Architectural possibilities of using PVC window units in historical buildings

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Abstract. The work presents the possibilities of using PVC window units in the historical buildings. There are reasons of their widespread use in projects of adaptation of historical buildings for modern use. The analysis of possible replacement options of window units of the historical heritage is done according to their architectural and historical values of the exterior and the interior. A review is made of the existing technological capabilities of modern PVC window systems used in the historical buildings. Examples of application of PVC window units in historical buildings of various architectural styles are given. Examples of structural solutions of window units and stained glass windows made of PVC in historical heritage are considered. The analysis of perspective ways of the use of modern types of translucent fillings in historical buildings can significantly improve the energy performance of these buildings and provide them with conditions that meet the modern requirements of comfort and safety.

1 Introduction

Currently, the problem of historical buildings and architectural monuments preservation is very actual. Many of them are owned by the state, and are in poor or emergency technical condition (because of inadequate sufficient funding for maintenance and operation). One of the most convenient and economically justified preservation of historical buildings preservation mechanisms (for the state) is the transfer to private persons rent at a significantly reduced rate (compared to the market average), provided the restoration work and subsequent maintenance of the object in the proper form. The most optimal restoration option for potential investors is the historical buildings adaptation to modern use (see fig. 1) [1]. This process implies the preservation / reconstruction of the most valuable from the historical point of view building elements (for example, elements of the facade or the interior of the building), and also the provision of modern requirements for comfort, safety, operation and maintenance simplicity. It is observed most clearly in the process of the old window unit replacement on the modern window units.

The old window unit design solutions of historical buildings don't satisfy often modern requirements. In this time the modern windows have to perform next requirements [2-5]:
- thermal protection of buildings and temperature-humidity conditions in winter and summer;

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- acoustic microclimate, the minimum air pollution in the rooms oriented to roads;
- premises protection against break-in;
- structures tightness (air-, water permeability), resistance to wind loads;
- ergonomics, periodic maintenance convenience.

It is obvious that the most economically and technically justified way to ensure these requirements is the old window units replace on modern. At the same time, this problem requires detailed consideration from the standpoint of the architectural appearance preservation of each individual historical building.

Fig. 1. The example of the historical building reconstruction project
a – the building facade before reconstruction. b – the building facade project.

2 Architectural and technical requirements for the window unit replacement

The possibility of the window units replacing of the historical buildings is depend on their historical and architectural value. All historical buildings are divided into two categories:
- buildings without architectural and historical value. Most of historical buildings is included to this category.
- cultural heritage objects (monuments of history and culture). They are representing special value from the point of view of history, archeology, architecture, urban planning or art.

There are no special requirements to the architectural and constructive solution of the replaced window blocks in the buildings without special architectural and historical value. At the same time, the architectural pattern and the color solution of the profiles have to correspond to the replaced window units and the architectural style of the building.

The design, the profile material and the translucent filling type of new window units of cultural heritage object should correspond to the subject of protection. It is indicated in the security obligation or developed as part of the restoration project [6]. In this instance the main architectural parameters of the window units (architectural pattern, texture, color) and also the characteristic features of the architectural style corresponding to the place and time of building construction are taken into consideration. Simultaneously, the requirements of the current standards for windows and building microclimate parameters (with the considering functional building purpose after the reconstruction (for example, administrative, residential, shop, Museum, etc.)) are taken into consideration.

Usually, the typical old window unit solution in historical buildings is the separate window unit design with the outer and inner sashes with glass. In the case of windows replacement in cultural heritage objects the new window unit should consist of two separately manufactured window units – a window unit with single glass and a window unit with

insulating glass unit. In this case, the window unit with single glass ensures architectural requirements of the security obligation and is installed:
- from the building outside, if the building facade is the subject of protection (see fig. 2 a);
- from the building inside, if the protection object is the building interior (see fig. 2b).

The old window unit design is made in this case on the basis of measurement old window unit drawings with the materials specified in the security obligation. If the subject of protection is the interior of the building, window units should comprise also hardware elements (handles, hinges, etc.), corresponded to the historical building style.

The window units with insulating glass units ensures protecting functions of the room by external influences (thermal protection, sound insulation, protection from hacking, etc.). Its design solution should correspond to the functional building purpose after the reconstruction. At the same time, the color and texture of external window surfaces should correspond to the color building facades solution.

In historical buildings without special architectural value and also in cultural heritage objects (where the constructive window unit decision isn't regulated by the security obligation) old window unit replacement is possible full (see figure 2c).

