THE SOCIAL CLUB OF THE MANZANERA IN CALPE, ALICANTE (SPAIN) (WORK OF RICARDO BOFILL). STUDY OF THE ALTERATION OF HIS MATERIALS

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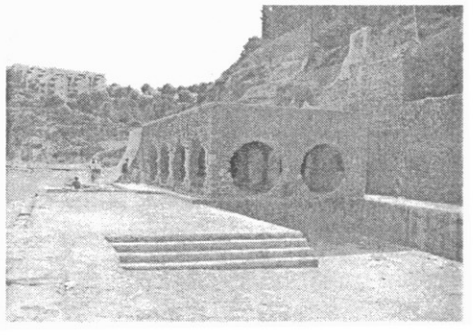
ABSTRACT

In this study one has taken to end an investigation on the constructive systems and the materials of construction used by the acquaintance architect Ricardo Bofill in the accomplishment of one of her first works on the coast of Alicante (Spain) as well as of the damages and alterations suffered by the abandon and the action of the sea, with offers for his recovery, since it is a question of a catalogued building of great architectural interest.

Introduction

The social club is at the edge of the sea, in the cove of the Manzanera, under a cliff on which there are the buildings of apartments of the Xanadú and the Red Wall, all of them projected and realized by the architect Ricardo Bofill between the year 1966 and 1975. The ancient social club of the Manzanera is a set formed by a small exempt building with kitchen and snack bar, two semi-detached houses to the walls of containment destined to toilets and store, swimming pools, platforms solarium and and accesses to different levels, all this perfectly adapted to the way, both for the scale and for the treatment of materials (F1).

In effect, for his construction Bofill it chose the stone in dry extracted from the proper cliff, to realize the vertical walls that go adapting to the orography of the coast.



F1. ***General sight of the Social Club***

The concrete in the flat elements and the glass in the shape of bubbles in the glazing. With all this it obtained an architectural work of high level and perfectly integrated to the natural way.

The set is included in the municipal catalog of Calpe at level of integral protection. Regrettably his current state complicates enough above mentioned protection and it will have to intervene with eager willingness if his finished destruction wants to be avoided.

In spite of the architectural values the quality of the construction leaves enough that to wish: The platforms are executed by a base of skittles and a crossbeam of concrete in mass of little thickness. The structures are walls of load with forged of prestressed small beams autoportantes without mallazo and the covering is realized by an asphalt cloth by layer of mortar. All this has deteriorated in different grades on having been in a marine ambience.

His situation down the cliff has given place to that loose rock of the same one there is the impacted one in the covering sinking the wrought one. A few meshes have been placed that the direct impacts prevent but materials keep on detaching. Due to the abandonment of the facilities, the action of the time there has joined that of the sea, which breaks his waves against the base of the crossbeams and the vandalism, with glass break, tiles and bricks, provoked fires and starter of facilities.

We can say that only the walls stay as useful elements of the set, and that the architectural spaces need a structural entire, both and functional rehabilitation.

Capture of samples and analysis

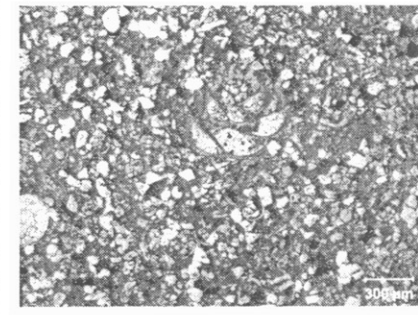
For the study of the stony materials (natural stone and concretes) of different types and characteristics used in the execution of the set, there have taken the samples necessary for his analysis in laboratory.

The number of samples to realizing has decided in agreement to the protocol indicated by the **RILEM** for each of the materials (stony, mortars...) and it(he,she) is depending on the number of fronts, of the orientation, of the height with regard to the soil and of the degree of alteration of the materials.

With the above mentioned samples the pertinent works of laboratory have been realized for the determination of the characteristics of the materials and her processes of alteration, as well as of the treatments to realizing for his conservation.

The natural stone used in the walls is the one that better has behaved, with very punctual injuries, especially in the walls faced the sea, but the concrete in mass has turned out to be seriously affected by the action of the sea, both for the undermining of his base and for the action physicist chemistry of the chlorides on the cement.

