A CASE STUDY: RESTORATION OF HISTORICAL MUSEUM IN SARAJEVO (1963) – A MODERNIST RUIN

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ABSTRACT

The Historical Museum, originally built as the Museum of Revolution in 1963, is an abstract modernist building; a stone-clad lapidary volume placed upon a transparent ground floor creates a strikingly simple and dramatic geometric and material contrast in the best manner of minimalism. The architects influenced by 'less is more' created an audacious building in architectural, material and structural scheme. In structural design and building physics less is, in most cases, simply less, and structural and surface/material deterioration is very visible on the building. This also affects the functionality of the entire building that needs to consume enormous amounts of energy (for cooling and heating), threatening an ever fragile budget of the institution of the museum. Due to its architectural values and cultural significance, the building is protected by law, as a national monument. Interventions must be performed to not only improve the conditions of the building but also maintain its original character and authenticity. A project for restoration of this building is emerging and proving to be even more challenging than initial estimates, especially for the structural aspects of the building that are far from current and needed dimensioning or fire protection codes, which is the case of many buildings from this era. The article will outline the proposals (part of the work is in implementation) and approach for restoration of several elements: structure, insulation, roof light, stone cladding and transparent façades. One of the most prominent features of the structure is the skeletal structure based on slender steel, **+**-shaped columns and hidden concrete grid beam system locked within thin slabs. This presents a challenging task for us – structural engineers and architects – to work in the domain of the hidden, the invisible in order to maintain the building's original ethereal appearance.

Keywords: Historical Museum, modern heritage, skeletal structure, modernist ruin, national monument, roof restauration, static assessment, structural design.

1 INTRODUCTION

The Historical Museum, former Museum of Revolution, is a masterpiece of minimalist architecture. Museum did not undergo through significant alterations, it is architectural intent, material and structure truthfully represent an era. It is almost a perfect poetic ruin, idolized by many architects, a symbol yet again of resistance against the current fast-paced and under-regulated building in Sarajevo that does not pose the identity, structure and meaning of its predecessors. Heritage of the modernist era is very significant, especially today when a society is caught in a permanent 'transitory and developing' political and economical agenda. It was a time when one believed in progress and ideals, a time when architects and structural engineers brought pure, abstract, timeless architecture. What was specific about Sarajevo and Bosnia and Herzegovina is that architects of that time recognized the 'modernity' of existing traditional archetypes and made a powerful statement by using the familiar forms in modernist manner, thus creating buildings of an era, but firmly rooted in place and substance of the city (Getty Conservation Institute [1]).

The History Museum, built in 1963, was designed through a competition that took place in 1957. Architects were Edi Šmidihen and Boris Magaš who later received numerous awards for their design (Kaljanac et al. [2]). The building's minimalist approach is also reflected in its structural system that is composed of slim iron columns and grid-type concrete beams for floor structures, elegant and on the edge of load-bearing capacity – partly a reflection of its time (Fig. 1).

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Figure 1: White stone cladding and glass façade, 'modernist ruin'.

The ideal is as always in clash with reality. Damaged from war (1992–1995), the building is in dilapidated condition. Main cause of this is also lack of maintenance and knowledge about modern materials. The main question is structural stability, fire protection and adequate methodology for restoration of this masterpiece. Restoration of modernist building is significantly different to the traditional ones due to their specificities: architectural authorship, tendency towards minimalism that is reflected intensively in structural and building material and physics. These specificities along with the current legal building codes (safety, emissions, fire protection) make the restoration process even more contentious than the 'traditional' historical buildings.

This research article will discuss the diagnostics, methodology and subsequent consequences of actions or interventions. One must be very clear that the restoration will inevitably cause loss of authenticity and 'modernist ruin image' due to replacement or material upgrade of certain elements.

2 METHODOLOGICAL APPROACH TO RESTORATION

2.1 Analysis and Diagnosis of the Current Condition of the Building

The process of protecting and upgrading the building to contemporary requirements has become relevant and pressing issue. The basic function of the museum is threatened by roof leaks, inability to heat and ventilate space or by pieces of stone cladding falling off. The building needs to be adapted to acceptable standards of comfort for users, and at the same time to recognize the importance of preserving the architectural heritage.

