Opportunities for rehabilitation of facades of historic buildings in Moldova with limestone elements

To cite this article: D C Albu and A Lesan 2021 *IOP Conf. Ser.: Mater. Sci. Eng.* **1209** 012008

Opportunities for rehabilitation of facades of historic buildings in Moldova with limestone elements

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Abstract. Most buildings of historical and architectural value located in the Republic of Moldova are built of limestone or brick. The facades are decorated with columns, semi-columns and pilasters, balusters, bas-relief, and consoles. The degradation of historic buildings over time leads to the need for rehabilitation and restoration. Often privately owned buildings are repaired with the application of modern materials without taking into account the original materials, without researching the original elements and materials. Authentic decorative elements are replaced by polyurethane foam elements, which due to their easy installation and relatively low cost, can significantly reduce the financial costs of finishing and decorating facades. The interior walls of the brick are covered with plasterboard. The exterior walls of limestone are plastered with cement-based mortar instead of lime-based mortar. In some cases, the walls were covered with polystyrene. All these replacements reduce the architectural and historical value of the buildings lead to the loss of their authenticity. In order to preserve the value of historic buildings, it is necessary to use local materials. This research examines the possibilities of using limestone both for the rehabilitation of masonry and for the restoration of the decorative elements of buildings built in the XVIII-XX centuries.

1. Introduction

Historical buildings have an important cultural significance and impact on the development of the younger generation.

A current problem for the whole world is the maintenance, consolidation, and rehabilitation of heritage buildings. Historical buildings are highly vulnerable due to the way they are built and the way they are constructed.

In Chisinau, the capital of the Republic of Moldova, there are many historical buildings in an inadequate condition, which require reconstruction or complete rehabilitation [1]. A series of historical buildings in Chisinau have been destroyed and others are in ruins or in an advanced state of decay [2]. Since the early 1990s, architectural monuments have been destroyed to be replaced by hotels, shopping centres and residential buildings.

The purpose of this work is to highlight the limestone elements that can be used to restore the exterior walls of historic buildings.

In this article the author examines the diversity of limestone elements that can be used in the rehabilitation of historic building facades. The technical characteristics of the architectural elements and the technologies for the rehabilitation of facades of historical buildings in Chisinau are examined.

The authors use a variety of research methods such as historical methods, analysis, and synthesis to make it possible to highlight the historical building elements restored with limestone; inspection and technical evaluation make it possible to determine the restoration project to be carried out; comparative analysis can choose the most appropriate method. To repair the building under study.

2. The diversity of limestone elements for the rehabilitation of historic building facades

The historical buildings in Chisinau in 18th-20th centuries were built in an eclectic style with rococo elements.

The majority of the facades of the historical buildings were clad with natural stone and limestone elements. Over the years, the facades become deplorable for several reasons.

New trends in the rehabilitation of historical facades by replacing stone elements with decorative polystyrene elements lead to the loss of the architectural and historical value of the building.

The Republic of Moldova has sufficient resources of limestone, which allows the rehabilitation of historical buildings with original elements. The buildings rehabilitation with limestone elements allows to preserve not only their shape but also their unique architectural value.

From an architectural point of view, various elements shown in Figure 1 can be rehabilitated using limestone.

Figure 1. Limestone elements for façade.

Figure 1 shows the basic limestone elements of a facade, which can be custom-made depending on the architectural style of the historical building.

The natural stone *columns* are based on limestone, which is extracted from mines from the Republic of Moldova on demand. Their properties are unique, so no artificial material can be compared to a natural and environmentally friendly product.

In construction, the limestone used for making columns is of the brand M50 or M75. In the mines of the Republic of Moldova limestone is of 2 types: oolite and of shell. For the precise shape of the columns, oolitic limestone should be used, as it is more compact than the shell limestone.

The limestone columns have a seismic resistance up to 8 degrees on the Richter scale. The density of the columns can reach 1900 kg/m^3. High durability and wear resistance are some of the advantages of using natural elements in reconstruction. The limestone does not destroy as quickly as concrete and is less affected by moisture and temperature changes.

Decorative stone columns serve as load-bearing columns in a building. For example: they support the roof, or the platform of the veranda, the balcony. The use of this material guarantees the durability and safety of the construction.

