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Repair the old concrete parts of the Hydro Plant "LUMBARDHI" in Decan-Kosova

N.Kabashi[1], ; C. Krasniqi[2],; R. Hadri[3],; Q. Kadiri[4],
University of Prishtina; Department of Civil Engineering, Prishtina, Kosova

ABSTRACT: Request for reactivate the Hydro Plant is directly depend of the state of the accumulate water basin. The present state of the part of concrete was critical and impossible for using the water accumulations.

The concrete parts are damage during the long period of attack from different factors.

Removing and replacement of the parts of old concrete is directly in connections with the examinations of concrete and after the proposal the new materials and methodology for repairing.

In this study work we used the nondestructive and destructive methods for analyses the existing concrete state for proposal the new materials, especially in the surface treatments.

INTRODUCTION

The existing concrete in water-accumulations basin is done long time ago, about 50 years ago and the life time was under the very different environments conditions during this year's. The building is on the mountains, were is the high of mountains is 1200 m and this region is under the very long winter were the temperature is -20^0C for the 3 month durations.

One of the main thinks is the used materials during the building of constructions are very non usually, especially the cement and building technology are not in same level like now.

The building was in functions during the long period, and time by time it was repairing, especially the channels and the accumulation basin were the water is linking through the cracks created in concrete constructions.

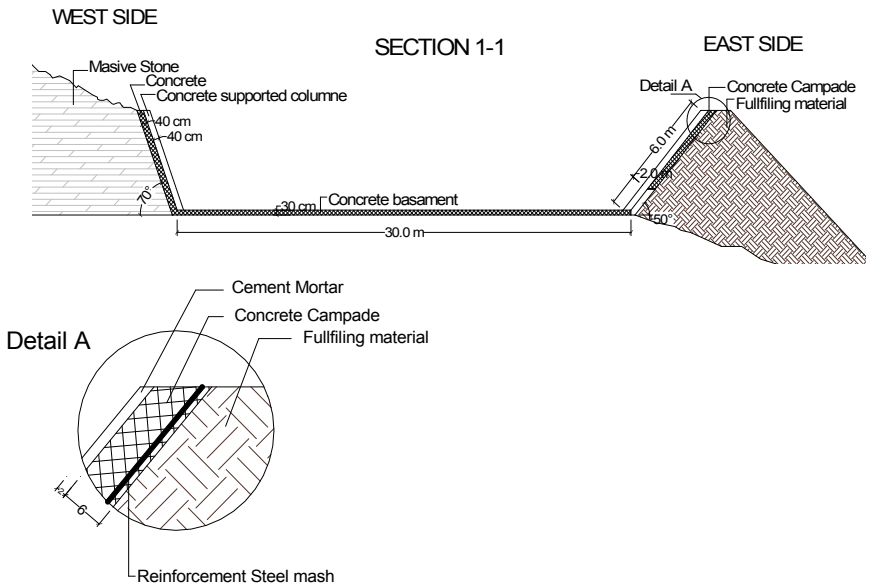
Maintaining and repairing building stock has been a recurring need owing to the natural degradation of materials and structure under the combined effects of loads and environmental factors. In the past, the practice was to replace old parts of buildings that had deteriorated or that were no longer suited to their original purpose. More recently, the widespread deterioration and the high cost of replacement give us no option but to repair and rehabilitate.

Current rehabilitation techniques and practices have been derived largely from those of new construction. However, new construction and rehabilitation differ from each other in several important respects, including project scale, technology management and financing. For instance, because ambient conditions such as temperature and humidity are less easily controlled in rehabilitation, the materials used in this case should be less sensitive to those conditions. The use of proper procedures in repair and rehabilitation are critical to success, yet these procedures are not nearly as well defined by codes and standards as those for new construction. Repair and rehabilitation involve much smaller quantities of materials and, therefore, application procedures ordinarily considered in new construction may not be best suited for them. The result is that engineers often the repairs have to be re-done within a short period an enormously costly exercise .

1. GENERAL DATA

The constructions of accumulate water basin is based on the concrete campads with the dimensions 200x600x8 cm. Between the campades are the joints spall with the bituminous materials. The basement, especially on the east side is compacted soil and gravel and on the top is the con-

crete with the thick of 8 cm. The deterioration of concrete arrived not only on the top but on the depth and is evident the corrosion of the steel mesh. In general the degradations of concrete result on the east side. On the west side the basement is on the rock, and also on the top are concrete campades but supported with the columns concrete elements
The section of the constructions is present on the fig.1.



