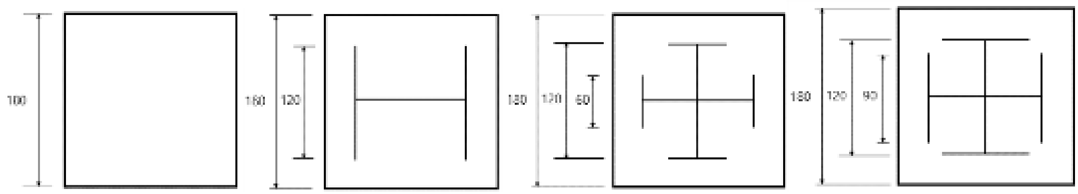
(a) Compressive strength (b) Elastic modulus

Fig. 1 Mechanical properties of concrete

Wide-flange steel   Thin acrylic panel with width of 0.5 mm is used instead of the wide-flange steel in SRC columns because the main purpose of this study is to identify the long-term deformation of SRC columns due to the different moisture diffusion. The acrylic panel do not affect the strength of the specimen and only disturb the moisture diffusion.

2.2 Specimens

Four kinds of column specimens are made for the experiment. Width and depth of all columns are 180 mm and the total height is 500 mm. One type called 'A0' is for RC column and it does not contain the acrylic panel and the moisture freely diffuses. The others such as ‘A2’, ‘A4-6’ and ‘A4-9’ are for SRC columns and they contain the acrylic panel with various length as shown in Fig. 2. Fig. 2 shows the cross-sections and names of the specimens depending on the shape of wide-flange steel.



(a) A0 (b) A2 (c) A4-6 (d) A4-9

Fig. 2 Cross-sectional plan of columns

The height of the acrylic panel is 480 mm and it is fixed by thin wire. Embedded strain gauge is set in the column specimens at the center as shown in Fig. 3.

(a) Top view (b) Side view

Fig. 3 Installation of embedded strain gauge

The surfaces of top and bottom of columns should be flat to avoid stress concentration during the creep test. Therefore, cement paste is placed to the top of the columns to make the surfaces smooth. After removing molds, column specimens are cured in the water of 20℃ in 14 days.

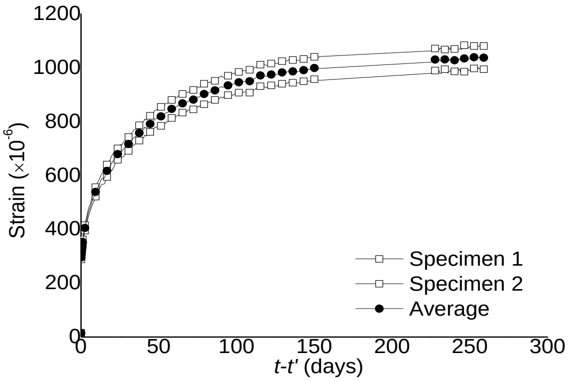
2.3 Test method

After 14 days of curing, experiment on creep of column specimens starts. External stress is about 20% of compressive strength of concrete. Two specimens for every type of column are tested in the same creep frame as shown in Fig. 4. In addition to the embedded gauge, two LVDTs are also set as shown in Fig. 4.

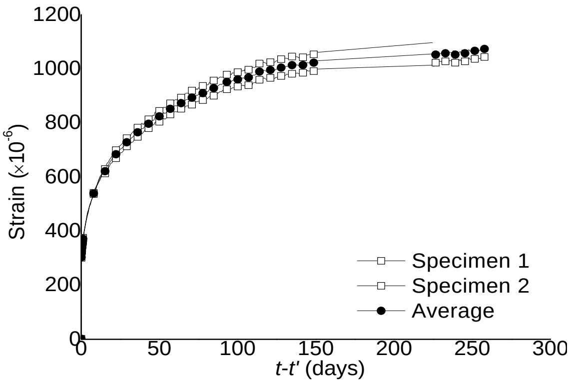
Fig. 4 Creep test of column specimens

3. RESULTS AND DISCUSSION

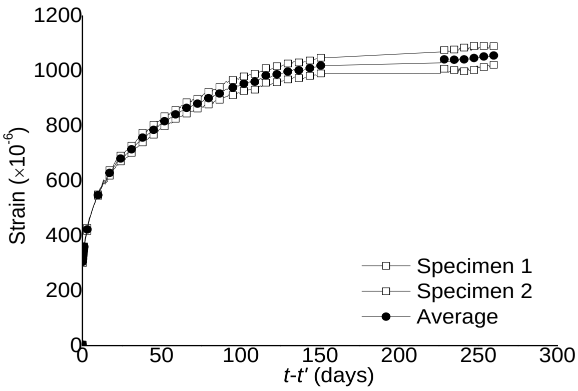
Experimental results of creep of four types of columns are shown in Fig. 5.