There are stone facade columns of various shapes shown in Figure 2 - rectangular and cylindrical constructions, including difficult passageways, various decorative elements, balustrades, keystones and consoles.

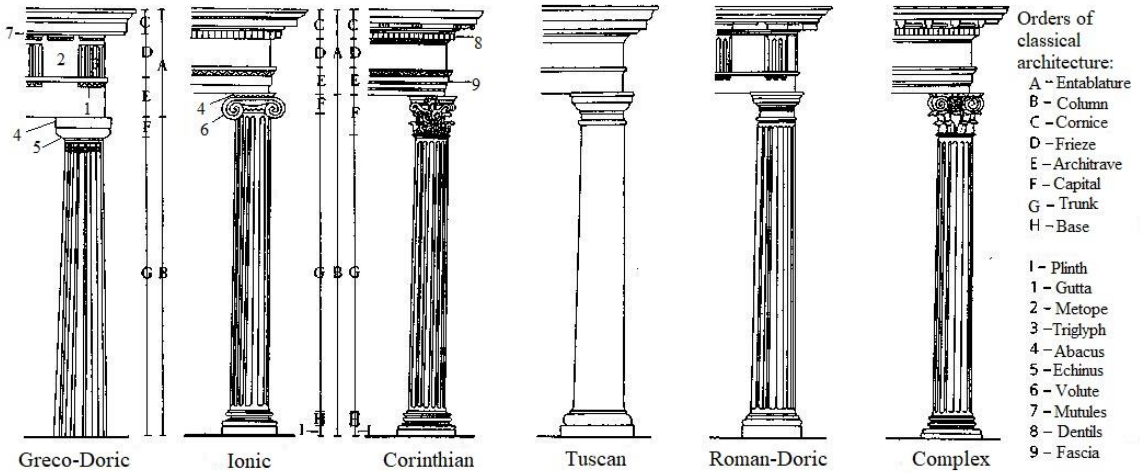

Figure 2. Types of columns and its elements.

The manufacture of limestone *cornices* requires complex production technologies, skills, time, and professional high-precision tools.

The limestone used for the cornices can be of the M25 and M35 marks. This type of limestone has a lower strength compared to the M50 and M75. The compressive resistance of limestone blocks ranges from 0.4 MPa to 300 MPa.

Depending on the size of the desired cornices, limestone blocks are extracted from the Cricova mines to be handed over to the craftsmen, who process the stone, cut out everything superfluous, creating new shapes. The advantages of limestone cornices are as follows:

- Sustainability;
- Longevity;
- Resistance to temperature changes;
- Moisture resistance;
- Ability to create shapes of any difficulty;
- Possibility to create articles of various proportions;
- Choice of colours, shade of material, from which the stone cornices for the building facade should be produced.

Carved stone *consoles* are a special type of decorative construction, which are used for the ornamentation of facade elements such as windows, balconies, doorways and cover plates. The application of consoles is actual in the decoration of buildings of various styles, starting from classical and ending with the "empire" and "baroque" styles. Due to its variety of sizes and oases, limestone consoles can be used for the reconstruction of buildings of historical interest.

In Chisinau, facade consoles can be seen not only on old buildings in classical style, but also on most modern buildings.

Facade consoles have a wide range of other advantages such as:

- High durability and temperature resistance indicators;
- Ability to use a unique style when implementing the design;
- Speed of making stone consoles;
- Simple installation, thanks to which installation costs are significantly reduced;
- Possibility to make the facade look unique;
- Preservation of the full external appearance throughout the entire service life.

Because natural stone is an expensive material, many similar products have appeared on the local market, such as expanded polystyrene, fibre-glass reinforced concrete and artificial stone - all these materials are cheaper, but the high quality of natural stone items allows them to be used for a longer period of time and to serve as a formidable ornament for the entire period of use of the building.
The natural stone *panel* presents a unique decorative element, which is made of limestone and is used to decorate facades. The use of stone elements in the creation of the facades highlights the style of the 18th-20th centuries of buildings, as well as gives the building originality. So natural stone items have a wide range of use.