There are two key issues to consider while making a design for restoration:

1. The structural assessment and subsequent needed interventions on the existing construction should make the structure safe to use and functional in the future life span of the building.

2. Architectural restoration that must keep the overall concept of fine modernist details and materials reflected in its skin – the façade layer composed of relatively thin iron profiles and single glazed glass, and white stone cladding of the first floor cube.

Through a detailed architectural survey and drawings, current state of the building has been recorded and analysed. In general, one can state that the outer shell – surfaces of roofs, façades and pavement – is in a state of disrepair and even crumbling. It is possible to state that 50% of stone cladding is damaged or missing and that ground floor's transparent glass and iron façade has severe corrosion throughout all segments and some are nearly collapsing (Fig. 2).

All roof surfaces have major leaking problems that were partially addressed during the last 10 years, but there was never a comprehensive restoration of the entire or large portions of the roof. Flat parts of the roofs are damaged and they consist of layers, thermal insulation, water drainage pipes and surface inclines that are inadequate.

The building's skeletal construction consists of frames tensioned with vertical diaphragms and the elevator shaft. The beams on the first storey are laid in the steel concrete beams. The + cross section of steel columns is 28 and 35 cm on the ground floor and 16 cm on the upper storey; there are nine columns on each storey. The storey concrete slab leans onto the 9-cm-steel concrete grid. The structure of the flat roof is also comprised of steel concrete panels, and the gauge of which is 7 cm in the lower part and 15 cm in the upper part. The oblique parts of the light are constructed using steel hollow rectangular glass-roofed profiles (Fig. 3).

The main bearing system of the horizontal frame bearings on the roof structure level is comprised of four grid bearings with overhanging eaves leaning onto the already mentioned steel columns made as +-shaped profile. In order to reinforce the stability of the existing grid bearings, two hollow steel diagonal poles (Fig. 4).

The building has been assessed not only for constant and movable load but also for the load of seismic zone VII of the MCS scale, Soil Category II. A peculiar characteristic of the building that has been included in the seismic analysis is the fact that the first mode of the

Figure 2: Ground floor openings that show improvised repairs.

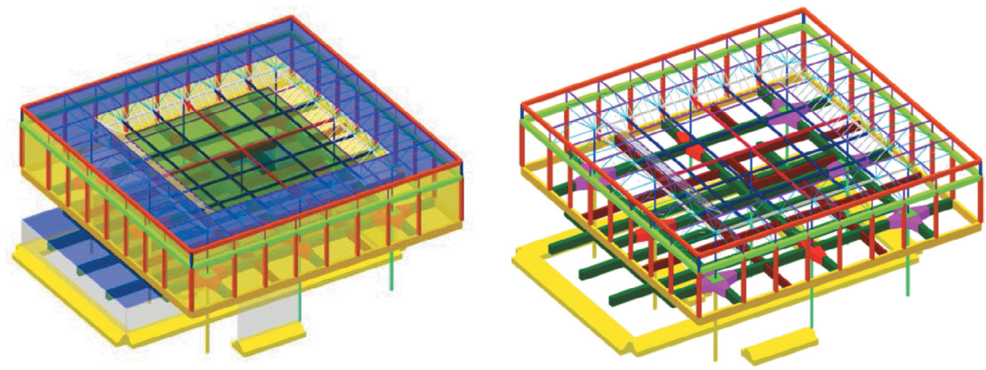

Figure 3: Static model of museum's structure with and without walls.

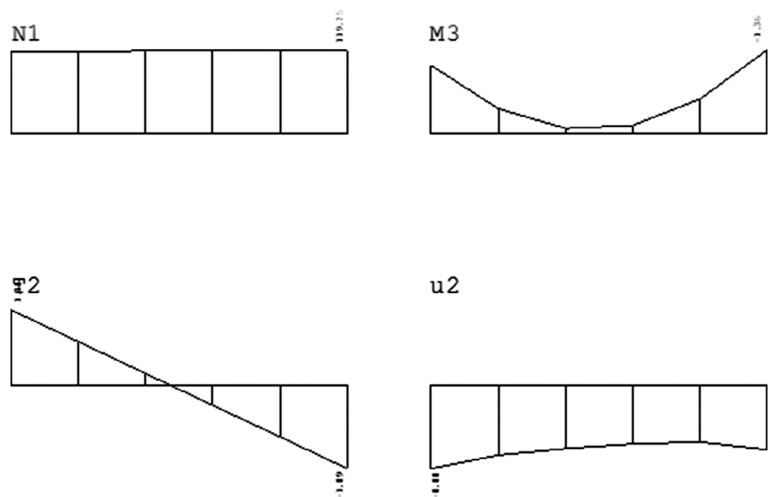

Figure 4: Internal forces and displacement in the most loaded carrier glass cladding.