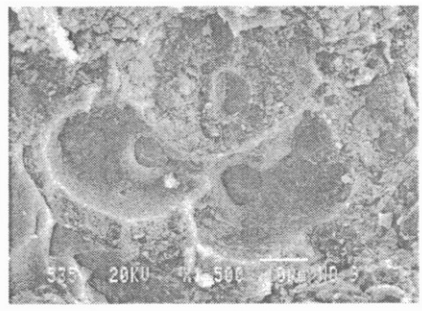
All the stony materials of the social club of the manzanera, Calpe, can come from the same area of quarry, since it would be the proper cliff where it is located, although for the content in detritical components his classification changes from a fossiliferous limestone (Biomicrite as Folk), to the sandy biocalcarenitas, being able to speak even about sandy limestones (**F2**). It is normal if there is born in mind the heterogeneity of materials that can be observed in the front of the cliff. In the optical microscope image is possible to see the texture of one of the observed samples.



F2. ***Optical microscope image of the sandy fossiliferous limestone.***

Observed to the S.E.M. (**F3** and **F4**) the materials, both stone and mortar, show clearly the action of you goes out marine, with attack of chlorides for dissolution in the whole surface.

They appreciate abundant microfissures and intraparticle porosity.



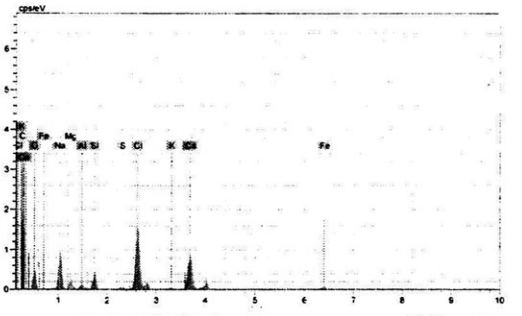
F3. ***SEM image of the sandy limestone.***

F4. ***SEM image of the stone surface showing sodium chloride.***

Also abundant crystals have been detected of ettringite very expansive, formed by reaction of the C3A of the cement by sulfates (**F5**).

F5. ***Needles of ettringite in a crack***

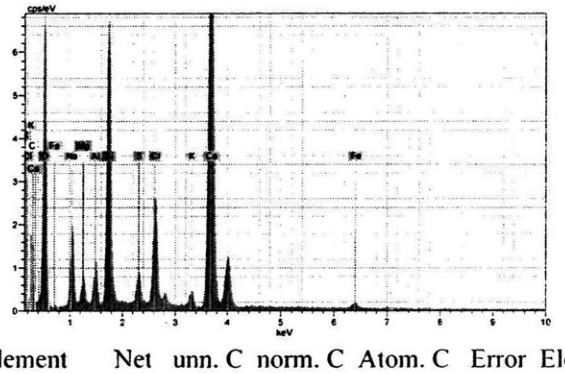
The attack verifies for the analysis for fluorescence of X rays (**F6**). In this case the saline compounds (sodium + 36 %) has substituted largely the originals of the concrete (calcium + oxygen 50 %) demonstrating the attack for sea water.



F6. ***Graph and results of the concrete analysis for fluorescence of X rays.***

Element	Net	unn. C [wt.-%]	norm. C [wt.-%]	Atom. C [at.-%]	Error [%]	Element	Net	unn. C [wt.-%]	norm. C [wt.-%]	Atom. C [at.-%]	Error [%]
Carbon	107	1.75	1.74	3.37	3.2	Sodium	3971	15.94	15.86	16.07	1.1
Magnesium	886	2.90	2.88	2.76	0.2	Aluminium	403	1.04	1.03	0.89	0.1
Silicon	1807	4.05	4.04	3.35	0.2	Sulfur	121	0.24	0.24	0.17	0.1
Chlorine	9865	20.98	20.88	13.72	0.8	Potassium	182	0.46	0.46	0.27	0.1
Calcium	6328	16.85	16.77	9.74	0.6	Iron	529	2.82	2.81	1.17	0.2
Oxygen	1968	33.45	33.29	48.47	8.1						