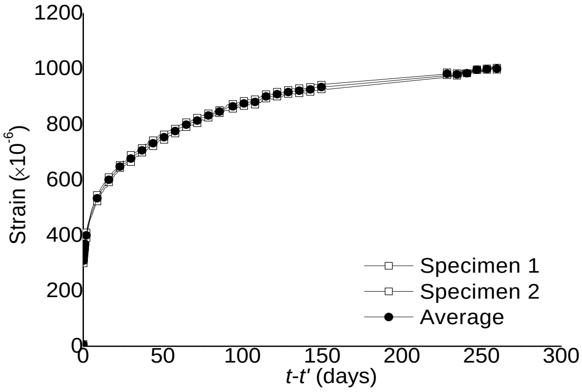
(a) A0



(b) A2



(c) A4-6



(d) A4-9

Fig. 5 Experimental results of column specimens

From the experimental results, creep compliance of each column specimen can be calculated as shown in Fig. 6. Average value of each type is used for Fig. 6.

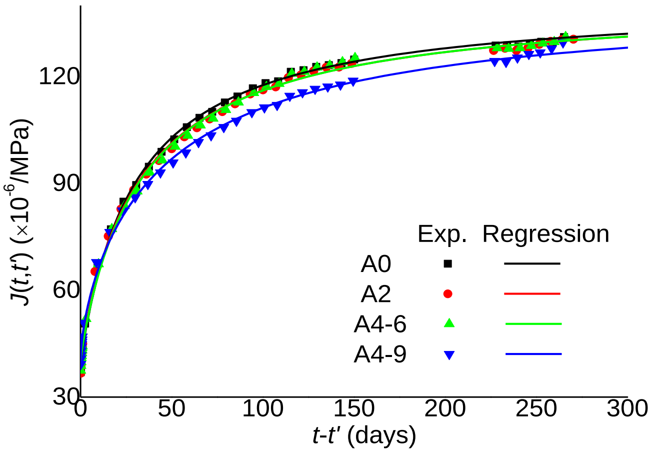


Fig. 6 Creep compliances of columns and regression results

In Fig. 6, creep of SRC columns such as ‘A4-9’ is developed slower than RC column, ‘A0’, as expected. Therefore, some correction factors for the existing creep coefficient model are necessary to predict the long-term deformation of SRC columns.

Eq. (1) is creep coefficient model suggested by ACI (ACI Committee 209, 2015) with new correction factors, α and β.

$$\phi(t,t') = \left(\frac{(t-t')}{\alpha d + (t-t')} \right)^{\beta} \phi_u \quad (1)$$

where $d = 26e^{0.0142v/s}$, t is age, t' is the age of loading, ϕ_u is the ultimate creep coefficient, α and β are correction factors suggested in this study.

Regression analysis of experimental results in Fig. 6 with Eq. (1) are conducted to find the factors. Coefficients are relatively decided by setting the column ‘A0’ as a standard. Results of the regression analysis are included in Table 2.

Table 2 Correction factors depending on the type of column

Type / Factors	A0	A2	A4-6	A4-9
α	1	1.25	1.20	2.44
β	1	0.88	0.92	0.63

As shown in Table 2, the correction factors of ‘A2’ and ‘A4-6’ are very similar because the effect of wide-flange steel on moisture diffusion is similar. Also, ‘A4-9’ shows the most different factors compared to ‘A0’ column because the shape of wide-flange steel is the most effective to hinder the moisture diffusion.

4. CONCLUSIONS

Experiments for long-term deformation of various SRC columns are conducted to investigate the effect of wide-flange steel compared to RC columns. Results show that the long-term deformation of SRC columns is different from that of RC columns. Some correction factors for the current creep model are suggested to reflect the characteristics of SRC columns and to give better prediction. Analytical study on the long-term deformation of various SRC columns with respect to column size or environmental condition is the subject of further research to develop better correction factors because experiments for all cases are practically impossible.

ACKNOWLEDGEMENTS

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