EFFECT OF COATING TO INHIBIT AAR IN CONCRETE STRUCTURE

Koichi Ono & Mamoru Taguchi, Konoike Construction Co., Ltd. Osaka Japan
Shitoki Kanefuji, Toshimi Tokuno, Dainippon Toryo Co., Ltd.
Nobuyuki Yamada, Sanko Toryo Co., Ltd.

Effective technique to inhibit AAR has not been developed yet in Japan. It is inferred from characteristics of AAR that waterproofing might be one of the effective methods to inhibit AAR. Therefore, coating method was tested as inhibition technique of AAR. As the first step, effect of acryl gum, epoxy resin, polybutadiene and polymer cement were tested using prism specimen. The laboratory test indicates that the polymer cement type of coating might be effective to inhibit AAR.

These coatings were also applied to various AAR damaged concrete structures and the effect has been monitored for several years. Although the monitoring period is short, there is an indication that polymer cement type of coating might be also effective.

This paper presents the effect of various coatings to inhibit AAR in concrete structure.

LABORATORY TEST

Coating

Among many available coating materials, 6 different types of coating were selected to check effectiveness to inhibit AAR of concrete. Epoxy resign, polybutadiene and acryl-gum are waterproof type of coating. These coatings do not allow water to penetrate into concrete and to evaporate from the concrete as well. Polymer cement, silane monomer + polymer cement and silane origomer + polymer cement are aeration type of coating. These coatings also do not allow water to penetrate into concrete but allow moisture to evaporate from the concrete surface. Table 1 shows coating materials used for this test. In this table, the order of coating operation, standard usage of each coating material and finished coating thickness are also listed.

Test Specimen

Prism specimens of 75x75x400mm were employed for this test. Table 2 shows the mix proportion of the concrete. The content of reactive aggregate in the total coarse aggregate was fixed to be 40%. Bronzite andesite was used as the reactive aggregate. Alkali content of the concrete was adjusted to be 8kg/m^3 in Na_2O_{eq}.

Storing Condition and Operation of Coating

Specimens were stripped at the age of 1 day and stored in the room of 40°c and RH100% for 1 month. Expansion of specimens was about 500x10^{-6} at this stage. Then, the specimens were replaced in the room of about 20°c and RH80% and kept there for 1 week. During this period, each coating was operated. The water content of the specimens was about 5 to 6% when coated. After coating, the specimens were left in the atmosphere for about 3 years. For the comparison, uncoated specimens were also stored in the same way. Expansion and weight change of each specimen were measured periodically. Each measurement was made in the room of 20°c and RH80% after keeping the specimens for 24 hours in the room.

TABLE 1 - Coating Method

Coating Material No.		The order of operation	Material	Standard usage (kg/m^2)	Thickness (mm)
No.1	Epoxy	Base coat	Epoxy resin primer	0.10	0.5
		Main coat	Flexible epoxy resin	1.20	
		Top coat	Flexible polyurethane resin	0.12	
No.2	Polybutadiene	Base coat	Epoxy resin primer	0.10	0.6
		Main coat	Polybutadiene resin	0.80	
		Top coat	Flexible polyurethane resin	0.12	
No.3	Acryl-gum	Base coat	Epoxy resin primer	0.10	0.5
		Main coat	Acryl-gum	1.50	
		Top coat	Flexible acryl emulsion	0.16	
No.4	Polymercement (Evercon)	Base coat	Polymer cement primer	0.15	0.4
		Putty	Polymer cement putty	0.40	
		Main Coat	Polymer cement	0.90	
No.5	Silane-monomer +polymercement	Base coat	Silane-monomer	0.15	1.0
		Main Coat	Polymer cement	2.30	
No.6	Silane-origomer +polymercement	Base coat	Silane-origomer	0.20	1.0
		Main Coat	Polymer cement	2.30	

TABLE 2 - Mix Proportion of Concrete (per 1m^3 of concrete)

Gmax (mm)	Slump (cm)	Air (%)	W/C (%)	S/a (%)	W (kg)	C (kg)	S (kg)	G(kg)		Alkali content (kg)
								Non Reactive	Reactive	
20	18	4	54.3	43.9	190	350	754	581	388	8.0

Test Results

Several cracks appeared on the surface of uncoated specimens within 1 month, then cracks increased gradually. On the surface of No.1 epoxy and No.2 polybutadiene specimens, cracking and failure of coating occurred about 2 years and a half after coating. On the surface of the other specimens, no cracking has been observed up to 3 years and a half. Figure 1 (a) shows expansion of the specimens after coating. This result indicates that No.4 polymer cement and No.6 silane origomer + polymer cement coating have been effective to inhibit AAR for at least 3 years and that No.1 epoxy and No.2 polybutadiene coating were not effective to inhibit AAR. Figure 1 (b) shows weight loss of the specimens by evaporation of water from the surface of the specimens. This result indicates that aeration type of coating does not interrupt water to evaporate from the surface of the concrete. From this laboratory test, aeration type of coating seems to work to inhibit AAR.

