EXPERIENCES WITH IMPREGNATED CONCRETE SURFACES:
PARCO MARAINI IN LUGANO

Cristoforo Bissig,
Wolfseher und Partner AG, Zurich

ABSTRACT

The structure above Parco Maraini in Lugano was constructed in 1986 and extends to four independent building complexes. The outer shell of the buildings was executed as a bracket-mounted façade.

In the spring of 1993, Wolfseher und Partner AG inspected and assessed the condition of the weathered steel-reinforced concrete components of "Casa Amabile". The proportion of reinforcement in the carbonized concrete is approx. 1%. The proportion of corroding reinforcement is low, however, thanks to the adequate concrete cover. The application of a water-repellent coating as a sanitation measure was proposed for this reason.

A start was made on the commissioned work in March 1995. The work was completed after 8 months, at the end of October 1995. Around 8'000 m^2 of concrete surface in total were protected with a water-repellent coating. The quantity of material used was approx. 1'100 kg. Approx. 9'000 l of water-repellent emulsion were applied, giving an average square metre consumption of 800 to 1'200 g/m^2.

The application of a water-repellent coating based on silanes and oligomeric alkoxysiloxanes produced an average reduction in water absorption of 0.3 to 0.05 $kg/m^2h^{0.5}$.

1 INITIAL SITUATION

The structure above Parco Maraini in Lugano was constructed in 1986 and extends to four independent building complexes. The outer shell of the buildings was executed as a bracket-mounted, rear-ventilated façade. Stacked white cement concrete slabs from 6 to 14 cm in thickness were used as the bracket-mounted façade elements.

As a result of the surface unevenness of up to 2 cm caused by stacking, heavy soiling had already occurred in some cases on the exposed concrete surfaces only three years after completion of the building. Cracking and flaking of the concrete surface had occurred at some points on the weathered

exposed concrete components in areas above corroding reinforcing bars located close to the surface.

In the spring of 1993, Wolfseher und Partner AG inspected and assessed the condition of the weathered steel-reinforced concrete components of "Casa Amabile". A sanitation concept was drawn up on the basis of the results of the inspection. The primary concern of the building owner was to restore and conserve the original condition.

FIG. 1 General view of the structure over Parco Maraini

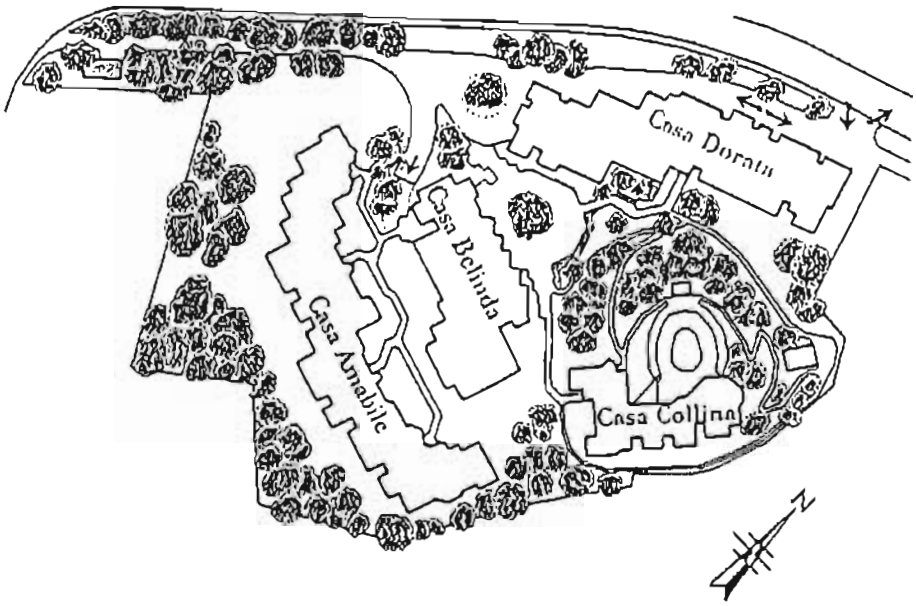

FIG. 2 Projection of south façade

2 MEASUREMENTS AND RESULTS OF CONDITION ANALYSIS

The following damage pattern was identified on the basis of the visual examination:

- Exposed, corroding reinforcement.
- Occasional flaking and cracking above corroding reinforcement close to the surface.
- Defective and embrittled compound-filled joints.
- Twisting and tilting of individual bracket-mounted elements.
- Heavy contamination of façades due to missing roof edge covers.

