Effect of expansion due to sulfate attack on shear strength of reinforced concrete wall

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1. Introduction

Nuclear power plants buildings are built on the seaside to supply cooling water. Some areas, such as UAE, has high concentration of sulfate ions in sea waters due to high temperature. Sulfate attack into concrete affect the performance of the material properties of concrete. Expansion and degradation of compressive strength of concrete are expected. Therefore, test about sulfate attack has been conducted on concrete in various environments and concrete mixture proportions.

Artificial Neural Network (ANN) theory is one of the optimization techniques and is used in various disciplines. In this study, ANN is used to predict the expansion ratio due to sulfate attack.

2. Prediction of expansion

Due to sulfate attack, concrete expansion, degradation of compressive strength, and carbonation of concrete are expected. In the case of sulfate attack, the governing equation of diffusion is not yet clearly defined. However, the deformation due to expansion can be directly measured during experiments. Concrete expansion due to sulfate attack was tested in various conditions (Tikalsky (1993), Barghabra et al (1995), Irassar et al (1996), Al-Dulaijan et al (2003)). In this study, the expansion ratio of concrete exposed to sulfate was predicted based on approximately 1,500 experimental data. Table 1 shows the range of database.

Table I: Database

	Range
Cement type	I, II, III, IV, V
W/C	0.28 – 0.77
Water	107 - 1477
GGBS	0 – 85
FA	0 – 40
SF	0 – 20
Gravel	0 - 1150
Sand	420 - 1456
SP	0 - 14
AE	0 - 3

[*]W/C: water cement ratio, GGBS: Slag, FA: Fly ash, SF: Silica fume, SP: Super Plasticizer, and AE: Air-Entraining Agent

Figure 1 shows the predicted results using ANN. To prevent overfitting, the database was classified as three groups (Modeling, Cross-validation, and Verification).

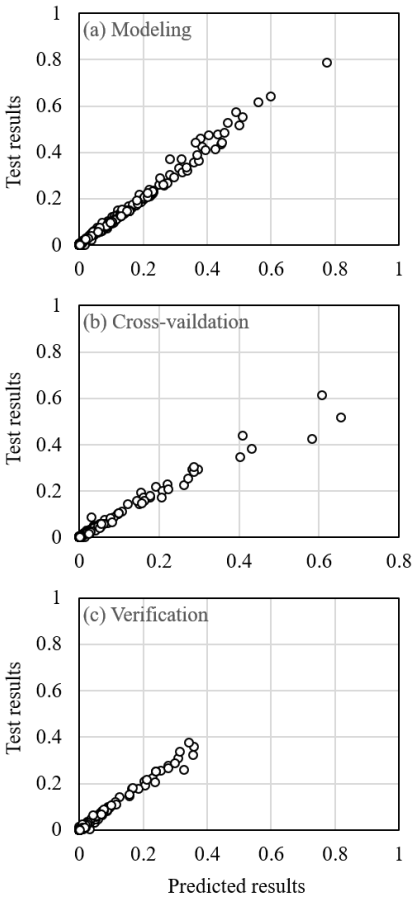

Fig. 1. Comparison of test and predicted results.

3. Evaluation of RC wall with expansion

Finite element analysis was conducted to investigate the effect of concrete expansion on the performance of shear walls. The shear wall model without any degradation was based on the shear wall test. Since no finite element analysis program provides a function to input expansion values due to sulfate expansion, the analysis was conducted using the initial strain or thermal expansion features.

Figure 2 shows the strain distribution of reinforced concrete wall with expansion before and after lateral deformation. Figure 3 shows the relationship of lateral

load and displacement of reinforced concrete wall with and without expansion.

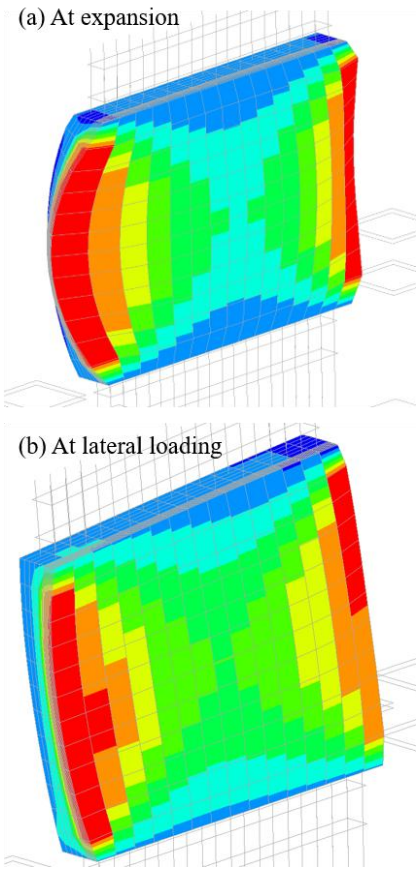

Fig. 2. Strain distribution of RC wall with expansion.

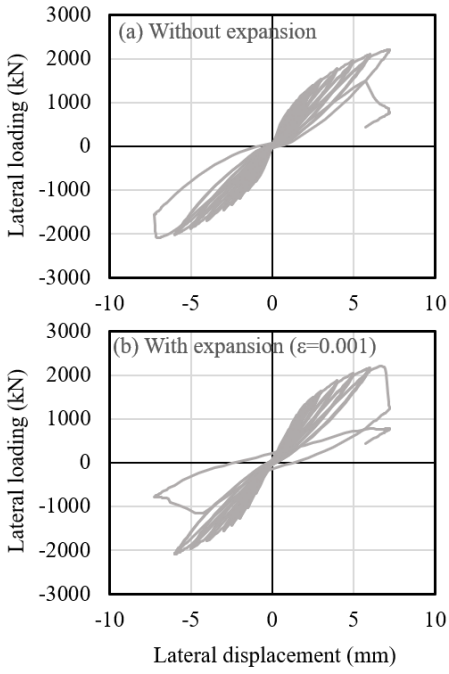

Fig. 3. Relationship of lateral load and displacement.

The maximum reaction forces of RC wall without expansion were 2203 kN and 2090 kN in positive and negative directions, respectively. On the other hand, in the case of considering expansion, the maximum lateral forces were 2200 kN and 2097 kN in positive and negative directions, respectively.

4. Conclusions

Finite element analysis was conducted to investigate the effect of cover sulfate expansion on shear strength of RC wall. The initial strain due to expansion was assumed as 0.001 mm/mm. Before lateral loading, the wall deformed like curved wall due to one-side expansion. The maximum lateral loading, stiffness and capacity of wall were not decreased.

When analyzed based on the analysis results, it was confirmed that the damage caused by sulfate attack had no effect when only expansion was considered. However, in this real case, the compressive strength degradation of concrete due to sulfate attack is expected. Therefore, the strength degradation of RC wall might be larger in the real case.

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