MONITORING OF REPAIRED PIERS

Some of the AAR damaged concrete piers have been repaired by coating using various materials. The effect of each coating has been monitored.

Following are some of the results.

Polyurethane Coating

Figure 2 (a) shows AAR damaged column of a bridge pier. This P1 column was constructed in 1977 and repaired in 1985. polyurethane coating with thickness of about 0.06mm was used for the repair without injection of any material into each crack. Polyurethane is waterproof type.

Figure 3 shows expansion of P1 column in the circumferential direction. Expansion of P2 column is also included in the figure. P2 column had no damage but was coated by the same material for the comparison. Expansion of these column includes effect of the ambient temperature. According to the result, polyurethane coating was not effective to inhibit AAR in this case. P1 column cracked again within a year after coating as shown in Figure 2 (b).

Polybutadiene Coating

Figure 4 (a) shows AAR damaged abutment of a motorway bridge. This abutment was constructed in 1969 and repaired by coating. Detail of this repair is unknown. In 1986, this abutment was repaired again by polybutadiene coating with thickness of about 1mm. Before coating, major cracks were filled with flexible epoxy resin. After the repair, cracking started again and became visible in 4 years as shown in Figure 4 (b). Polybutadiene coating was not so effective in this case.

Epoxy Coating

Figure 5 shows damaged beam of a bridge pier. This pier was constructed in 1976 and the cracking was discovered in 1980. Major cracking occurred in horizontal direction at the side of the beam and in the longitudinal direction at the top of the beam. In 1982, this beam was repaired by epoxy coating with thickness of about 0.1mm. The major cracks were filled with epoxy resign before coating. After the repair, cracking became visible again and expansion of the beam also reached the order of 2000×10^{-6} in 7 years. Therefore, the epoxy coating was not effective for this beam. The beam was again repaired by silane monomer + polymer cement coating.

Evercon Coating

In 1986, T-shape bridge pier with AAR cracking in the beam was repaired by Evercon coating with thickness of about 0.4mm. This pier was constructed in 1971. Before coating, major cracks were filled with flexible epoxy resin.

Figure 6 shows expansion of the beam in the horizontal direction after coating. Expansion of the beam in about 5 years is very little although expansion of the core stored in the room of 40°c and RH100% was the order of 1500×10^{-6}. At least 5 years' effect to inhibit AAR by Evercon coating has been recognized in this case.

Silane Monomer + Polymer Cement Coating

This coating was applied to another T-shape bridge pier similar to that of Figure 6. This pier was constructed in 1972 and repaired in 1989. This coating has been effective to inhibit AAR expansion of the pier for 3 years, although the expansion capacity of the drilled core when repaired was the order of only $200 \sim 300 \times 10^{-6}$.

CONCLUDING REMARKS

Each structure repaired and monitored in this research has own individual conditions such as degree of AAR, structure size, the ambient condition, age and moisture content of concrete when repaired, coating thickness etc. However, from the laboratory test and field monitoring made in this research, aeration type of coating seems to be effective to inhibit AAR of concrete structures.

Since the monitoring period has been limited within several years, durability of these effective coating has not yet recognized. These monitoring is planned to be continued.

