THE INFLUENCE OF ASR EXPANSION ON THE EFFECTIVENESS OF PATCHING REMEDIAL WORK

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1. INTRODUCTION

Patching method is considered to be effective as remedial work for concrete structures deteriorated by Alkali-silica reaction (ASR). In concrete structures ASR occurred, it is difficult to predict the ASR expansion behaviour exactly. It is reported that the residual expansion may occur after applying the repair materials such as surface coatings and/or patching material[1)].

In this study, the experiments were performed to investigate the influence of ASR residual expansion on the patching material and the interface condition between base concrete and patching material. In this experiments, the expansion strain of base concrete and patching material and adhesive strength between patching material and base concrete were measured.

2. EXPERIMENT OUTLINE

2.1. Specimens

"Base concrete" was prepared to simulate the existing concrete structure affected by ASR. Andesite sand was used as reactive fine aggregate. Additional alkali was added in order to promote ASR and its expansion. The equivalent alkali content (NaO_2eq.) was set to 5kg/m^3 by sodium hydroxide. The mix proportions of base concrete are shown in Table 1. Prior to application of the patching material, base concrete specimens were cured under conditions of 80^{o}C of temperature and 97% of relative humidity until the expansion strain reached the values of 800μ. After attending the planned expansion, specimens were restored in the room condition (20℃) and 4 types of patching materials were applied and cured for 4 weeks. These specimens were exposed again under accelerating conditions. The specification of patching materials and the number of specimens were shown in Table 2. The dimension of the concrete test specimen with the patching material is shown in Fig 1.

2.2. Expansion strain measurement

The expansion strain of specimens was measured by contact gauges (base length: 250mm). The contact gauge chips were attached at four sides of specimens. On each side of a specimen, contact gauge chips were attached at three positions: the upper part (U Chip), the lower part (L Chip) of the base concrete and the part of the patching material (P Chip) as shown in Fig.2.

In order to reduce the error, expansion was measured two times for each position of contact gauge chips at the same measurement.

Table 1 Mix proportion of base concrete (kg/m^3)

W/C (%)	W	C	S	Sr	G	AE	NaOH
55	168	305	550	236	980	0.16	5.23

W/C: Water Cement ratio; W: Water; C: Cement;
S: Fine Aggregate; Sr: Reactive Fine Aggregate;
G: Coarse Aggregate; AE: Air Entraining Admixture

Table 2 Specification of specimens

Expansion after patching	A	B	C	D
Series 1 (800 μ)	No.1	No.2	No.3	No.4
Series 2 (1500 μ)	No.5	No.6	No.7	No.8

A - High Strength Polymer Cement Mortar + Acrylic Primer
B - High Strength Polymer Cement Mortar + Epoxy Resin Primer
C - High Toughness Polymer Cement Mortar+ Epoxy Resin Primer
D - General Polymer Cement Mortar

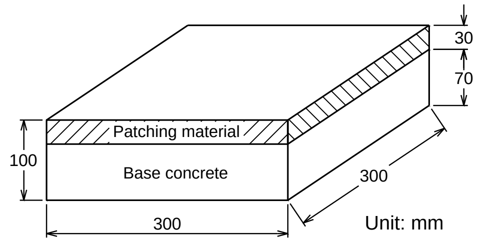

Fig.1 Dimension of experimental specimen

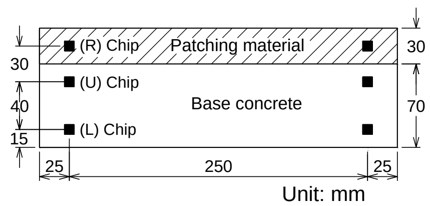

Fig.2 Contact gauge chips position

2.3. Adhesive strength test

In order to investigate the influence of expansion on the interface between patching material and base concrete, the adhesive strength was measured by the pull-off test.

On the surface of specimens, notches were made along a square of 50mm×50mm and the depth of the notch was 40mm. The adhesion tests were carried out at two stages of the attended expansion of 800μ and 1500μ.

