Light & Engineering
Vol. 27, No. 3, pp. 26–31, 2019 *https://doi.org/10.33383/2018 - 076*

INSPECTION OF THE STATE (GENERAL AND INSTRUMENTAL) OF HISTORICAL TRANSLUCENT STRUCTURES OF THE PUSHKIN STATE MUSEUM OF FINE ARTS

Alexander V. Spiridonov and Nina P. Umnyakova

Research Institute of Building Physics of Russian Academy of Architecture and Construction Sciences, Moscow
E-mail: spiridonov@aprok.org

ABSTRACT

The article is focused on the general and instrumental survey of historical translucent structures in the Pushkin State Museum of Fine Arts in 2018. It is shown that they don't complying with the current requirements, neither in heat transfer resistance nor in air permeability. The improvement recommendations have been developed. It is noted that in case of preservation of metal window frames (according to the requirements of the law on protection of cultural heritage sites) the large-scale computer calculations should be performed to determine the best ways of window restoration.

Keywords: restoration, historical translucent construction, frame, sash, survey, testing, heat transfer resistance, air permeability, condensate, recommendations

In 1990–2000, many people lamented, seeing the destruction of entire quarters of old buildings in many large and small Russian cities. Often the sites "necessary" for new construction were simply burned out. In their place the elite housing, huge shopping and entertainment malls, office centres appeared, and the spirit of the old cities was lost. For example, the charming cosy places of Zamoskvorechye in Moscow, two-three-storey buildings with amazing balconies in Kazan (when preparing for its millennium anniversary) and many others disappeared. (By the way, many cast iron balconies appeared later (some say) in the dachas of rich Tatarstan officials.)

Fortunately, the situation has changed dramatically – today there is just a boom of construction restoration. In Moscow alone, more than 300 old buildings were renovated in 2017. Externally, they look beautiful, according to ancient drawings and photographs, and inside the amazing halls are furbished up.

Unfortunately, very often on the renovated facades "false teeth" can be found – plastic windows (mostly white), which in no way fit into the beauty of buildings of the 18th – early 20th centuries: because then there were no window structures made of PVC profiles.

This is due to the fact that one of the requirements for modern reconstruction (in addition to restoring the old facade) is to increase the energy efficiency of old buildings to current indications. And it is very difficult to do this with old windows for several reasons:

– Modern window technologies provide very high indicators of thermal and luminous efficacy of structures, which even at the beginning of the 20th century, the engineers and the architects could not dream of;

– All technologies of old windows production are lost – to replace the rotten and lost parts often needs to "reinvent the wheel";

– Full restoration of historical translucent structures with bringing their characteristics to the mod-

ern level will be much more expensive than the windows, which domestic builders used to install in typical modern buildings.

That is why there are many restored old buildings with white PVC windows in almost all cities (for some reason most of all in St. Petersburg [1]), which should not be. By the way, it is in St. Petersburg very often at night the old windows and stained-glass doors are stolen (so that there is nothing to compare with, probably).

It is difficult to find interesting domestic publications on the restoration of historical translucent structures (on the Internet for such a request you get a lot of proposals not for reconstruction, but for replacement of windows). The authors were able to find only one such article [2]. At the same time, our colleagues abroad understand the importance of preserving the historical heritage. In particular, *Historical Windows of New York, Inc.*, is successfully functioning in the not so old New York.

Probably, it is necessary to establish the supervision over the restoration of translucent structures in complex works on old buildings and to change the price approach to these works – the quality restoration of windows cannot be cheap.

The authors had the opportunity to participate in the survey of historical translucent structures of the major building of the Pushkin State Museum of Fine Arts in the first half of 2018, and to develop recommendations for their improvement.

The works were carried out as part of the restoration works for this site under the general name "Complex reconstruction, restoration and adaptation to modern museum technologies of the major building of the Pushkin State Museum of Fine Arts (Moscow, Volkhonka Str., Bld. 12)" [3].

The museum was built on the initiative of Ivan V. Tsvetaev by architect Roman I. Klein. Most of the funds for its construction were donated by the Russian philanthropist Yuri S. Nechaev-Maltsov.

The Museum of Fine Arts named after Emperor Alexander III (so it was called before the Revolution) was opened in a solemn ceremony on May 31 (June 13), 1912 (Fig. 1).

Today, after the transfer to the Museum of many unique collections (including famous collectors, Moscow Old Believers merchants Sergey I. Shchukin and Ivan A. Morozov), it is the largest collection of foreign art in the Russian Federation.

The major building of the Museum is recognized as a cultural heritage site of federal importance and is subject to the state protection.

Many engineering structures have not been repaired since the building was put into operation (that is, more than 100 years), have become relatively unusable and, mainly, do not comply with the requirements of current construction regulations.