Total: 100.50 %



Element	Net	unn. C [wt.-%]	norm. C [wt.-%]	Atom. C [at.-%]	Error [%]	Element	Net	unn. C [wt.-%]	norm. C [wt.-%]	Atom. C [at.-%]	Error [%]
Carbon	2934	4.46	4.02	7.02	2.2	Chlorine	15180	4.77	4.31	2.55	0.2
Sodium	7722	5.18	4.67	4.26	0.4	Potassium	1505	0.50	0.45	0.24	0.0
Magnesium	2408	1.10	0.99	0.85	0.1	Calcium	71876	26.87	24.25	12.68	0.8
Aluminium	3639	1.29	1.16	0.90	0.1	Iron	1506	1.38	1.25	0.47	0.1
Silicon	34382	10.80	9.75	7.28	0.5	Oxygen	27070	53.37	48.17	63.10	9.3
Sulfur	3584	1.09	0.98	0.64	0.1						

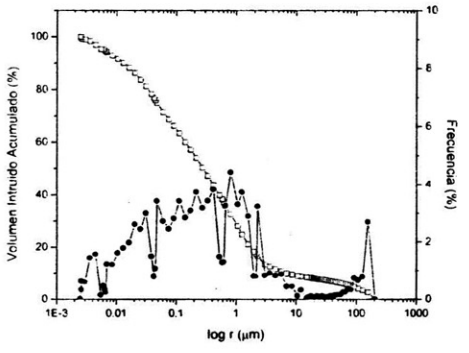
Total: 110.80 %

F 7. ***Graph and results of the stone analysis for fluorescence of X rays.***

Also in the stony materials the same phenomenon is detected. The stone of the building, defined as a sandy biocalcarenita, (calcio+oxígeno 79 %) but with high place contained in

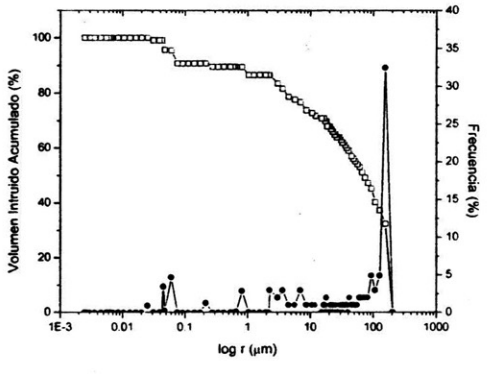
fillosilicates (silica 10,8 %) and with white of egg he(she) attends of you go out (sodio+cloro 10 %) that demonstrate the assault for water of sea, since they are not own percentages of these stones (**F7**).

The porosimeter allows to quantify the entire porosity and in different status as his diameter (**F8 & 9**). In case of the concrete there is observed a high percentage of porosity connected to the status of the average diameter of the pores much down, for what the water can climb more easily for capillarity. The conditions are suitable so that the water crosses the material for his capillary network. The thickness is normal.



F8. ***Piled up curve and distribution of radioes of pores obtained with of intrusion of mercury porosimetry of a sample of concrete.***

Connected porosity, P(Hg) [%]	**19.01**
Removed way, r_m (Hg) [µm]	**0.28**
Superficial area, S(Hg) [m^2/g]	**5.14**
Thickness combined, ρ_C (He) [g/cm^3]	**2.72**



Connected porosity, P(Hg) [%]	**2.01**
Removed way, r_m (Hg) [µm]	**70.36**
Superficial area, S(Hg) [m^2/g]	**0.03**
Thickness combined, ρ_C (He) [g/cm^3]	**2.71**

F9. ***Accumulated curve and distribution of radioes of pores obtained with intrusion of mercury porosimetry of a sample of concrete.***

The porosity connected of stony this one is very low, and the average very high radius of the pores, which he supposes that it he does not have capillary net. The density is the normal one in calcareous stones.

Water absorption

The percentage of water absorption has been calculated in all the samples since it is directly related to the accessible porosity of the materials.

In no case the results of absorption are raised, since the top limit is 6 %, which explains, close to the previous information of porosity, the good general condition of the materials in spite of his situation opposite to the sea.

Ultrasound

By means of the portable device of ultrasounds " Ultrasonic tester E-46" have realized diverse measurements in ashlars, specially in cracked elements, in order to determine the sonic speed in every case, following the methodology described for Facaoaru&Lugnani in 1993. For his interpretation it is necessary to think that the high values of the above mentioned speed correspond with a major density and compacidad of the material, whereas the low ones or the nonexistence of sign, they owe to a major heterogeneity, fissures and porosity in general, or to discontinuities since it can be a crack assistant.