In most cases, stone panels are made of materials such as limestone, granite, marble, travertine or onyx. The combination of the given stones can bring refinement to any building.

Natural stone panels in Moldova are becoming more and more popular due to the fact that this material has many positive properties, which ensure its distinction from artificial similarities. Among the distinguishing features are:

- Long term of exploitation;
- Minimum care requirements;
- Can be shaped into a wide range of forms and styles;
- If necessary, it can be advantageously combined with other materials;
- The stone is environmentally friendly and doesn't present any danger.

Natural stone is a very durable material, so the panel will last a long time.

The limestone *keystone* from Moldovan mines has a high resistance and a long period of exploitation, it is not vulnerable to low temperatures, high temperatures, snow and rain. Therefore, such an item will serve for a long time. The limestone used to make the keystone resists without signs of damage to a minimum of 6 cycles of freezing at -15° and thawing at +15±5 °C.

High durability is one of the basic factors when choosing raw materials. The keystone for facade vaulting is the supporting detail for arch constructions, passages, cupolas. It is installed during cladding at the end. In most cases it has a pointed shape, which allows the article to be integrated into any construction and fixed with an adhesive.

Natural stone facade anchors in Moldova are used to decorate windows, facing the same direction of the building as the entrance group. The facade is the face of any building and its appearance influences the perception as a whole. If on the outside natural raw material is used for columns, balustrades and other details, then it is reasonable to use window frames and facade anchors made of natural stone to get unique compositions.

The metal or plastic does not have the necessary properties and qualities. Metal over time gets covered with rust deposits, and other materials, such as mould and moss. The resistance of plastic to low temperatures decreases with each passing year. Continuous stretching and compression gradually lead to the destruction of the anchorage, and moisture completes this process.
Stone window anchors can serve decades and even centuries. An example are historic buildings that require rebuilding after centuries, but the resistance to external factors is impressive compared to the longevity of the building. Many of the buildings are still built in the 18th century, but the anchorages have been preserved to the present day.

Instead of repairing and restoring facade every year the elements that have been deteriorating over time, it is safer to use durable and qualitative materials. Natural stone window frames and other items are better than most similar products. It is a beautiful, durable, and environmentally friendly material.
Natural stone *railings* are used for both interior and exterior works. They are used on staircases, balconies, verandas, or to create large decorative elements. On balconies these elements serve as support structures for the balustrade, and on stairs - for the staircase balustrade. In the first case they can be combined with small columns. If limestone balustrades are used in compositions, then railings become component parts of the construction.

Figure 3 shows the types of railings that can be made from limestone.