construction's vibration period T_1 is actually torsion. The roof structure has been assessed for the snow load of 1.50 kN/m^2 (Fig. 5).

2.2 Restoration and Evaluation of Modern Heritage

Restoration of historic buildings has been a challenging and divisive endeavour for architects and structural designers, as well as for relevant international institutions that issue guidelines and charters in order to respond to all complexities and phenomena of cultural heritage. Mostly we are able to deal with the pre-modern heritage restoration in a proper architectural, methodological and material manner. This is partly to accumulated knowledge and practice on traditional, mostly masonry or wood materials and techniques. This has not always been the case – for instance, early restoration attempts of Parthenon produced even more damage due to inadequate connection material that rusted and ill-fitted elements.

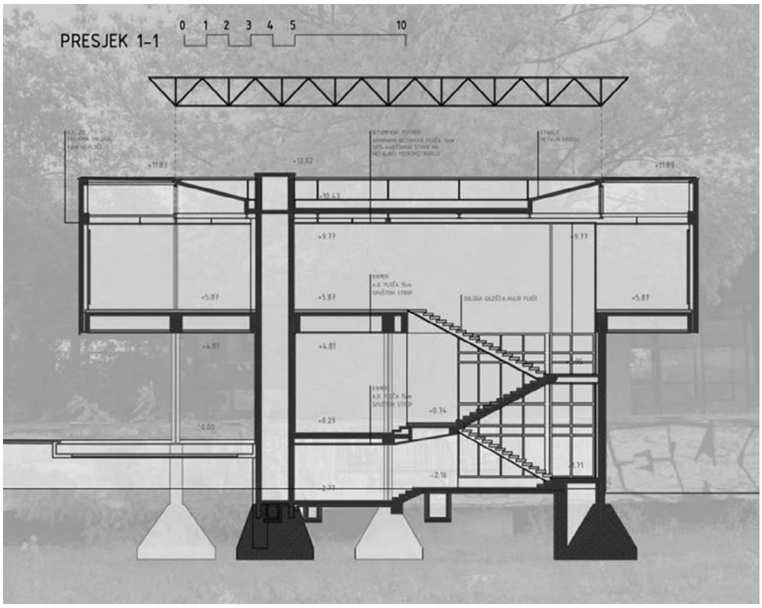

Figure 5: Cross section of the museum.

It is the very material and structural composition of traditional historic buildings that allows dismantling, partial replacement and intervention, and also they are a product of centuries of building experience that is not the case with modernist buildings.

The valourization of building heritage of 20th and 21st centuries is also quite a recent process; the World Heritage List has inscribed modern buildings mostly starting from the beginning of the 21st century out of 1,031 properties (802 cultural) in 2015 and only 10 belong to contemporary architecture.

This information is indicative of the level of difficulty in appraisal of buildings which mostly are in active use and have been subjected to various retrofitting interventions that may have compromised the integrity and authenticity of the buildings.

There have been many cases of restoration of modernist buildings (such as the Weissenhof complex, Corbusier building in Stuttgart, or Viipuri Library) and results are in a way always a form of compromise, even more so that with traditional buildings since using same technical solutions only leads to same problems that will appear over time and will not provide a reasonable amount of user comfort (Kulic [3]).

Essentially there are two approaches: either make double skin leaving all the existing and compensation with another layer that introduces a new element but allows the preservation of the authentic, or replacement of the original with new elements with high technological and precise craftsmanship that can to an extent visually replicate the dismantled segments.