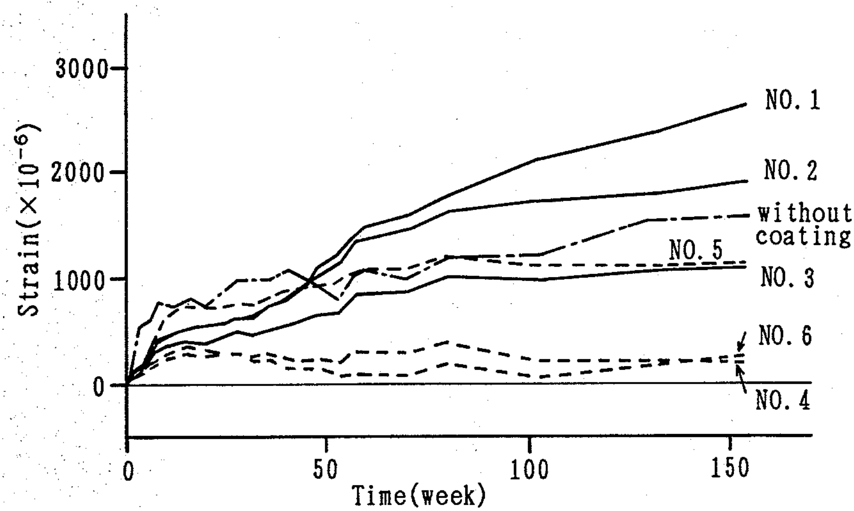

Figure 1 (a) Expansion of the specimens after coating

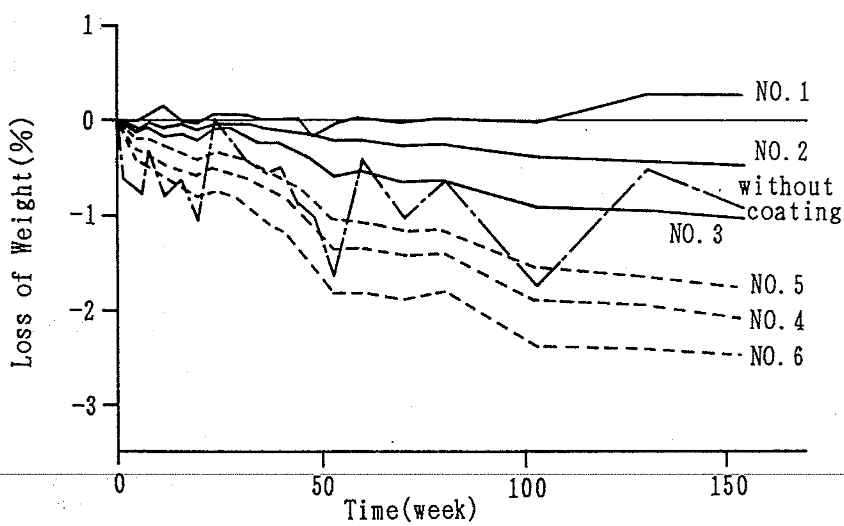

Figure 1 (b) Weight change of the specimens after coating

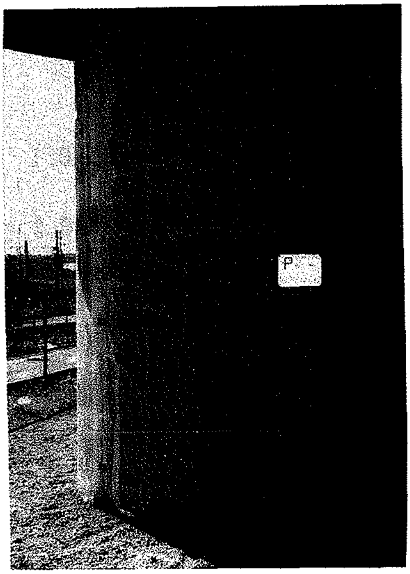

Figure 2 (a) Before repair

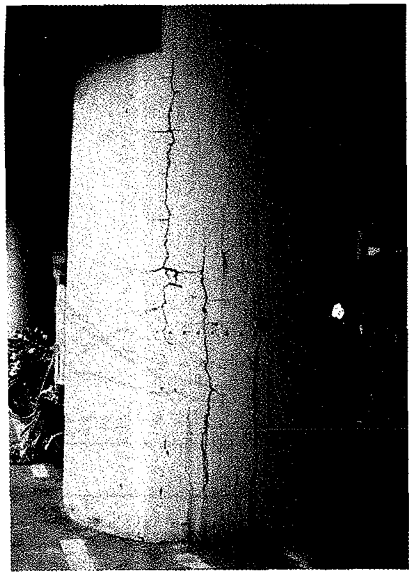

Figure 2 (b) Recracking of the repaired column

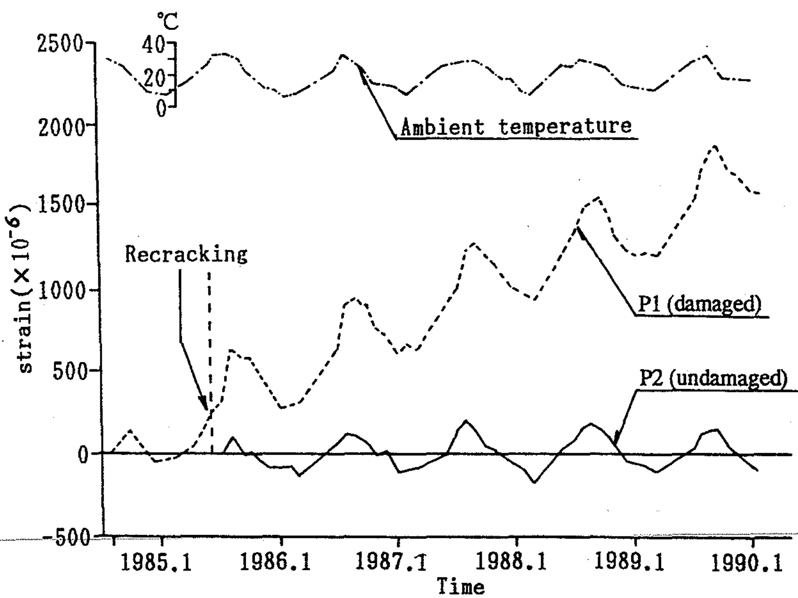

