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The water repellent treatment of building materials in thermal baths

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SUMMARY: The paper describes the construction problems of the Budapest thermal baths and the damages that they suffered over times. Two measures for the reduction of this problem based on the application of water repellents are discussed.

SUMMARY 2 (Optional) – A cikkben a budapesti műemlék termálfürdők építőanyagai tartóssága kerül megvitatásra. Az anyagkárosodások javítására és a felhasznált anyagok tartósságának növelése érdekében két új termék alkamazása javasolt.

KEY-WORDS: thermal baths, water repellent treatment, volume impregnation

INTRODUCTION

"…There at the base of a rock-formed holy shrine,
Four centuries stand witness to your flow,
As testimony to all of human kind:
Blessings also come from the depth below.
As springs well from the core of fiery earth,
Where radium and iron are awash,
Where the sick can go through curative re-birth,
You are their healer, my good old Rudas." A poem by Pál B. Bodrogh (1922)

THERMAL BATHS IN BUDAPEST

Four hundred years ago (1555-1556) the thermal baths in Budapest (Turkish baths: Király, Rudas and Rác) were constructed and it was a major challenge for the master builder because they were built on very wet soil. The restoration of these baths was equally complicated, the major reasons being the following:

- In the vicinity of the baths there are several natural and dug fountains: some of them are connected and act as a coupled system.
- Several thermal springs flow down from the mountain side.
- Floods from the Danube river permanently endanger the environment.
- The ground water level constantly changes because of the vicinity of the Danube river.

Building use and its problem

The spa building structure must be protected against:

- High water temperature,
- Very aggressive water,
- Cleaning materials.

One of the main problems in the spa is the wall temperature since it is constantly at/or below the dew point. In a climate with a temperature of 20-25^{o}C and a relative humidity of 75-95%, mould starts growing within a couple of weeks, regardless of the material used for the walls construction.

The water is alkaline and with a high content of calcium bicarbonate resulting in severe incrustations being formed on the surfaces in contact with it and where evaporation takes place. These are then cleaned with an acid cleaning material ("Interacid" 30% hydrochloric acid and phosphorus acid from Dinax Kft. – www.dinax.hu) is used for the scaling.

Figures 1-4 illustrate the action of the above mentioned effects.

Figure 1. Corrosion of the steel reinforcement in concrete.

Figure 2. Effect of the cleaning materials on stone elements (limestone) and pointing material.

Figure 3. The wall covered with Turkish render after thermal water attack.


Figure 4. An iron fitting used for thermal water pipeline.

PROTECTIVE MEASURES: MATERIALS

The damages shown in the previous figures could be reduced in the monumental thermal baths if the following materials were used or applied:

- A newly developed cement admixture (“StrongGuard” water-proof plaster Ferenc Törőcsik , Hungary [1]) for an integral water repellent impregnation.
- Cement with very low shrinkage (C- Mix cement by Martauz and Kekanovic, Slovakia [2]).

The cement admixture has the following properties:

- 90 % calcium oxide is present in admixture,
- Density 400-450 kg/m^3,
- Average diameter of the grains of StrongGuard (SG) admixture is about 4-5 µm,
- Contact angle depends on temperature and solid material face, and can be close to the 140^o (Fig. 5).

Figure 5. Drops of a water suspension of the hydrophobic admixture on a paper surface.

The low shrinkage cement (C-Mix) was developed by Martauz and Kekanovic at "Pozavska Cementaren" in Slovakia with the caveat that the cement is still in the experimental stage of testing [2]. Table 1 lists its principal physical characteristics for a cement produced with a w/c <0.42.

Table 1. Physical characteristics of C- Mix cement.