3 STATIC ASSESSMENT

At the very beginning, the preliminary detection and diagnostics were made, a detailed assessment of the original project documentation, in order to get familiar with the building as a whole, especially its structure elements, architectural details, equipment and installations. All potential obstacles and damages had to be registered. Unfortunately, the original project documentation was partly available and some of the drawings were not completed to the necessary degree to be considered professional but were enough to confirm the dimensions and details of the basic elements of the structure. There is always a possibility of hidden damages that are often detected only after ‘opening’, i.e. beginning of construction works.

Complete insight into the existing condition of the building and its structure was impossible due to the fact that the building was open for visitors and that the budget was limited. That is why it is necessary to make another, secondary round of diagnostics and in that way complete the static assessment before beginning with the construction works. During the process of opening the roof structure and the building structure, i.e. co-operate with the chief designer with the aim of conducting an additional static assessment if necessary and offer a final solution regarding all interventions, especially those pertaining to the roof structure. Considering the circumstances and the fact that a major part of the building and especially its roof structure was not accessible for inspection, detection of possible damages and visual inspection, it is of utmost importance to fulfil this requirement. In this phase, the dimensions, the quality and the type of materials used for construction elements that were hidden or inaccessible will be re-examined. Certainly, to preserve the construction scheme of the original design, it is necessary to make a quality assessment of the character and degree of damage.

4 PROBLEMS AND SPECIFIC FEATURES

At 19 July 2016, works on the roof have started. After booting the cover strips and existing reinforced glass on the south-western parts of the roof we discovered bays. Supervisors noted that the sheet metal and insulation under glass are in a degraded state and therefore unusable.

The discovered bay also showed unacceptable damage to the reinforced concrete beams that support steel sections, which do not meet current standards for this type of structure. These existing concrete structures have significantly reduced cross section with a visible structure, forks that are not closed and concrete largely separated from the beams. It is necessary to replace the collapsed concrete.

The damage in reinforced concrete structures caused by external loads manifest cracks in concrete (vertical and inclined cracks) and separation of the protective layer of concrete reinforcement. These cracks still do not represent a sign of unsatisfactory capacity of the structure. Cracks in this case allow access to reinforcement, and the aggressive actions of environment further cause a change in the structure of the steel reinforcement. The reinforcement that is corroded with reduced cross section does not meet the required capacity and on the surface of the concrete causes peeling (Fig. 6).

Figure 6: Degraded state of sheet metal and insulation under glass.

From the damaged grid diagonals and other damaged elements of the steel structure, it is necessary to cut out samples further to be examined in lab for hardness using the Brinell hardness test method (depth of indentation, D = 10.0 mm). The built-in steel is from the group of soft steel and we will examine its quality by assessing whether it possesses mechanical balance, i.e. if it may be classified as steel of desired quality.

As for corrosion, the nodes of the construction were more exposed to corrosion due to standing water and debris. It is to be concluded that, apart from rehabilitation of the damaged and deformed elements, it is necessary to clean the structure by means of sanding techniques and by applying appropriate tools for removing corrosion in difficult-to-reach spots. Considering the thinness of the construction elements, it is recommended that special attention in the rehabilitation process be given to synchronized purification and primer application. It may be concluded that a quality change of the mechanical features of built-in elements and the whole system occurred. Only after conducting the above-proposed activities, including potential laboratory examinations, it is possible to make a quality decision on all interventions regarding the construction. Starting with the assumption that a correct secondary detection, while recognizing causes of the existing damage, has been carried out, and taking its purpose into account, it is possible to make a decision on measures that would enable certain functions and their future status. It is, therefore, necessary to ensure spatial hardness of the structure by establishing its predictable response to a potential future shock/earthquake.

As a rule, the columns are most gravely affected and damaged in the lower third of the height as well as in places where they are connected with the cross-bars.

During works on the roof the remaining parts of ties were discovered. There were three ties in both directions that facilitated the lower parts of the construction which is cantilevered left outside the main cube. Today there are only anchored parts, the ties are missing and investor should fine the way to finance its construction (Fig. 7).

The circular (CHS – circular hollow section) and rectangular (RHS – rectangular hollow section) hollow steel grid bearings have priority in contemporary civil engineering and construction over the commonly used grid bearings made of hot finished sections due to a range of advantages: less heavy, the anti-corrosive protection is cheaper, the O/A relation is lower, the aero-dynamical shape is better, there are greater possibilities for constructive and

Figure 7: Remaining anchored parts.