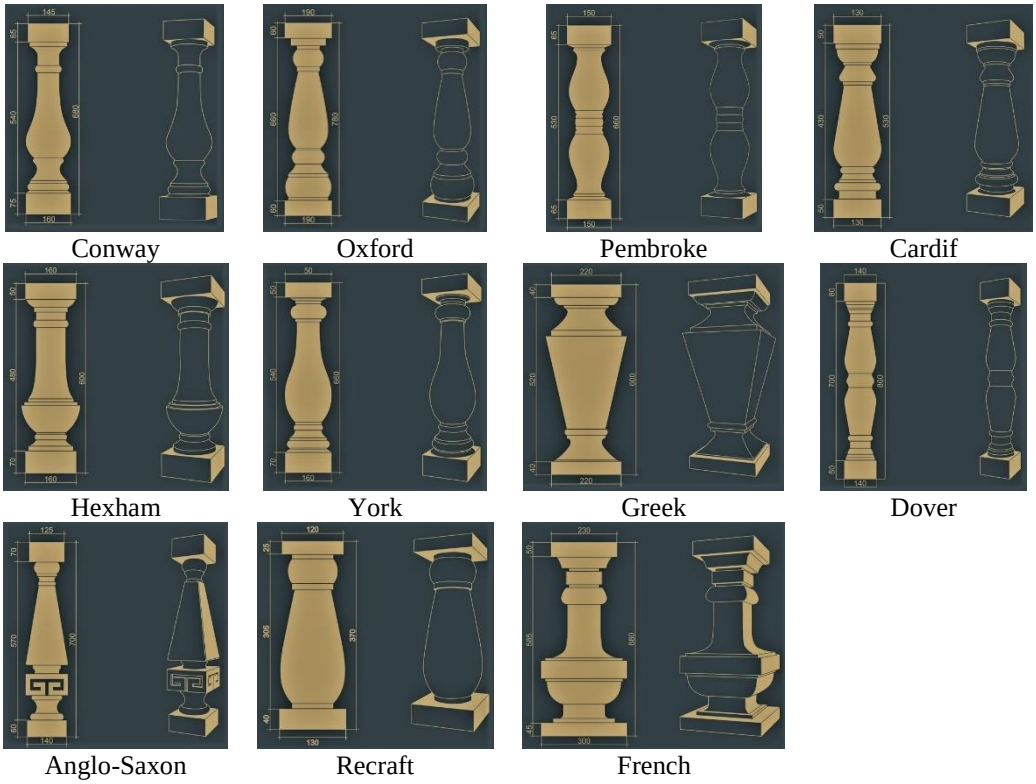

Figure 3. Types of natural stone railings.

The shape of the railings, its size and other parameters are determined individually for each case. The limestone balusters have the following advantages:

- Undeniable aesthetics;
- Long life span;
- Resistance to high humidity;
- Resistance to high/low temperatures and sudden temperature changes.

The decorative element, such as the stone *balustrade*, consists of several component parts: balusters and their supports, stringers, parapet, pillars, spheres, and other elements, which embellish the construction.

Natural raw materials like sandstone, limestone, travertine, and others are used to make balustrades (except those cast from reinforced concrete). They differ in density, processing methods, structure, and other parameters.

The profile is the standard element, representing a plate of well-defined sizes and shapes. However, in most cases the stone facade band can be decorated with ornaments or carvings.

The advantages of a stone panel over similar products made of other materials are:

- Resistance to heat and cold;
- Resistance to atmospheric precipitation;
- Wind resistance;
- Direct sunlight resistance.

Wood, plastic, metal, etc. also have some advantages, but they do not always achieve the desired operating characteristics. Simplicity of processing, the possibility of creating beautiful natural stone articles with difficult shapes, durability, strength is just some of major advantages.

Various types of limestone can also be used as raw material and such an amazing stone as travertine, which is also called Tibur stone or limestone tuff.

Natural stone cladding is a durable material to serve as a stunning decorative element over a long period of time and is an excellent material for the rehabilitation of historic buildings. The facades of

natural stone cladding have many advantages, thanks to which they have become popular since the 16th-17th centuries. Among their characteristics are:

- Maintaining the original exterior appearance regardless of weather conditions;
- In high humidity conditions decorative stone for facade collects moisture;
- The material is not vulnerable to the sun's rays;
- The load-bearing structures of the house are not subject to additional weight;
- The stone combines beautifully with other elements of interior and exterior decoration;
- Total resistance against harmful mechanical action.

Decorative stone in Moldova is widely used to finish residential houses, villas, as well as hotels, sanatoriums and tourist complexes, so it is no less important than building stone. Also, the reconstruction of historical monuments and facades, using decorative limestone helps to preserve the historical-architectural appearance of buildings.

The modern market for cladding materials offers consumers, in addition to natural stone and artificial cladding stone, 2 other types:

- limestone cladding, involving the use of limestone;
- cotilet classing, involving the use of cotilet stone;

The rehabilitation of historical buildings in Chisinau is carried out with the help of modern materials, which do not have a long resistance to climatic factors. The author proposes the use of natural stone and limestone elements, which provide resistance to the facade and ensure the preservation of the authentic historical-architectural appearance of the buildings.

3. Rehabilitation of the facades of historical buildings in Chisinau, 18th-20th century

Over the last 30 years, the cultural-historical heritage of the Republic of Moldova has been in a state of continuous degradation. In the period 2003-2006, 977 monuments with the status of protected monument of national and local category were identified in Chisinau and registered in the Register of Monuments of the Republic of Moldova [3]. Already in 2010 it was found that more than 25% of them are either destroyed or in active process of destruction. In Chisinau, 82 monuments have been demolished, of which 44 were demolished between 1993 and 2006 and 38 between 2006 and 2012. 160 of these monuments have undergone illegal interventions. The total number of buildings that have suffered due to non-compliance with the legislation on the protection of monuments is 254 monuments with the status of protected monument of national and local category. And this figure continues to rise, primarily due to existing corruption and non-compliance with legal provisions [1].