2. REPAIR METHODOLOGY

Preliminary and detailed investigations often contain varying levels of some of all of the following items:

1. Document review
2. Field investigation
3. Sampling and material testing
4. Evaluation
5. Preparing the report

- The preliminary investigations develops an initial assessment of the concrete structure's behavior, conditions and existing performance based on an established objective or reason for performing the rehabilitation.

The preliminary investigations commonly recommended the need for a detailed investigation thoroughly evaluate the concrete structure.
A preliminary investigation should, as a minimum, include acquisition of available document from the owner and known sources, field observations and measurement of the structure to survey for conditions an conformance to documents, and local sampling or testing.

- A detailed investigation is performed when the initial site visit or preliminary

investigation has identified a need for a more in depth assessment of the concrete structures behavior or condition to meet the owner's goals for the work and rehabilitations objectives.

2.1. Document review

A thorough review of the available documentations was the first step for evaluations of rehabilitation of existing project. The presented existing documents are only parts of calculations and behavior the concrete structures but based on the dam part.
Field survey is followed with the drawings to provide the essential information's about the structures and the dimensions.

2.2. Field investigation

The inspection through the structure was the adequate step to establish the project scope and to define the projects needs.
Field observation was not only address the as-built geometry and materials of constructions, but also present the conditions of existing structure, its environment and loads to which it is subjected.
The field investigations was divided into the following three major steps:

-preparation and planning
-verification of as-built construction
-Condition of survey of structures

The present situations of concrete surfaces is presented through the fig.2&3.

Fig.2. The view of the accumulations basin and degradation of concrete in concrete campades

Fig.2. The joint connection between the floor and wall; joint between the concrete campades

2.3. Sampling and material testing

In addition to field observations, it's necessary to applied the nondestructive tests on component of the structures or in place materials to investigate their conditions and strength or to take samples for laboratory tests.
Nondestructive testing supplements visual observations and yield valuable information's decision regarding further testing and evolution. In this work the nondestructive tests we used to locate the reinforcement as an alternative to exploratory openings. In some of positions we compare the position and diameter with the exploratory openings. Also in some of positions we used the hammer testing to estimate compressive strength, but the thickness of exanimate elements and surface in some of places are the barrier to make the examinations.
Exploratory openings help us to determine the used methodology and dimensions of structure.
We take the samples from the both sides (east and west) and from the base of basin.
In the east side the sample are taken with the diameter of 5 cm,(sample "1") because the thickness of structures was smaller than 10 cm, and in west side and base of basin the samples are taken with the diameter of 10 cm.(sample "2")
The samples are prepared and examinated in two laboratories "IRMA" Ljublana-Slovenia and in "IBMS"Prishtina-Kosova.
The samples and results are presented in fig 4 and table 1&2

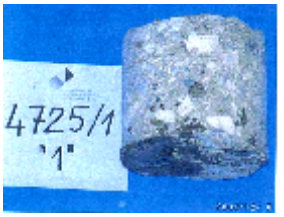


Fig.4 The samples taken from the east side "sample 1" and the west side "sample 2"

Table 1. Results of examination samples in laboratory "1" taken from east side

Test nr	Position	Date of prep.	Age (days)	Dimensions (D/H)mm	Density (kg/m^3)	Compression Strength (N/mm^2)
401	Wall-East	/	>50 years	45/45	2380	34.19
402	Wall-East	/	>50 years	45/47	2350	21.74
403	Wall-East	/	>50 years	45/47	2380	40.07

Table 1.1. Results of examinated samples in laboratory "2" taken from west side

Test nr	Position	Date of prep.	Age (days)	Dimensions (D/H)mm	Density (kg/m^3)	Compression Strength (N/mm^2)
398	Wall-West	/	>50 years	100/105	2420	35.56
399	Wall-East	/	>50 years	100/105	2380	33.56
400	Wall-East	/	>50 years	100/104	2380	47.34

Table 2. Summary results of laboratory tests

Pos	f_{ck} (N/mm^2)
Wall-East	20
Wall-West	>30
Basement	>40

Most critical situations based on the results was the East Wall, and the next activities are concentrated on the repairing of this positions, but in some of small positions also the West wall and basement.
Also the Reinforcement steel was corroded in openings places and need necessary to removed in some places or to repairing in other places.