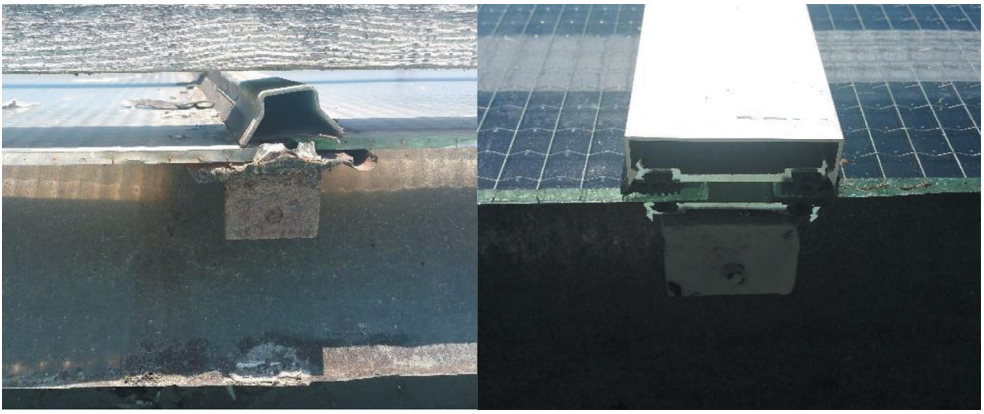

Figure 8: Connection between reinforced glass (old and new ones).

architectural shaping, and so on. They are made of CHS or RHS. All the filling elements are welded. The angled welds are 4.0 mm thick along the whole contour of the joining structures.

The designed horizontal and vertical dimension lines and steel structures should be completed in the final stage. The constructor, prior to construction works, has to develop elaborate workshop documentation on cutting and welding, taking into account the effects of deformations due to welding – such as shrinkage and distortion of elements – in order to make it possible for the final shape and measures to precisely correspond to the plan after assembling. The material-processing details have to be adjusted to the hot galvanization technology in order for the welds not to be damaged.

Only after the secondary level of detection has been carried out, all the necessary sketches of the current condition indicating which spots are damaged will be completed and classified according to the type along with an accompanying textual description (technical report on the conditions found) as the ways and methodology by which the damages will be eliminated. The constructor will be provided with corresponding sketches and textual instructions, and static analysis with construction details, if necessary. Bearing all the listed reasons in mind, it is necessary to make an assessment plan for the replacement of the existing elements of the steel structure the cross section of which is 25–30%.

About 70% of existing undamaged reinforced glass is thoroughly cleaned and reused. Appropriate procedures for the reinforcement of the structure are needed. We suggest using some of these methods: rehabilitation of beams by using additional steel stirrups, reinforcing beams by increasing the cross section and reinforcement, reinforcement beams connecting the existing and additional reinforcement, the use of steel sections glued with epoxy adhesive for concrete section or reinforcing section with carbon strip (Fig. 8).

5 FIRE PROTECTION

Fire protection is another important issue that has to be addressed. In case of fire, especially sensitive are steel structures, and to a lesser degree, concrete steel structures as well. It is necessary to improve the fire protection system. The sprinkler systems are designed to control fire until fire fighters arrive. Their success rate is quite high in EU countries, which make them, from the engineering point of view, among first choices when compared with other methods of fire protection.

It is also necessary to ensure protection of the bearing structure by applying appropriate coating. The protective coatings used in steel structures are paints or metal coatings or the combination of the two. In their essence, paints comprise the pigment, the binding mass and solvents. The surface has to be cleaned of rust, debris and grease. Old layers of paint that have started to peel off need to be completely removed. In the process, the outside temperature has to be at least +10°C (the temperature of steel +5°C at least). The type of paint and the thickness of the layer applied depend on the corrosive aggressiveness of the environment. The coatings are allowed to be used exclusively in the interior parts of the building and in no way on elements that are constantly exposed to high degrees of humidity and aggressive fumes. Once applied, this coating must not have any additional coatings. The surface coating has to be regularly maintained.

In order for the coated steel elements to fulfil fire protection report requirements regarding construction elements, it is possible to apply galvanization of steel elements. Such a fire-protective coating creates a layer of insulation intended for the bearings (full bearings with special requirements regarding bending characteristics), columns and grid structures. The process known as 'hot-dip galvanizing' implies that hot zinc coatings are applied by immersing steel structures in a tank of molten zinc at a temperature of about 450°C.