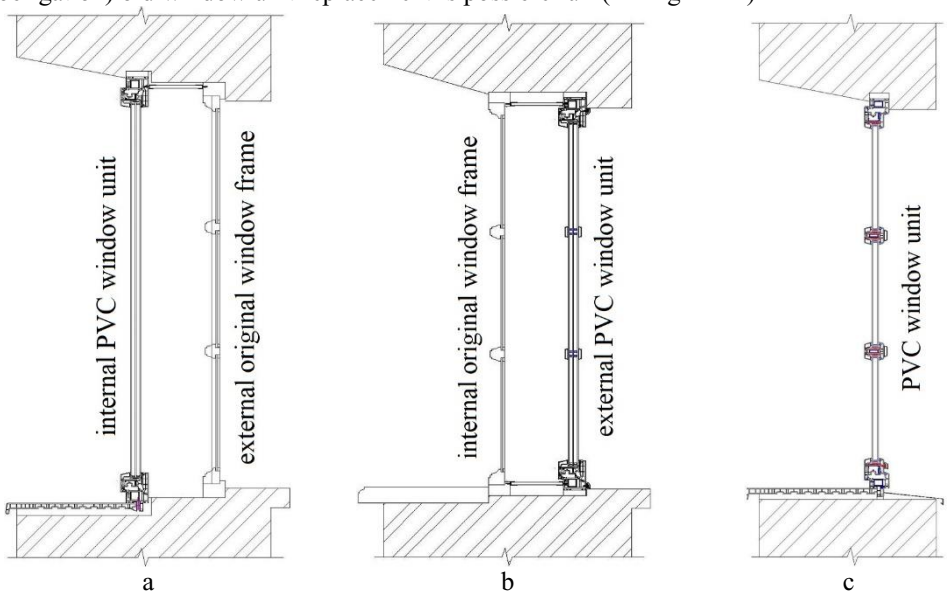

Fig. 2. Principal schemes of the window unit replacement in historical buildings
a - for cultural heritage objects (protection object is building facade).
b - for cultural heritage objects (protection object is building interior);
c - for cultural heritage objects (if the window units aren't protected) and historical buildings without special architectural and historical value.

3 Architectural possibilities of PVC windows system in historical buildings

Currently, PVC window units are the most common type of window used in historical buildings. This is primarily due to their lower cost compared to the modern wooden window units with similar characteristics. Using modern PVC window systems makes it possible to produce window units with similar exterior appearance as the replaced windows. This applies to both the general design of the window units (see figure 3a), color, surface texture and

geometry of its core elements (see figure 3b), and their architectural pattern and decorative elements (see fig. 3c).

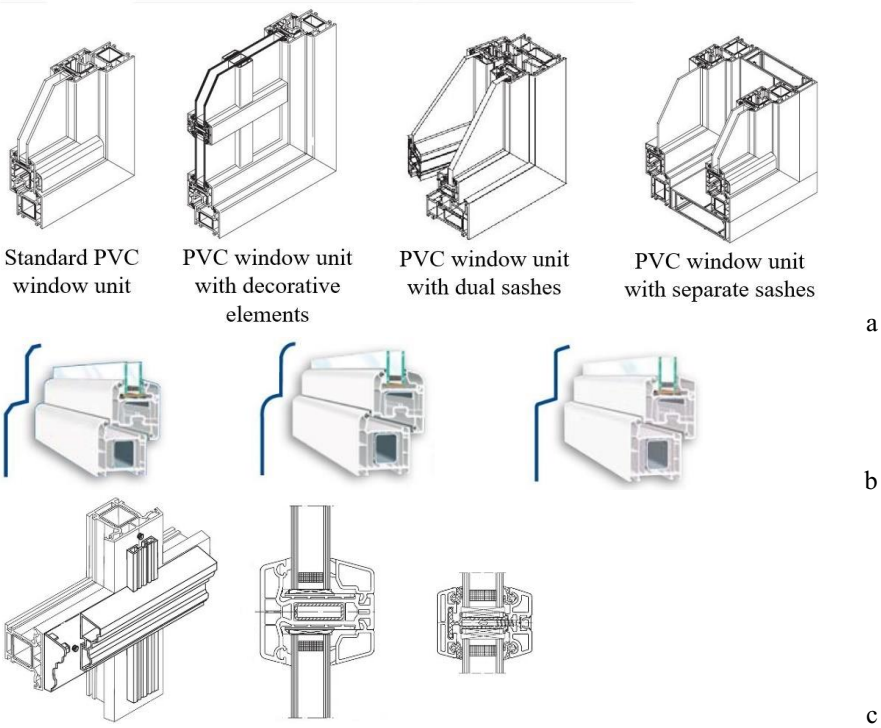

Fig. 3. Technological capabilities of modern PVC window systems for use in historical buildings
a - possible constructive solutions of window units;
b - some of the possible geometric shapes of profile elements;
c - the possibility of applying decorative profiles to create an architectural window unit design

Special restoration frame profiles have been designed in the developed PVC window systems which can be used to install new window units on top of old window frames without their dismantling (see fig. 4).