3. EXPERIMENT RESULTS

3.1. Expansion behaviour

The results of the expansion strain of the base

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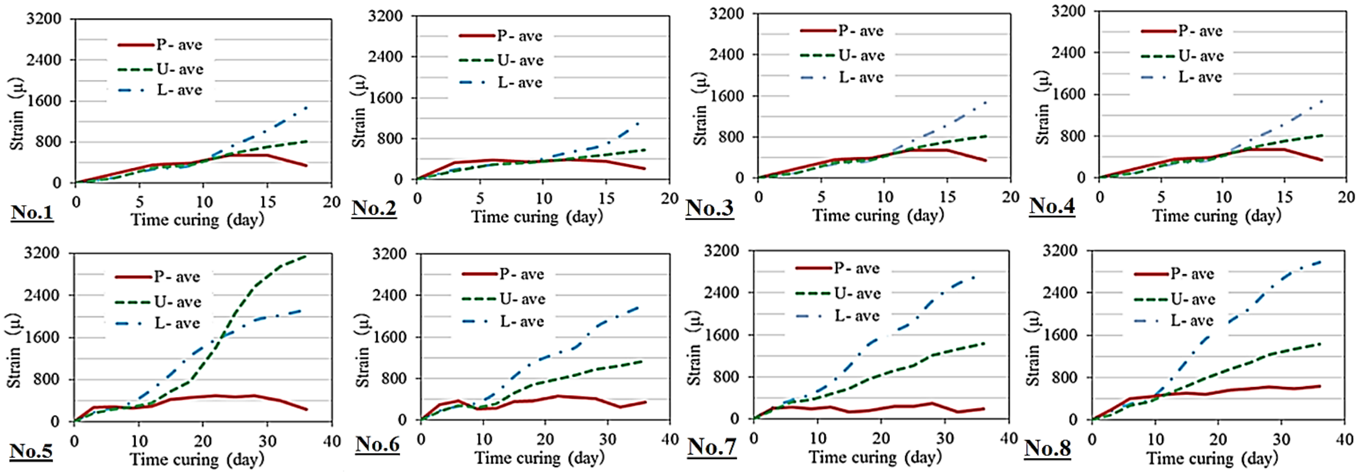

Fig.3 Expansion strains of specimens

concrete and the patching material are shown in Fig.3. U-ave, L-ave and P-ave in Fig.3 represent the average values of the strain of U Chip, L Chip and P Chip on four sides, respectively. In the case of expansion strain which were larger than approximately 500μ, almost specimens showed a similar expansion behaviour. When the expansion strain was not too large such as lower than 500μ, it seemed that the deformation of patching material was nearly the same with the expansion of base concrete. Therefore, it is considered that the integrity of interface between base concrete and patching material were maintained.

In the case of the expansion strain which were larger than 500μ, the expansion strain of the lower part of base concrete was larger than the upper part. On the other hand, the expansion strain of patching material was changed slightly and some cracks were seen on the sides of base concrete. Although the patching material restrained the expansion of the upper part of base concrete, the integrity of inner side of base concrete may be reduced.

3.2. Adhesive strength test

The adhesive strength results of the experiment at the attained strain of 800μ and 1500μ are shown in Fig.4 and Fig.5, respectively. The black dashed lines in the figures indicate the value of 1.5N/mm^2, the lower limit of adhesive strength required for the patching material. Regarding the case of high strength polymer cement mortar and acrylic primer (No.5), the patching material was peeled off during the expansion progress and a gap about 5mm occurred finally. The adhesion test could not perform in this case.

The adhesive strength of 800μ series was smaller than that of 1500μ series. The adhesion tests showed that the failure happened only in base concrete and almost adhesive strengths were under the required value. Therefore, the reduction of the mechanical properties of base concrete affected by excessive ASR expansion resulted in the reduction of the adhesive strength.

4. CONCLUSION

The patching material has contributed to restrain the expansion of the upper part of the base concrete.

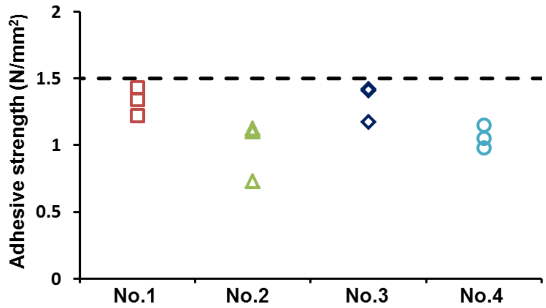

Fig.4 Adhesive strength (800μ strain)

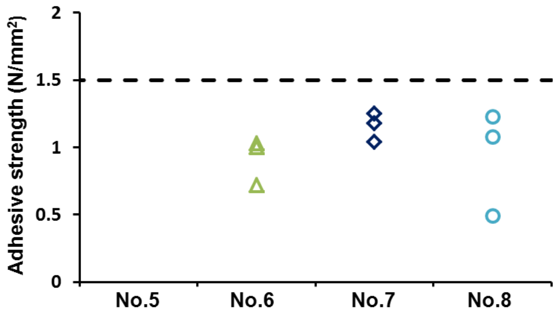

Fig.5 Adhesive strength (1500μ strain)

However, the expansion of the lower part of base concrete was continued. It is considered that this results in the reduction of mechanical properties of base concrete. Consequently, the adhesive strength of base concrete may be decreased due to the reduction of mechanical properties of base concrete affected by excessive ASR expansion.

REFERENCES

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