ELEMENTS OF ENERGY SAVING IN THE RESTORATION PROJECTS

Dubrovnik, April 2011

Introduction

The cultural entirety of Dubrovnik is the area of the historic city centre with its close surroundings, (Figure 1) placed on the UNESCO world heritage list in 1979. In the same year the City was badly damaged by the earthquake of intensity 7º MCS scale when 833 objects were damaged. The estimated damage in 1980 was over 436 million US$. (Figure 2).

Figure 1 Bufer zone

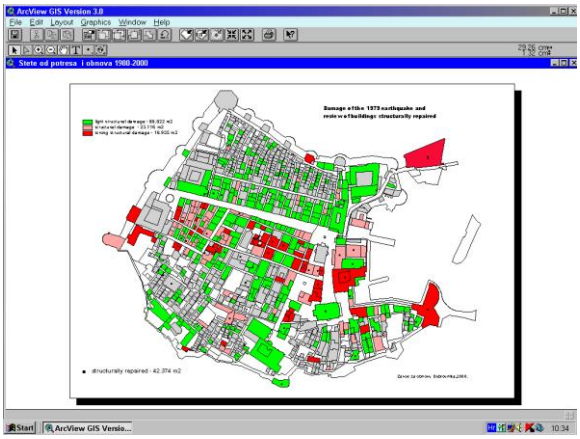


Figure 2 The map of damages

Due to the severe damages of the monuments and the need for their long-lasting renovation, the Institute for Restoration of Dubrovnik was founded as an institution that would organize the restoration of the cultural heritage of Dubrovnik and take care of the preservation of its genuine urban, architectural and cultural values (Figure 3). With that goal the Law for restoration of the endangered historic centre of Dubrovnik was introduced in 1986. as the unique law on that kind in Croatia.

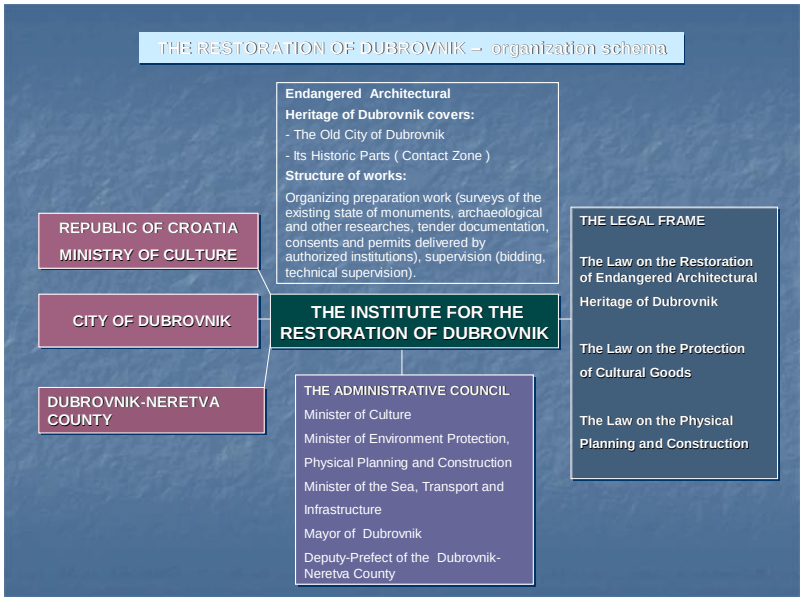


Figure 3 Organization scheme

Though *the renewal* means the elaboration of various different interventions on a monument (renovation, restoration, reconstruction, removing recent deformities etc.) the prime goal of the renewal is the seismic renovation of the damaged monuments from the earthquake of 1979 and the renovation in the post-war period from the war damages.

After the thirty-year period of systematic work in renovation we can state with certain satisfaction that we have today achieved a well-balanced relation between the degree of reinforcing the monument and its cultural and historic values. For these purpose, in addition to the genuine materials it is most frequently used the timber, steel, carbon laminas and fibres in the most sophisticated and reversible methods.

By renewal, the restoration and renovation of the historic parts are performed as well as the reinforcement of the monuments to reduce the seismic risk.

It was invested over 90 million US$ in the renewal of monuments through the Institute of Restoration of Dubrovnik till 1991 (Figure 4).