The research identified a building of historical value, which requires a complete rehabilitation of the facade.

The following steps should be taken into account before starting to rehabilitate the facades of historic buildings:

1. Identification and/or classification of existing materials;
2. Assessment of existing facade systems, including drainage systems, insulation, vapour barriers and structural supports;
3. Thorough inspection of all items, documenting all signs of damage and defects;
4. Investigation of deterioration of materials by field and laboratory test methods;
5. Identification of potentially hazardous and/or unsafe conditions [4].

Damage to the facades of historical buildings is caused by weathering, invasive plant growth, pollution, and the accumulation of dirt. Other damage can occur through erosion as a result of stone movement, defective or broken anchors and even human error in design, engineering or construction.

Restoration of historical buildings facades can be achieved by the following methods:

- Restoration by stitching involves fixing cracks in the facade and this method can be of 2 types:
  - Mechanical stitching is performed using steel beams;
  - Chemical stitching involves injecting chemical adhesives into cracks.

- Restoration by injection;
- Restoration through reconstruction involves partial or total replacement of architectural elements of the historical building facade;
- Restoration by disassembly and reassembly;
- Restoration by reinforcement with support;
- Restoration by rebalancing trends;
- Restoration through trend stabilisation;
- Restoration by completion involves adding missing elements;
- Restoration by replacement;
- Restoration by casting;
- Restoration by cleaning;
- Restoration by hardening using iron bonds [5].

The historical monument under analysis is the *House of Report with rooms for social functions* on 148 Stefan cel Mare Boulevard, corner with M. G. Bănulescu-Bodoni Street.
In the 1930s Ivan and Annastasia Monastârsky built 2 two-storey houses next to each other in the neighbourhood bordered by Stefan cel Mare Boulevard and Mitropolit Gavriil Bănulescu Bodoni Street. In the 60s of the 19th centuries, these buildings were rebuilt and integrated into one, for the location of Theological Seminary. After 1870 the building was rented by various educational institutions. In 1874 a lease was concluded with Charl Sailladeni, a citizen of Switzerland, who rebuilt it for the hotel "Suisse". During the Second World War the building was damaged and rebuilt in the late 1940s according to the E.R. project. Spirer, who benefited from the consultations of the academician A.V. Shchusev, with the raising of the attic floor. The building occupies the side of a narrow block, has a square plan with facades aligned with the red lines of the side streets, shown in Figure 4. The facades have symmetrical compositions, with side elevations, superimposed by porticos with four columns of the Ionic order, supporting triangular pediments [6].

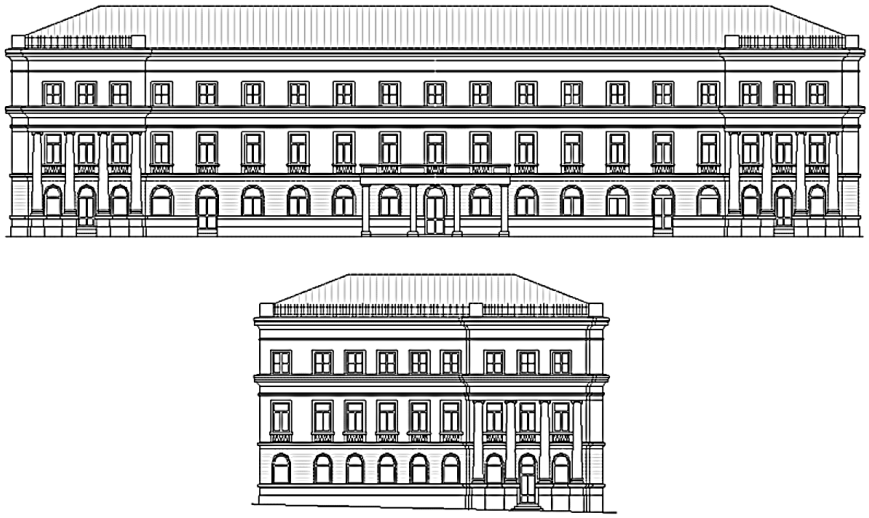

Figure 4. Sketch of the facade of the historical monument on 148 Stefan cel Mare Boulevard, Chisinau, Republic of Moldova [6].