The procedure consists of measuring the time that is late in the wave be transmitting between two points placing the transducers to a certain distance, obtaining values of the speed in mm/seg.

Comparing with values boss (3000 mm/seg in limy compact or 5000 mm/seg in mármoles), it is possible to classify the stony material of the building as of an average compacidad, since itchanges between 1419 and 1946 mm/seg in the healthy samples and in the environment of 1198 mm/seg when small cracks or irregularities exist.

The concretes have very low speeds between (294 and 862 mm/seg), which is normal since his porosity is very much major. Only in a point sign was not registered.

Hygrometer and thermohygrometer.

One has tried to know the degree of dampness in the whole perimeter of the building to locate the points of high concentration of water, as well as the origin of this one. Nevertheless it is necessary to bear in mind that, the epoch in which the measurements have been realized is not most adapted for a correct analysis of the characteristics higrotérmicas of the constructive elements. But it was indispensable to know, though it he is with a margin of mistake, the condition of the architectural set in relation with the dampness.

Besides the visual observation there has been used the device "Protimeter" it applying in the surface of the stone of the fronts 15 times in each of them and to two levels of the soil (30cm and 100cm) in the whole perimeter of the building with a whole of 55 measurements. Have distinguished themselves the points in which the measurement is over 22, in the red scale of the device, which supposes 40 % of dampness and which almost always coincides with the height of 30cm of the soil.

The zone in that the level reaches 40 (80 % dampness) is located in an alone sample. Though in the night the levels will ascend notably, in spite of the presence of the sea the materials do not come ever to saturation.

Offers of intervention

Of the obtained results it is possible to deduce that the damages in the social club of the Manzanera in Calpe, answer more to the abandon and the vandalism that to the quality of the construction, which has met affected by the constant action of the sea, provoking physical damages like the collapses of the crossbeams and chemist - physicist, for action of you them work out marine in stones and concretes.

The offer of intervention passes for recovering the elements that have a resistant mission or a marked functionality in the building and that have met altered with the passage of time,

avoiding besides the risk of total ruin or of fall of fragments. The offers that are realized are directed to solve the structural problems as well as to restoring the stony fronts.

The purpose, it is to manage to stop the processes of deterioration and to recover the original character of the building, respecting the architectural aspect without spoiling it with aggressive interventions.

In the most serious cases the wrought ones and crossbeams must be replaced destroyed. The walls of stone and part of the crossbeams can recover if there are applied the treatments that are indicated later.

Specific offers of solutions are done in the following aspects:

- Superficial Wash of stone and concretes in good condition of conservation based on drinkable water to low pressure (1 to 2 atm.) or if it is possible by means of water steam, by means of portable compressor with lance and brush of smooth sows to eliminate the little adhered ware deposits.
- In the zones of major soiling, with incrusted elements microprojection will be in use using silicate of aluminium, sand of minor hardness that the cut stone or glass pearl.
- In both cases it will be necessary to realize tests of the effect desincrustante to fix the pressure of the most suitable water or the quantity and diameter of the sand or the glass pearl.
- In very punctual cases, when the previous systems are not effective, one will proceed to clean the surface by means of the application of chemical cleanser of pH neutral, especially in spots of oxides, fats and bitumens.
- The cleanliness with papetas will be applied for the extraction of you works out soluble. In the zones affected by saline efflorescences one will proceed, after the cleanliness, to the application of an inhibitor of efflorescences type Tecosel or similar, applied to two hands by means of nebulizador on the stone.
- Preconsolidación, or consolidation, according to cases, of masonry, concretes or revocos by means of silicates of ethyl with catalyst hidrolítico in dissolution of ethanol, with addition of mineral powder in cases of great hollow.
- Solutions for the reimbursement of stone, re-joined, sealed of cracks. The re-joined one of the factory of stone that it should re-put, will carry out by means of reof integration mortar obtained with the mixture of air lime, resin epoxi in emulsion and white sand in the proportion 1:3, of thin size and grain adapted to the sheet FL-90. It will be possible use a prefabricated mortar which characteristics adapt to the fixed ones.
- The rubbles that present breaks of importance with loss of fragments will re-become total or partially for others of stone of characteristics similar to the existing one, to being able to be of stone recovered of the cliff. They will join the base by means of anchorages of unoxidizable steel and resin epoxi. When simply they are cracked, the cracks will be refilled by injection of mortar Emaco-4, eporit F/G or similar, formulated from resins epoxi of low viscosity, tixotrópicas and great power of penetration. The sealed one of the exterior face will carry out with the same mortar of the re-joined one.
- Sewings by means of rods of glass fiber and resins in very punctual cases.
- Sealed of cracks with mortars of cement or resins of polyester with estireno that must be realized by means of injections to low pressure.
- The factories hidrofugarán to protect them from the action of the water and to avoid the deposits of dirt. For it a product will use formulated with metil-polisiloxano transparently as the Tegosivin HL 100 of the house Goldsmith or similar, or for application of Fakolit's, soluble FK-7 to the water, which they avoid the water entry that moves you work out soluble or it hydrates the minerals, provoking increases of volume that alter the stone.

