The water repellent treatment of building materials in thermal baths

János Major
University of Debrecen, Faculty of Engineering, Debrecen, Hungary,
drmajorjanos@gmail.com

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 is 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 (with turkish mortar) after thermal water attack

Figure 4. - The 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 surface of a paper

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)**	**Dimension**	**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 were prepared as follows: the C-mix cement was mixed with the hydrophobic admixture SG in a 10:1.2 ratio. Cement was mixed with sand in a 1:3.5 ratio, and this mixture with water in a 10:1.8 ratio.

The mortar was applied as a coating on cement column 40x40x160 mm with a 3-4 mm thickness. It was left to cure in a humid chamber for 7 days. On the specimens

- after 7 days of wet curing the test started,

- the specimens without (Figure 6.) and with coating (Figure 7.) were submerged in the thermal water for 30 days.

Figure 6. – Concrete specimens without hydrophobic coating

It was observed that the water could not pass through the coating, it is water repellent. No capillary suction can be observed on the specimen surface (Figure 7.). In case when we use the hydrophobic material for concrete mixture, we will have as result the "volume" impregnated concrete structure.

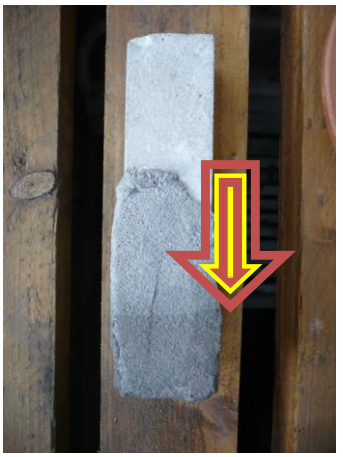

Figure 7. - Specimen with hydrophobic coating, arrow points to the acting-water level

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.

- the oil-powder mixture is heavier then water,
- the oil-powder drop is sinking very quick on bottom with low air bubble (Figure 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:

- steel corrosion – water repellent concrete stops the water penetration into concrete structure,
- the embedding mortar and pointer durability depends on water or cleaning material intrusion depth and very low material volume-deformations,
- wall and mortar durability is longer if the water can't act in structure just on surface.
- the SG admixture is environmental-friendly, and it is high-quality adsorbent of oil products being on water and solid surfaces.

References

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

[2] MARTAUZ, Pavel, JANOTKA I., BACUVCIK M., STRIGAC J. - *Chemical resisistance of novel hybrid cement in various aggressive solutions*, Proceedings of the 2014 RILEM International workshop on performance-based specification and control of concrete durability, RILEM Publications S.A.R.L.,11-13 June 2014, Zagreb, Croatia, pages 15-23