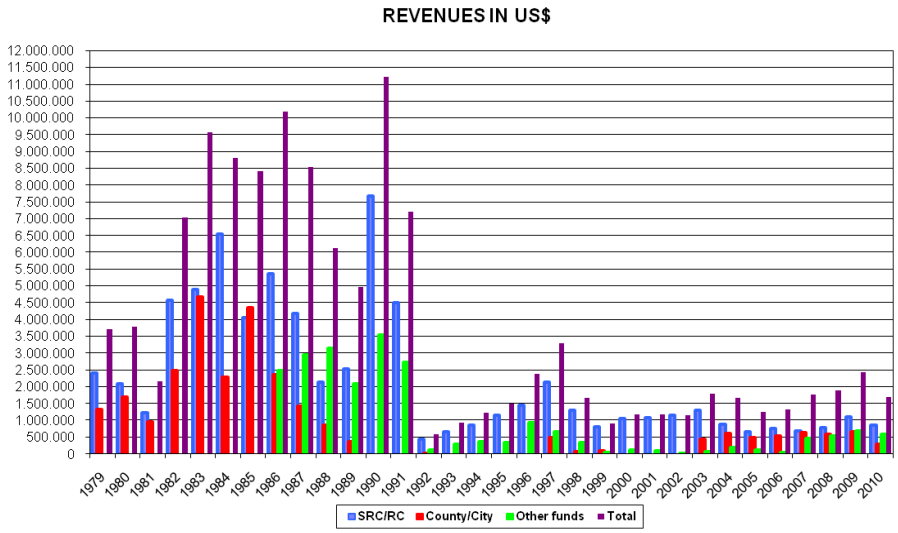


Figure 4 Diagram of invested means in the renewal

In the war destruction of the City the damages were registered on 473 objects and 70% of the roofs in the City, which was estimated on the amount of 20 millions US$. Since 1991 through the Institute it was invested 19,7 millions US$. for the renovation from the war damages. (Figure 5)

Figure 5 The pictures of the restoration from the war destruction

After the war destructions in the historic centre there are still 390 buildings with damaged construction to be renovated. Since 2000, the renovation has been continued on the monuments damaged in the earthquake and till today it has been invested 107 millions kunas.

Constructive elements and the characteristics of the original construction

The restoration projects are made for public, sacred and residential buildings as well as for infrastructural interventions (setting up new transformer stations, reconstruction of the streets with city installations, bridges, fortifications etc.) (Figure 6, renewed objects: the Rector's Palace, the school, the fortress Revelin, the block in front of the Rector's Palace). They are based on the systematically documented and studied monument.

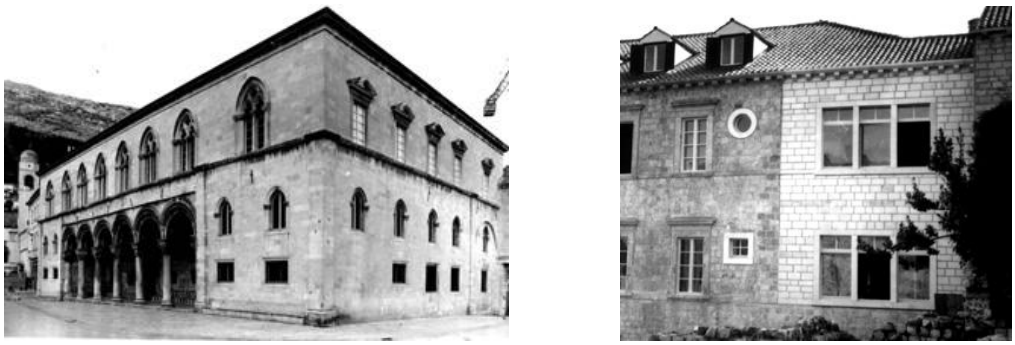
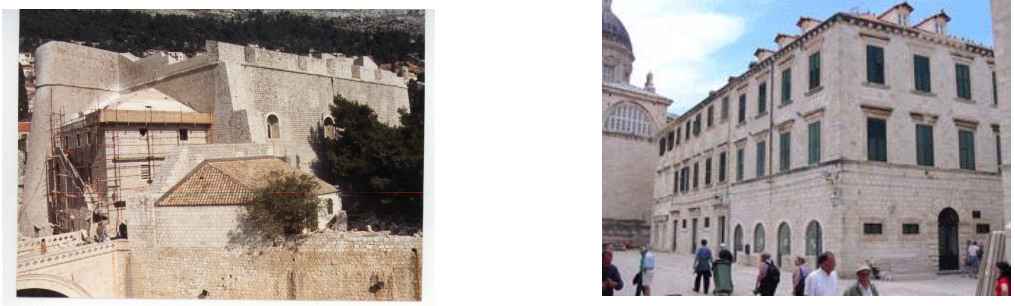


Figure 6 Renewed objects



We witness urban typology and position of rows and streets, a very good quality of its original construction, usage of constructive elements and artisan details which contribute to energy saving and economic maintenance of the microclimate inside the buildings, for example:

- predominant orientation on building the residential rows NE-SW (northeast-southwest) which ensures morning or afternoon's insolation of rooms
- urban matrix of construction in a row where buildings have only two outside walls in rows with a sewage canal *'klončina'* between, or one outside wall when two parallel rows are joined (Figure 7),
- similar effects of joined masonry construction in a block also with only two outside walls (Figure 8),
- classic masonry of outside walls 60 – 80 cm thick which fulfils the thermal coefficients of the environment,
- low first floors (190 to 220 cm height) on the buildings where the storage of the ground floor was placed before, with small windows, or the last floor where the supposed space for attendants was placed (and looking after kids), all to function easier maintenance of the certain temperature (Figure 9),
- narrow high windows on the main floors enable the sun entry and the blinds put inside the windows to protect from the loss of heat (Figure 10),
- the use of materials in the interior like timber, tiles and stone define the kind of space, its purpose and the owner's status (partition walls made of timber and mortar, staircases' and floors – timber floors in small residential houses of several levels, in public buildings and palaces the stone staircase).(Figure 11).

These are only a few of specific elements of original construction.

Figure 7 One outside wall Two outside walls

Figure 8 Block with only two outside walls

/ The rows NE-SW orientation/

Figure 9 Low first and last floor Figure 10 Narrow high window Figure 11 Stone staircases

Elements of energy saving through the renewal realization

We emphasize the aspect of energy efficiency in the first restoration projects done in the period from 1980 till 1990. The complete renovation was performed on the most valuable monuments, mainly public buildings where contemporary solutions and installations were projected and installed. The central air conditioning system (heating and cooling) with the central air conditioning plant room was performed in the urban complex of 5 objects; the Rector's Palace, the theatre Marin Držić, the city coffee shop, the Municipality building (City government seat) and the cinema. Three heat pumps, made in Croatia, with sea water–to-water heat exchanger were built in. The water is conducted from the heat pumps to the objects and is used in fan-coils, underfloor heating and ventilation systems.

The underfloor heating is installed in 5 objects inside the historic centre, i.e. in the primary school Marin Getaldić, Art school Luka Sorkočević, in the Rector's Palace, the city coffee shop and the exhibition hall beside the city coffee shop.

The monumental Revelin fortress with the hall of 400 visitors is air conditioned by means of air-water heat pumps.

The use of heat pumps is planned in several other objects which were stopped due to the war destructions (5 palaces and 2 blocks of buildings in Pustijerna, the fortress Veliki kaštio in Ston etc.).

The central air conditioning is also planned to be built in the Bishop's Palace which renovation is being underway. It was inventively solved the air intake to the air conditioning plant room in the attic through the roof windows and hardly visible lifting of a tile (Figure 12, Figure 13).

Figure 12 Roof windows

Figure 13 Lifting of a tile

The actual partial renovation of the outer bearing construction of the blocks of buildings has an influence on returning back the original attributes of the monuments in regard to their resistance to climatic and other impacts.

The revitalization of the City structure is being gradually performed by series of complete or partial interventions that improve physical properties of buildings:

- the rebuilding of low-quality masonry is done to reinforce and consolidate the masonry (Figure 14)

Figure 14 Rebuilding of low-quality masonry

Figure 15 Constructive reinforcements

- constructive reinforcements are done and seismic risk diminished by mounting the stainless steel beams as well as performed composite construction in steel, mounting the timber glued *kerto* boards (instead of reinforced concrete slabs) which also serve as thermal insulators (Figure 15, Figure 16),
- the outside walls are plastered, facades made of porous stone are coated by hydrophobic materials to prevent moisture penetration into the walls,

Figure 16 Kerto boards

Figure 17 Roofs' renovation

- during the roofs' renovation all objects got 2, 4 cm thick board covers and the foil. This additional layer to the roofs diminishes the coefficient of heat passage and improves the physical properties of the building. (Figure 17)
- chimneys and damaged roofs windows are being repaired,
- the *iso* glass is mounted on the windows of the palaces where the complete renovation is being performed,
- the damaged stone ornaments of the facades and stone canals (caused by shell fragments) are being repaired to prevent moisture penetration into the walls.

Finally, the use of a renewed monument as the seat of the institution, i.e. the Institute for Restoration of Dubrovnik and its permanent maintenance, represent the successful compromise of demanding conservators' principles and the fulfilment of contemporary requirements of the working conditions of our institution.

Figure 18 The use of the existing openings - outside and inside view

The recently built-in the multi split type air–conditioners by use of the existing openings (doors, windows), in cooperation with the Conservation department, is a good example of how contemporary solutions can be installed without disturbance to the authentic elements of the monuments (Figure 18).

The author:
M.A. Ivanka Jemo, arch.

Associates:
Andrija Tolja, arch.
Sanja Krželj, arch.
Nada Brigović, eng.
Mario Doršner, mech. eng.