- Accomplishment of concretes of discharge compacidad for the repair of the deeply depressed zones of the crossbeams, using arid of crushing which maximum size is of 20mm, I clean of powder and a cement type II/B-S 42,5 N/SR resistant to sulfates and to the water of sea, with minimal dosing of 350 Kg for m3.

References

LOUIS, M., GARCÍA DEL CURA, Mª. A., BERNABÉU, A. LA IGLESIA, A, SPAIRANI, Y., HUESCA J.A.& PRADO, R. (2006). The Restoration of a stone bridge in semiarid environment: Puente Viejo of Elche (Spain). Heritage, Weathering & Conservation. In: FORT, R., ALVAREZ DE BUERGO, M. GÓMEZ-HERAS, M. & VAZQUEZ CALVO, C. (Eds.) Vol 2: 881-885. Taylor & Francis Group. London. Balkema.

BRADLEY S and THICKETT D. (1992). An investigation into the movement of moisture and soluble salts in stone. Preliminary observations and experiments. 7 th. Int. Cong. on deterioration and conservation of stone. Laboratório Nacional de Engenharia Civil, Lisbon.

BEHLEN A., STEIGER M., DANNECKER W.(1997): Quantification of the salt input by wet and dry deposition on a vertical masonry. Scientific editors Rhodas, ~~1997~~.

BRIMBECOMBLE P., CLEGG S., REEVES N.(1997): Thermodynamics, expert systems and salt damage to porous stone. Scientific editors Rhodas, ~~1997~~.

C.N.R.-I.C.R. (Centro dei Studio Cause di Deperimento e Metodi de Conservazione delle Opere d'Arte. Istituto Centrale del Restauro) 1983. "Coeficiente di assorbimiento capillare" Doc. Normal 11/82, Roma.

FACAOARU & LUGNANI (1993) Contributions to the diagnosis of stone and concrete historical structures using non-destructive techniques. Conservation of stone and other materials. Ed M. J. Thiel, London 1993 Ed FNSpon pp. 238-251.

LAZZARINI L. and LAURENZI M. (1986). Il restauro della pietra. *Cedam. Padova*, pp. 307.

LOUIS M., ALONSO J., ALONSO L. & GALVAÑ V. (1991). Geographic, climatic and environmental factors which influence the mechanism of weathering of stone used in the main Monuments of the city of Alicante -Spain-. *European Symposium Science, Technology and European Cultural Heritage. Commision of the European Communities, Oxford*, pp. 388-392.

LOUIS M., SPARIANI Y., CHINCHÓN S. (1997). Study of treatments for the elimination of soluble salst and dampness in the repair of coating stone buildings. . 4th International Symposium on the Conservation of Monuments in the Mediterranean. Rodas, pp. 177-191.

LOUIS M., GARCÍA DEL CURA M.A., SPAIRANI Y., DE BLAS, D. (2001): Los palacios civiles de la calle Gravina de Alicante: las piedras utilizadas en su construcción y su alteración por sales. Rev. Materiales de Construcción, Vol.51, nº 262. C.S.I.C. Instituto C.C.E.T., Madrid.

PAULY, J.P. (1996). "Altération alvéolaire: évolution et climatologie. Mém. Soc. Géol. France, 169, 421-426.

MAMILLAN M. (1981). Connaissances actuelles des problemes des remontées d'eau par capillarité dans les murs. The conservation of stone II Symp. de Bologne. Rossi-Manaressi, Bologne.

STEIGER M., BEHLEN A., NEUMANN H.H., WILLERS U. (1997): Sea salt in historic buildings: deposition, transport and acumulation. Scientific editors, Rhodas.