Due to the fact that a decision was made to establish Volkhonka Street and the adjacent streets of the Museum Quarter, the nearby buildings were handed over to the Pushkin State Museum of Fine Arts, where, like in the major building, large-scale reconstruction is being performed.

The goals of our work were to survey the existing historic windows on the first floor in order to identify the possible causes of condensate formation and to develop anti-condensation recommendations and a set of measures to modernize existing windows.

In the light openings of the first floor of the major building there are windows with steel sashes

Fig. 1. The Museum of Fine Arts named after Emperor Alexander III before opening in 1912

Fig. 2. Historical windows in the major building of the Pushkin State Museum of Fine Arts:
a – view from the outside, *b* – metal bonding ("ladder") between external and internal sashes

Fig. 3. Condensate formation on the inner surface of translucent cladding

made at the beginning of the last century (Fig. 2). They are external and internal massive steel sashes with a single glass thickness of 6 mm, spaced by 0.5 m. Most of the translucent first floor structures installed around the perimeter of the building have the dimensions of about 1560 (width) × 3740 (height) mm.

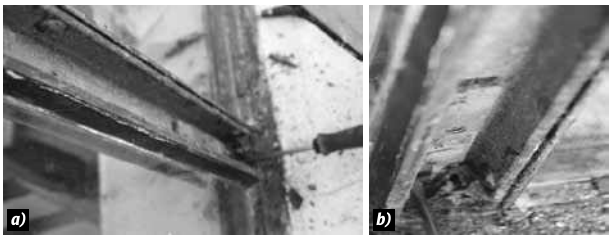

Fig. 4. Corrosion effect on one of the imposts of the inner frame (*a*) and the main (vertical) mullion of the inner frame (*b*)

Historical windows installed in the major building of the Pushkin Museum of Fine Arts as well as most other its structures are the cultural heritage sites and their replacement is impossible under the protection terms.

The surveys were conducted several times in different periods of the year – from February to June 2018. When conducting a visual examination on February 26, at the external air temperature $t_e = -15$ °C, the internal air temperature $t_i = +20$ °C and the relative humidity of the internal air (52–63)%. In almost all rooms on the inner surface of all windows, there was abundant condensation from top to bottom, flowing down to the window sill and even to the floor (Fig. 3).

The condensate on the interior surfaces of translucent structures is absolutely unacceptable in the premises where the works of art are exhibited. In addition, moisture on the windows and slopes contributes to the appearance of mildew and fungi on the inner slopes of windows, which is also not useful for paintings – they can also be infected.

The survey of historical translucent structures revealed the following (Figs. 4 and 5):

– Structures are made of iron, repainted multiple times, but never (judging by their condition) treated with special anti-corrosion compositions;

Fig. 5. Elements of historical translucent structures

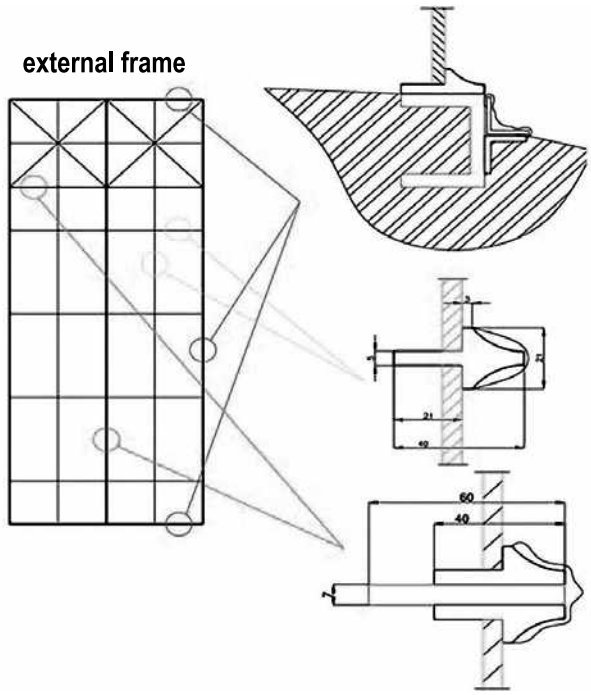

Fig. 6. Dimensions of external frame parts of historical translucent structure

– External and internal frames are made of sufficiently material-intensive corner iron, U-bars, T-bars, I-beams and shaped profiles;

– Ordinary transparent glass with a thickness of 6 mm is installed on external and internal frames;

– Translucent structures are installed in light openings without thermal insulation layers;

– The basic vertical imposts of window structures are very massive, and there are very strong corrosion processes inside;

– Under the blind casing on the internal frame structures, which are made with the use of sufficiently massive corner iron, the extensive corrosion damage is detected (probably the inner angle elements are to be replaced – they are almost decayed);

– In order to provide natural ventilation of exhibition premises in the early last century in translucent structures the ventilation windows were provided, which – in addition to exclusively original fittings – today (with the equipped air conditioning systems in the near future) are completely useless and even harmful.