Technical parameter	**Time (day)**	**Units**	**EN 197-1**	**Testing results**
Beginning of hardening time		minutes	min. 75	200± 20
Compressive strength	2	N/mm^2	min. 10	17.5±3.0
	28	N/mm^2	min.32.5 – max. 52.5	36.5±4.0
	90	N/mm^2	-	41.5±3.0
Tensile strength	2	N/mm^2	-	3.5±0.5
	28	N/mm^2	-	4.4±0.4
	90	N/mm^2	-	9.0±0.3
Expansion		mm	max. 10	0.5

EXPERIMENTAL TESTS

The water repellent mortar to be tested was prepared as follows:

1. C-mix cement was mixed with the hydrophobic admixture SG in a 10:1.2 ratio.
2. Cement blend was mixed with sand in a 1:3.5 ratio,
3. Water as added to this mixture water in a 10:1.8 ratio..

The mortar was applied as a 3-4 mm thickness coating on cement columnar specimens (40x40x160 mm) and was left to cure in a humid chamber for 7 days.

After wet curing the specimens without (Figure 6) and with coating (Figure 7) were submerged into the thermal water for 30 days.

Figure 6. Concrete specimens without hydrophobic coating.

Figure 7 shows one of the cement specimens, partly coated with the hydrophobic render, which had been stood up in a similar bath to that shown in Fig. 6 and was taken out for photography. The arrow points to the level to which the sample was immersed. It was observed that the water could not pass through the coating, as it is water repellent. No capillary suction can be observed on the specimen surface (Fig. 7). Using this hydrophobic material for a concrete mixture, a total impregnation concrete is achieved. .

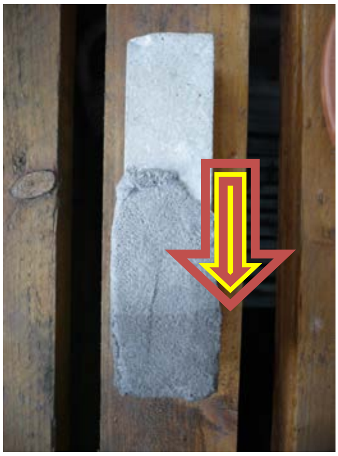

Figure 7. Specimen with hydrophobic coating, arrow points to the level of water immersion of the specimen that was taken out for photography. No capillary rise is observed.

The hydrophobic additive is also effective for oil decontamination. The photographic sequence (Figs. 8-9), show an experiment where olive oil is floating on top of water in a cup. Then the hydrophobic SG admixture is added and the adsorption process starts. Once the admixture adsorbs all the oil it will sink to the bottom of the cup as the oil-powder mixture is heavier then water and can entrain air bubbles (Fig. 9).

Figure 8. – Oil pollution on left picture (olive-oil), right picture oil with hydrophobic material.

Figure 9. The olive oil will be adsorbed and the oil- SG-air is sinking on the bottom.

The SG admixture surrounds the oil products, arranges it into a uniform bundle and cleanses the water surface totally. The application of the admixture can be intensive in environmental protection. The most important ones:

- Adsorbing oil when that is on water after a catastrophe,
- Cleaning the water from oil in harbours,
- Cleaning the water near oil derricks.

CONCLUSIONS

The above listed damages can be eliminated with help of two new materials:

- Water repellent concrete reduces water penetration into reinforced concrete structures retarding corrosion of the reinforcement.
- Bedding and pointing mortar durability depends on the penetration depth of water and/or cleaning materials, as well as any volume deformation of the material.,
- Rendered walls and mortar durability will be longer if the water can only act on the surface.
- The SG admixture is environment-friendly, and also is a high-quality adsorbent of oil products, which for the special case of the thermal baths is important..

References

[1] TÖRŐCSIK, Ferenc 2014. StrongGuard. www.strongguard.hu

[2] MARTAUZ, P., I. Janotka, M. Bacuvcik, J.. Strigac. 2014. *Chemical resistance of novel hybrid cement in various aggressive solutions,* Proceedings of the 2014 RILEM International Workshop on Performance-based Specification and Control of Concrete Durability, pp. 15-23. RILEM Publications S.A.R.L. Bagneux.