The concrete cover over the reinforcement measured on the building had an average thickness of between 28 and 40 mm.

The average value of the depth of carbonization varies between 8 mm on the north façade and 20 mm on the south façade. The progress of the carbonization is at its greatest on the south-facing building components, as might be expected, since the nature of the wet-dry cycles encountered there favours carbonization.

The water absorption measured on the building, using Karsten's method, is on average between 0.2 and 0.7 $kg/m^2h^{0.5}$. The maximum recorded value for a water absorption coefficient was 1.2 $kg/m^2h^{0.5}$. The average water absorption coefficient recorded on drill cores in the laboratory is of the order of 0.3 $kg/m^2h^{0.5}$.

The pore characteristics measured in the laboratory are increased due to the high w/c ratio (0.65 to 0.73). The total porosity is 16.6 vol. % on average, and the capacity of fillable pores is 14.9 vol. % on average.

The proportion of reinforcement in the carbonized concrete is approx. 1%. The proportion of corroding reinforcement is low, however, thanks to the adequate concrete cover.

As a result of the surface treatment used (stacking), cracks with a depth of up to 20 mm occur in the structure. The resulting cracks facilitate penetration by water and harmful substances. This leads to a reduction in the frost resistance, and in a locally increased depth of carbonization along the flanks of the cracks.

Fig. 3 Thin section through a concrete sample after mechanical pre-treatment (stacking)

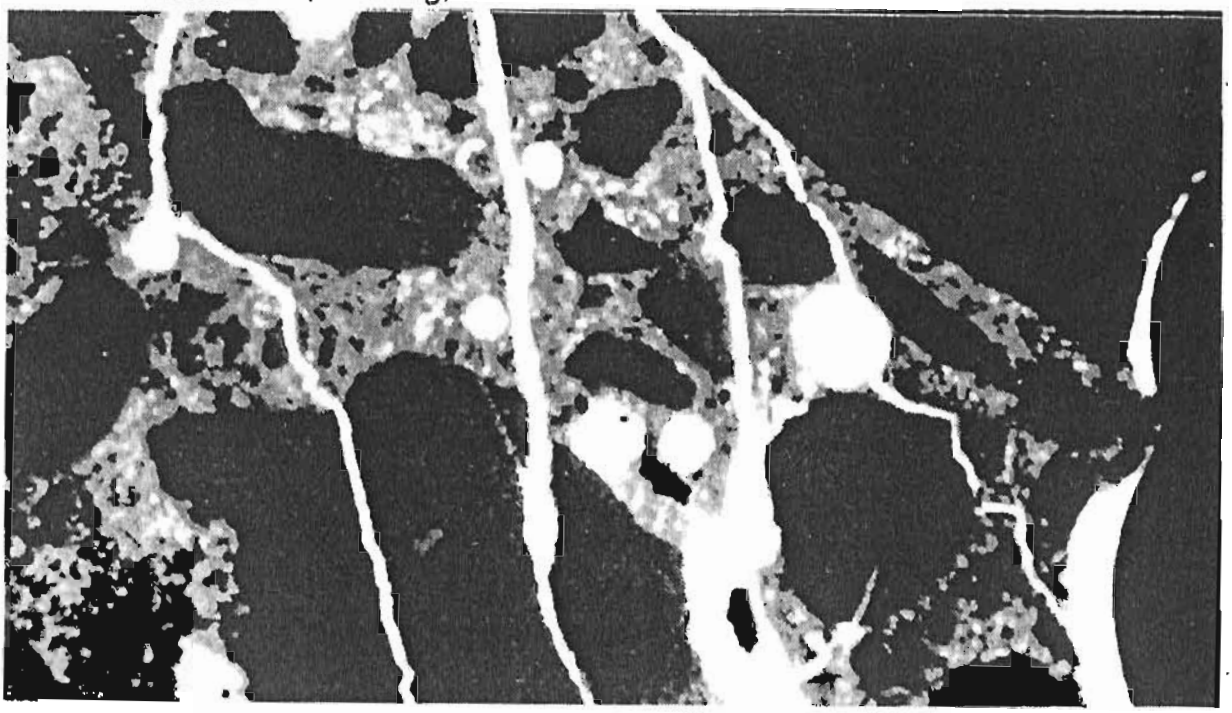

Table 1 presents a summary of the results of the condition analysis.