The building has undergone a number of restorations over the years, the last restoration being of the clean-up type. At present the condition of the facade is in a less than satisfactory state, shown in Figure 5. For the restoration of the façade, the method of restoration by reconstruction should be used, with architectural elements made of natural stone, namely limestone.

Figure 5. Facade of the historical monument on 148 Stefan cel Mare Boulevard, Chisinau, Republic of Moldova, 2021.

Before starting the restoration and proposing effective solutions, an on-site inspection of the facade was carried out and is shown in Figure 6.

Figure 6. Inspected facade of the historical monument at 148 Stefan cel Mare Boulevard, Chisinau, Republic of Moldova, 2021.

The main purpose of the reconstruction is to restore the building's architectural-historical exterior appearance, its technical and economic qualities. The main objective is to improve the operational comfort of the building.

During reconstruction, only the load-bearing elements of the building are preserved: solid walls, ceilings, stairs, and platforms. All others should be replaced in whole or in part. The following works are planned here:

- radical reorganisation of the structure of the object, including changes to the technical characteristics and overall dimensions of the structure;
- changing the function of the premises;
- complete re-equipment of utilities;
- reinforcement of load-bearing structures;
- additional measures to improve attics, basements, roofs, exterior finishes.

Before reconstruction begins, a project is drawn up taking into account the technical condition of the object, operational deficiencies and defects detected.

The following steps shall be taken to rehabilitate the facade of the historical monument at 148 Stefan cel Mare Boulevard:

1. Removal of old plaster;
2. Removal of destroyed items such as:
    a. Cornice;
    b. Railings;
    c. Console;
    d. Anchor;
    e. Columns.
3. Prime the walls;
4. Apply plaster over the mesh;
5. Priming walls over plaster;
6. Mounting the decorative limestone elements using adhesive.

The basic technology for applying stone and decorative limestone elements is shown in Figure 7.

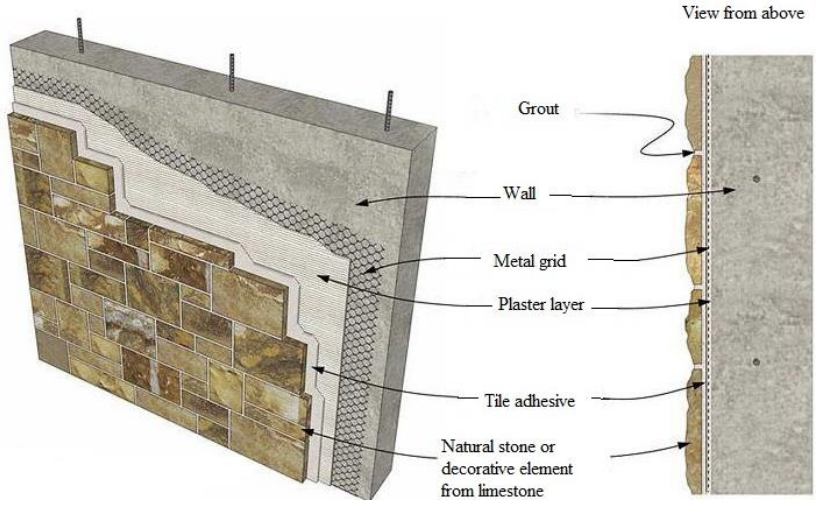

Figure 7. Technology for mounting natural decorative limestone elements on building facades.

Following the full analysis of the facade of the historical building on 148 Stefan cel Mare Boulevard, it was decided to respect the architectural appearance by applying decorative limestone elements described in section 2 and plastering the walls with decorative limestone-based plaster. Figure 8 shows the changes to be applied to the building facade.