In general, structural aspects of the interventions are complex due to the fact that building regulations of the time that required less safety margin and that contemporary solutions might impose some new weight or elements that must be integrated into the existing.

6 ARCHITECTURAL CONSIDERATIONS

Architectural and technical details that will emerge during the process of design and rehabilitation of the building will be serious compromise on many levels. As previously stated, the fragile and minimalist state of the building contributes to its overall appearance.

Referring to some cases of restoration of modernist buildings such as the Corbusier's building in Weissenhof in Stuttgart, upon close inspection it is possible to see that the restoration involved a series of compromises, even in its interior (Weissenhof Museum publication, 2008 [4]). The most prominent feature is the continuous strip window that has been replaced with new double glazed glass and frame.

It is the very nature of the compromises that make the restoration of modernist buildings even more delicate. It raises questions of overall integrity and authenticity of building and its concept and materials. The most delicate matter is its envelope elements: upper storey stone cladding and ground floor transparent glass/iron façade. The upper floor is composed of a thin concrete wall of 10 cm that has partial internal insulation blocks made from pressed wood 5 cm thick (Fig. 9).

The outer shell of the façade is made of 2.5 cm thick hard white marbleized limestone cladding directly glued/plastered to the wall. In case of thermal insulation there are technical solutions to place it within the object, but question remains as to how effective this would be, considering many weak thermal spots conduct the energy and in some cases are a moisture-generating zone due to hot and cold surfaces in contact. It is inevitable that a large portion of stone cladding will have to be replaced but will generate a visual distinction between existing and replaced stones due to their patina. This is something that has been already accepted in many cases of post-war restorations on stone masonry buildings and is a truthful and correct procedure in restoration.

An even more complex is the issue of the iron profiles and single glazed glass transparent envelope. To some extent, the current iron frames and mechanisms can be repaired but the main issue remains with the single glazed glass that does not provide sufficient insulation,

Figure 9: Condition of the roof (before and after).

or is the building functionally heated. Proposals range from replacement of frames with aesthetically and visually similar but double glazed thermal glass, or placing a glass curtain a second layer that will provide insulation and allow the building to keep its original framing. The first option is technically preferred due to its clarity and functionality but will lead to loss of the fragile authentic tissue.

Some other features will require interventions such as skylight roof but since these are less visible elements, their restoration can be achieved through sound contemporary solutions that will still keep the original structure.

The essence of this building is partly in its physical features and partly in its symbolism, at the time it was created (communist era), evoking a timeless abstract volume spoke about vision of architects and deeper universal meaning of the structure.

7 CONCLUSION

The delicate 'modernist ruin' image and heritage of the museum is fiercely defended by many architects due to the fact that it has been a part of collective memory, a kind of testament to a culture that has once been, which produced this architectural icon and the current transitional society moral that leaves these important institutions in derelict. This is a valid argument since many inhabitants of former Yugoslavia who romanticize socialist and modernist periods perceived stable and progressive (Štraus [5]).

On the other hand, the basic function of a museum is to preserve collections and items deemed valuable and in present state the museum is trying to function (due to enthusiasts and individuals who support and run the institution) despite the circumstances.

As architects and engineers who have closely inspected and recorded the building, one also has dualistic and mixed emotions and rationale about the actions to be undertaken on the building.

Modern heritage – its evaluation and restoration is becoming more a part of the issue among professionals, and cultural institutions are doing more to claim the buildings as heritage, but currently there is very limited experience in restoring them.

In addition to items of all heritage a minimalist intervention recommendation is to be followed here, although mostly will be irreversible. These minimal interventions would include the extensive repair of the flat roof and basic structural interventions upon inspection of main structural elements as well as their replacement or intensive maintenance.

As for the most visible alterations to the façade the most conservative approach would be preferred with minimal replacement of stone cladding and transparent elements.

In the case study of museum building that started out as a purely technical survey and assessment of conditions, the authors of the article become even more aware of deeper layers and meanings of the building, and of its metaphysical presence that has in the end dictated the main discourse for the process of restoration.

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