Figure 3 Expansion of P1 and P2 column after polyurethane coating

Figure 4 (a) Abutment before repair

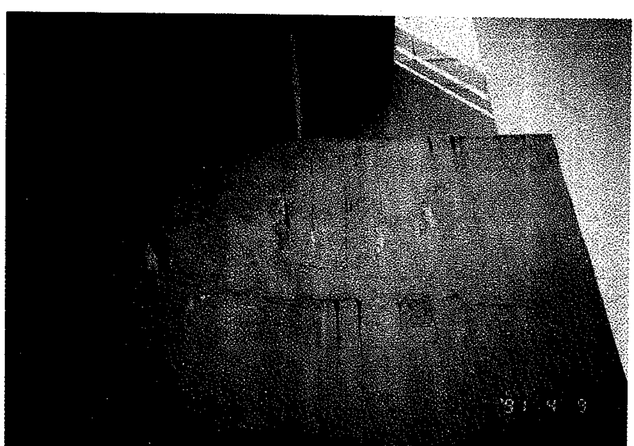

Figure 4 (b) Recracking of the repaired abutment

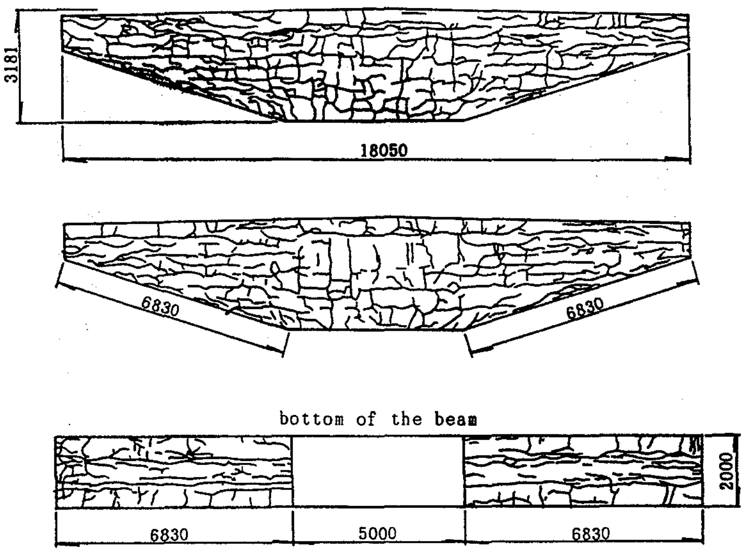

Figure 5 Damaged beam of a T-shape bridge pier

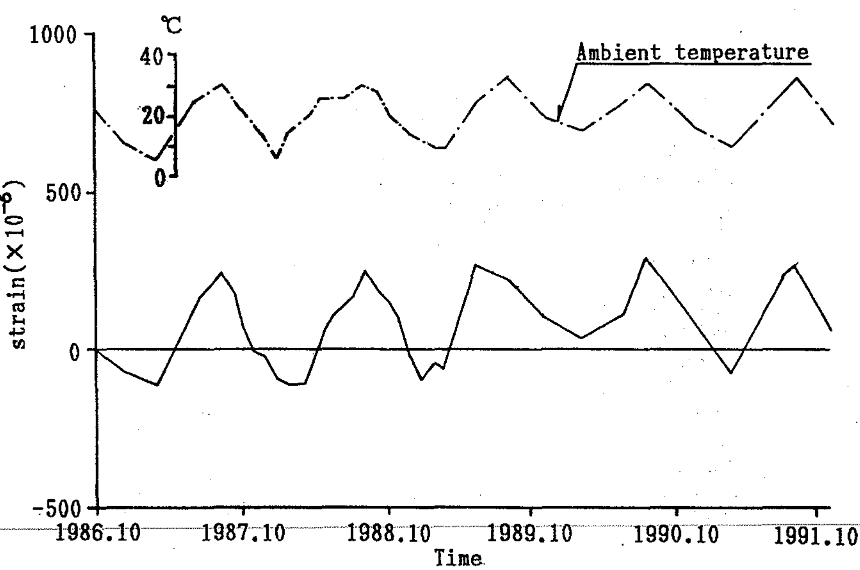

Figure 6 Horizontal expansion of damaged beam after repaired by Evercon