TAB. 1 Results of condition analysis

Measurements relating to condition analysis	Results
Visual assesment	- Exposed corroding reinforcement. - Individual flaking. - Defective and embritteled compound-filled joints. - Twisting of individual bracket-mounted elements. - Heavy contamination of façade.
Concrete cover	Average value: 28 to 40 mm.
Carbonization depth	Average value: 8 to 20 mm.
Water absorbtion using Karsten's method Water absorbtion in the laboratory	Average value: 0.2 to 0.7 $kg/m^2h^{0.5}$ Average value: 0.3 $kg/m^2h^{0.5}$
Pore characteristic value	Total porosity: 16.6 Vol. % Fillable pores: 14.9 Vol. %

3 SANITATION CONCEPT

In view of the fact that, at the time of the examination, the carbonization front had only reached the reinforcement in places, with the result that practically all the reinforcing bars still have a passive film affording protection against corrosion, the application of a water-repellent coating was proposed, with a view to lowering the risk of corrosion by reducing the available moisture and achieving inactivation of any micro-cracks that are present. There is an additional need to protect the concrete effectively against

penetration by other harmful substances, such as salt solutions. The wish of the property owner to retain the appearance of the existing concrete surface was taken into consideration when selecting the water-repellent coating as the means of repair.

The following is a list of the individual operations involved in the proposed sanitation:

- Erection of scaffolding.
- Exposure of corroding reinforcement bars, or those with less than 10 mm of cover.
- De-rusting of exposed reinforcement.
- Application of epoxy-based anti-corrosion treatment to the exposed reinforcement.
- Reprofiling of exposed areas.
- Securing loose elements.
- Cleaning concrete surfaces by water/sand blasting.
- Renewal of joints.
- Application of water-repellent coating.
- Installation of roof edge covers.

The water-repellent coating was subject to the following requirements:

- Environmental compatibility (no products containing solvents).
- Transparent.
- Water-soluble.
- Resistance up to a pH value of 9.0.
- Water absorption coefficient < 0.05 kg/m2h$^{0.5}$.
- Application by flooding.

The requirements stipulated for the product were met by selecting a silicon micro-emulsion based on silanes and oligomeric alkoxysiloxanes.
A pilot test was conducted on a reference surface in order to establish the appropriate mixing ratios for the product and the method of its application to the white concrete slabs to be treated with the water-repellent coating.

4 EXECUTION

A start was made on the commissioned work for "Casa Amabile" in March 1995. The work was completed after 8 months, at the end of October 1995. Around 8'000 m^2 of concrete surface in total were protected with a water-repellent coating. The water-repellent coating was applied unpressurized with a Birchmeier spray pump in three stages. The coats were applied wet-on-wet.

Table 2 provides details of the average consumption of the applied water-repellent coating:

TAB. 2 Characteristic quantities for the application of the water-repellent coating

Concrete surface	approx. 8'000 m^2
Mixing ratio for water-repellent coating	1. Application 1:9 2. Application 1:9 3. Application 1:5
Material consumption	approx. 1'100 kg
Applied emulsion	approx. 9'900 l
Consumption per m^2	approx. 800 to 1'200 g/m^2
Material consumption per m^2	approx. 140 g/m^2
Price per m^2	38.-- sFr./m^2

5 QUALITY ACHIEVED

The following tests and inspections were carried out in the context of quality assurance measures:

- Inspection of application conditions (application process, temperature, humidity).
- Testing the bubble suppression effect of wetting the surface.
- Testing local water-absorption, by Karsten's method.

Table 3 below presents the results achieved in the tests and inspections carried out in the context of quality assurance measures:

TAB. 3 Quality achieved

Tests carried out	Results
Application conditions	The application conditions stipulatedby the product supplier were met throughout the entire application process.
Bubble suppresion effect	The bubble suppresion effect noted is very good over the whole concrete surface.
Water absorption using Karsten's method	The local water absorption has an average value of: 0.05 to 0.08 $kg/m^2h^{0.5}$.

FIG. 4 Projection of north façade before sanitation.

FIG. 5 Projection of north façade after sanitation.

6 REFERENCES

/1/ Bericht Nr. 92.130.11, Wolfseher und Partner AG

/2/ Beurteilung und Sanierung von Betonoberflächen, Wacker