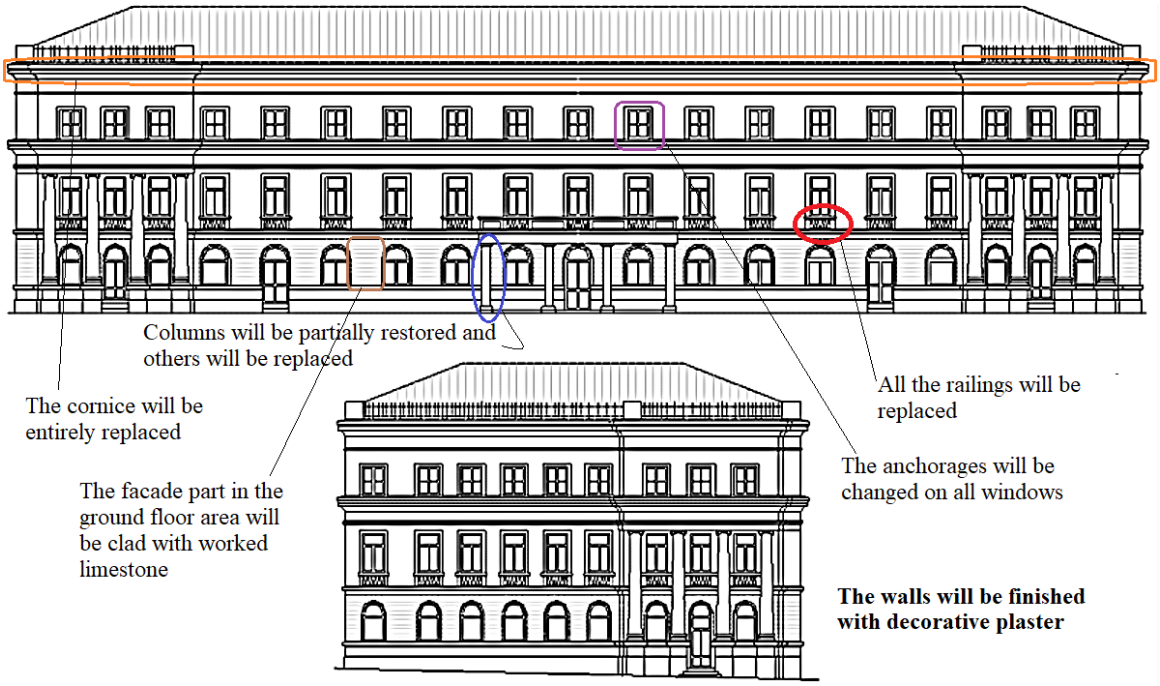

Figure 8. Sketch of the changes that should be made in the restoration of the façade.

Through the example shown above, it was intended to draw attention to the advantages of using limestone elements for the restoration of facades of historical monuments in Chisinau and the use of local materials.

4. Conclusions

In the conclusions we will point out the advantages of decorative limestone elements and the rehabilitation of historic building facades:

One of the main advantages is that limestone elements are natural and environmentally friendly. Other advantages of natural stone elements are frost resistance, of 50 freeze-thaw cycles, and wide range of density, from 800 (shell rock) to 2800 kg/m^3 (crystalline). Crystalline limestone is recommended for facade cladding.

Natural stone has low hardness according to Mohs scale - 3. The material is easy to work, can be cut and carved to form decorative elements in architectural styles from different centuries.

Due to its porous structure, limestone has a low thermal conductivity. The average coefficient is 0.5-0.9 W/m deg, which is comparable to silicate bricks and hollow bricks.

Although deterioration of limescale is inevitable over time, there are ways to slow down the process and prevent severe damages. Routine maintenance and inspections can reveal surface deterioration, displacement, and joint failure, which can indicate more serious underlying conditions. Early detection and prompt, careful attention is essential. Adherence to maintenance of limestone elements leads to longevity of the elements.

The opportunity of preserving the architecture of the facades of the historical heritage of Chisinau should be examined through the prism of facade restoration using decorative elements made of natural stone such as limestone. In our opinion, limestone elements will preserve the architectural authenticity of the buildings for many years compared to decorative elements made of other materials.

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Acknowledgments
The research was carried out within the project 20.80009.0807.34 Increasing the value of architectural heritage of the Republic of Moldova.