The technological capabilities of modern PVC window systems allow to manufacture window units of almost any geometric shape, which makes it possible to be used in historical buildings of almost any architectural style (see fig. 5).

Due to the use of special facade connectors made of PVC profiles it is possible to produce not only window units, but also large-size showcases and stained-glass windows (see figure 6).

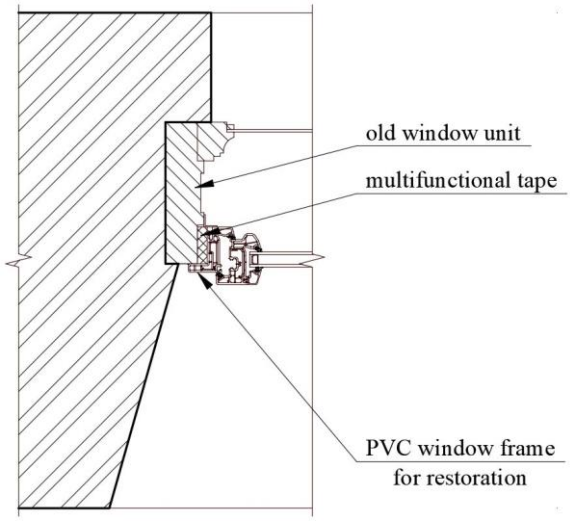

Fig. 4. An example of the use of PVC restoration window frame with partial replacement of window unit in historical building.

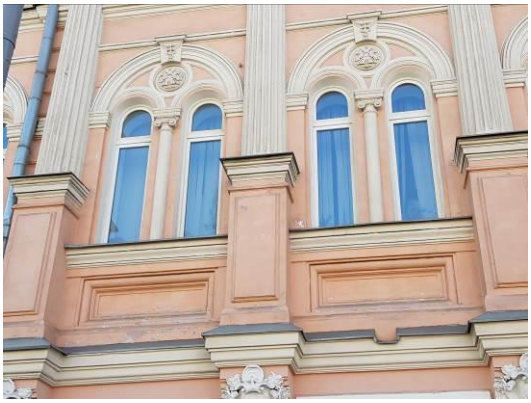

Fig. 5. Examples of using PVC window units in historical buildings of different architectural styles.

Fig. 6. An example of applying large-size PVC glazing in historical buildings.

4 Analysis of results

The analysis shows that the possibility of using modern PVC window units in historical buildings depends, primarily, on the architectural and historical value of the object. The appearance and design of the window units of cultural heritage objects depends on whether they are the subject to the protection of the object. In historical buildings without special architectural and historical value, the design of window units is determined mainly by the requirements of the current standards for windows and microclimate parameters according to the functional purpose of the building after reconstruction. Analysis of the technological capabilities of modern PVC window systems showed that PVC window frames can be used in buildings of almost any architectural style.

5 Discussion

The study considered only the most common practice in the construction solutions of PVC window units. At the same time, promising in terms of energy efficiency advance in historical buildings is the use of new types of glass - vacuum insulating glass units [7-11]. Due to the fact that they have a smaller thickness (8.5 mm) compared to standard insulating glass units (minimum 14-16 mm), they can be used instead of common glass in old window units after the milling of window glass holder.
The following technical issues of design and operation also require detailed study [12-28]:
- providing thermal protection of buildings when replacing window units in historical buildings during winter operation which was caused by a change in the thermal conditions of the junction of window units to the exterior walls.
- thermo-technical characteristics of combined window units of historical buildings ("PVC window unit + old wooden window unit" system), problems of overheating of the inter-glass space of this system in summer;
- economic efficiency and technical feasibility of using modern designs of windows in historical buildings.

5 Conclusions

In historical buildings without special architectural and historical value, as well as in cultural heritage objects (if the security obligation does not define special requirements for the appearance and design of the window blocks), it is possible to use modern PVC window units. Technological capabilities of the advanced PVC window systems allow window units to be used historical buildings of almost any architectural style. The use of modern PVC window units requires a detailed study for each individual historical building separately, both from the point of maximum preservation of the original architectural appearance, so ensuring proper subsequent operation of the reconstructed object.

References

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