2.4. Evaluation

The results of an investigation (document review, field observations and condition survey, material sampling and testing) are considered in the evaluation of the structures . The evaluation addressed the need for rehabilitation and feasibility options. In this case the effect of rehabilitation on the structural system and the anticipated functional and economic impact was considered.

2.5. Removing the materials

Removing the materials is in direct relations with the damage of the concrete structures, but the zones of damage concrete is not well defined. The state for all damage was not easy to determine for the each of material will be removal, and in this case for removal of materials we used the high water pressure from 200-300 MPa. The damage part are removal in depth of complete thickness of concrete , or in some of places the surface of concrete. The results of this activity was the clean surface and the quality of the concrete > 20 N/mm^2.

2.5.1. Preparing the concrete surface for repairing

When the concrete is removed from a structure by the water pressure, the concrete left in place are prepared by using the abrasive blasting and carefully the surfaces are conducted before placing the repair materials. Wetting the surface help us to identify the presence of eventually cracking. Removal concrete is saw-cutting on the perimeter to provide the adequate minimum thickness of repair material in the edge of the repair area.
Also in some of parts of removed concrete the thickness is more the minimum needed for repairing materials, in this case will be used the double layer of repairing.

2.5.1. Reinforcement repair

The cause of damage to reinforcement steel is corrosion for the long time of exposure under the different climate conditions. The first step in preparing the reinforcement steel for repairing is removing the deteriorated concrete surrounding the reinforcement. The damaged reinforcement is replacement and in some of areas is supplemented. For the other areas we used the cleaning with the wire brushing method to create the possibility for the coating of the reinforcement steel.

3. REPAIR MATERIALS

Different repair materials and many techniques are available to used and to place the repair materials depend of project and work conditions. Also the experience of the contractor to successfully perform the placement technique is important. At first we analyze the main factors of repairing surface and main requirements for the repairing materials, which are presented in table 3.

Table 3. General Requirements of Repair Materials for the Compatibility

Requirement	Relationship of Repair Material and Concrete
Shrinkage strain	R<C
Creep Coefficient (Repairs in compress.)	R<C
Creep Coefficient (Repairs in tension)	R>C
Thermal Expansion coefficient	R=C
Modulus of Elasticity	R=C
Poisson's ratio	R=C
Tensile Strength	R>C
Fatigue performance	R>C
Adhesion	R>C
Porosity and resistivity	R=C
Chemical reactivity	R<C

Repair and rehabilitation project require materials whose characteristics of placement and performance are distinct from those used in the this original construction. The main start points for proposed repairing materials is based on this points:

- Engineered materials with high performance, high durability and low maintenance, such as composites, block co-polymer and high-strength concrete.
- Products that are easy to use, increase productivity and reduce construction turnaround time.
- Desired properties will include a capability for high-flow and self-leveling characteristics, fast setting and rate of strength development, and a reduced sensitivity to site conditions such as storage temperatures and surface condition of the substrate.

The development of materials science offer us to chose materials from different producers and the different content. In this work we approved the Cement Grouts for the repairing surface, Coating substrate for repairing the reinforcement steel, Polymer Foam for fulfilling joints, Polymer materials for joints.

- Repairing the concrete surface: GROUT

- Coating the reinforcement steel: STEEL PROTECT
- Fulfilling joints between concrete parts: EXPANDED POLYMERS
- Protect of joints: PVC POLYMERS

- Coating the existing reinforcement steel

The process of coating of existing cleaned reinforcement steel will apply to protect the steel on the future from the eventually corrosion and to improve the life time of steel. The previous state and the necessary coating is presented in fig.5 (a&b)

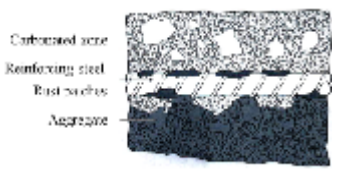


Fig 5; a/ Previous state of reinforcement steel; b/ Coating the cleaned reinforcement steel

- Repairing using the cement grouts

In general the grouts appropriate for concrete repair are categorized as either hydraulic cement or chemical. In this project we used the hydraulic cement grout.
The properties of this used grouts according the EN Standards are presented in table 4.

Table 4- Request properties of materials

Performance characte-ristic	**Test method**	**Minimum requirements acc. to EN 1504-3**	**Product performance**
Compressive strength (MPa)	EN 12190	>25 (after 28 days)	> 8 (after 1 day) >30 (after 7 days) >40 (after 28 days)
Flexural strength (MPa)	EN 196/1	none	> 2.0(after 1 day) >5.5 (after 7 days) >7.0 (after 28 days)
Modulus of Elasticity (GPa)	EN 13412	≥15 (after 28 days)	25 (after 28 days)
Bond strength to con-crete (MPa)	EN 1542	≥1.5 (after 28 days)	>2.0 (after 28 days)
Thermal compatibility according to EN 1542 (MPa) **-freeze-thaw cycles**	EN 13687/1	≥ 1.5 (after 50 cycles)	>1.5

Typical applications of hydraulic cement grout may vary from grout slurries for bonding old concrete to new concrete, to filling the large dormant cracks.
The grout is cast in placed with compression in properly consistent for this kind of repairing works, especially but the surface was in slope position. In this case the applied grout is capable for excellent bond between existing concrete and grouts.
The thin layer was about 20 mm, in general. When we need for additional we apply the second layer.
The final process it was the finalization the layer and results with very flat surface. This activities are presented in fig 6.

Fig.6. The cast in place and final smoothing the layer on the slope surface

- Joint Constructions

The type of constructions is content from the part of concrete walls connection with joints. One of the major problem was the damage of existing joints and especially the joints material of bituminous materials. During the cast in place of grouts we prepare the edge of concrete elements very carefully and in this way to prepare the joint constructions. The existing materials which was used for fulfilling the joints was removed during the surface preparations. After the final preparations of joints we used the new material expanded to fulfill the joints and in same way to realize the requested parameters in this project.
The methodology of placed this material is presented in fig.7.a&b

Fig.7: a/ placing the MAPEFOAM in joints; b/the view of joints after finishing

The joints are protected with the polymer PVC materials , in this way this material are compatible for eventually joint movement in concrete. The methodology and placed this material is presented in fig. 8. a&b.

Fig.8: a/placing the PVC materials to protect the joints; b/the view of protected joints

4. TESTING OF EXECUTIONS OF REPAIRING WORKS

The results of entire investigation and evaluation will be summarized in a final report. This report will include all activities using during the process of repairing, especially the materials selections (properties of materials) and the methodology of repairing. All activities will be under the EN Standard 1542, to improve the durability of new repairing structures. One of the request in this cases is the bond strength between the old concrete and new layer.
To verify the bond strength we used the “Pull of Test Method-EN 1542” and the methodology of examinations and results are presented in fig 9.a&b and table 5.


Fig.9. a/ examinations of bonding strength; b/ the results of bonding strength

Table 5. Results of examinated repairing concrete surface

Position	Reading "0"	Reading "F"	Force (kN)	EN 1542
1	0.28	2.16	1.88	> 1.5
2	0.34	3.41	2.97	> 1.5
3	0.30	3.75	3.45	> 1.5
4	0.41	2.78	2.37	> 1.5
5	0.90	3.16	2.26	> 1.5
6	0.20	1.75	1.55	> 1.5

5. CONCLUSIONS

Based on the specifications of this project and in general for the repairing works we can conclude:

- Analyze the environmental conditions and the indicative factors caused the damage in concrete structures are starting point for repairing the existing structure.
- Selection of repairing materials and methodology of repairing is approved after the analyze the compatibility of the materials and the existing materials in structures.
- The testing results are satisfactory for this kind of structures and based on the preliminary request.
- The structure is in good conditions after the five years of repairing.
- Using the materials based on the polymers is one of the good opportunity, in this case the materials from MAPEI-Italy have very good results.

Fig.10. The actual situation after 5 years

6. REFERENCES

1. *ACI 318-05: Building Code Requirements for Structural Concrete*
2. *ACI 546R-04: Concrete Repair Guide*
3. *MAPEI-Products and technical Data*
4. *Sustersic J.;Dobnikar V.;Leskovar I.:2004- Sanacije Betonskih Objektov-Ljublana*
5. *Elsner,B. :2000-Corrosion Inhibitors for Steel in Concrete, International Congress on Advanced Materials*
6. *Emmons ,P.H: Concrete Repair and Maintenance*
7. *MAPEI INTERNATIONAL;2005-Journal*