According to the results of field surveys of historical translucent windows, their basic general dimensions and dimensions of structural details were obtained (in Fig. 6 the elements of the external frame are shown).

As a result of numerous field surveys of historical windows of the first floor of the major building of the Pushkin Museum of Fine Arts, it became clear that it is necessary to carry out additional instrumental surveys and calculations for development of reasonable recommendations for restoration of historical translucent structures[1].

Detailed measurements of historical windows (Fig. 6) will be extremely useful for restoration works.

The NIISPh of RAACS (Russian Academy of Architecture and Construction Sciences) proposed to conduct a field survey of the existing structure in one of the premises of the Pushkin State Museum of Fine Arts at sub-zero t_e (which was carried out on 26.02.2018 at t_e = – 15ºC), and the evaluation of numerous possibilities of reconstruction of historical translucent structures by means of computer modelling.

In order to determine thermally homogeneous areas of the examined translucent cladding and to detect infiltration areas, a field survey was conducted using thermal imaging filming by the *NEC TH-910*

[1] They are in a terrible condition: Rust (almost on all structures), slits, inoperable fittings, etc.

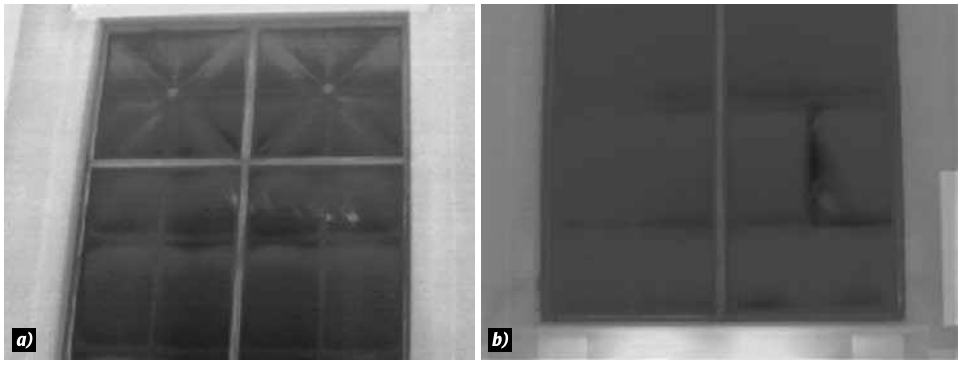

Fig. 7. Thermograms of upper (*a*) and lower (*b*) parts of unshadowed historical translucent structure at t_e = –15 °C and t_i = + 20 °C

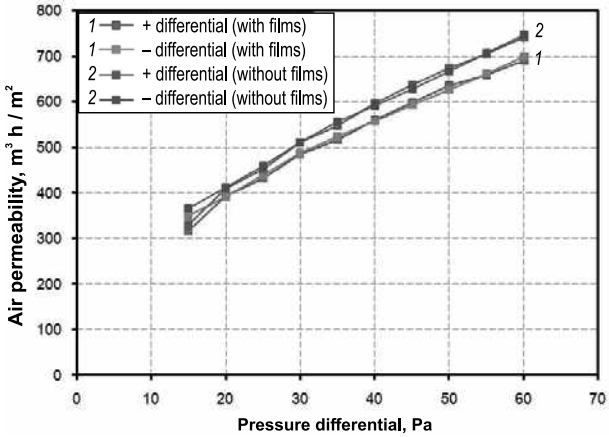

Fig. 8. The values of air permeability of the premises at positive and negative Δp

series thermal imager, in accordance with the relevant requirements [4, 5]. Some thermograms of the examined structures are shown in Fig. 7.

To determine the reduced R_o heat transfer resistance of translucent structure, a full-scale testing was carried out using heat flow and temperature meters in accordance with national standards [6]. The measurements were carried out within the period from 28.03.18 to 02.04.18. To perform the calculation, the period with the established temperature differential was selected: 28.03.18 23:00–29.03.18 04:00. During this period t_e and t_i were –10 and + 19.6 °C respectively. The testing result is: R_o = (0.37–0.39) m² °C/W.

Table 1. Dependence of Temperature in the Air Layer of Translucent Structure on Height

Height, m	Temperature, ° C
2.9	9.5
1.5	7.0
0.76	4.8

The temperature distribution in the interglass space of the historical translucent structure is given in Table 1.

The testing of the historical translucent cladding for air permeability was carried out in the utility service room of the restoration workshop. The doors and other possible air infiltration areas were sealed before the testing. The "*Blower Door*" complex was installed in the doorway. The testing was carried out according to national standard [7]. Positive and negative differential air pressure Δp equal up to ± 60 Pa respectively were set during the full-scale testing. At each Δp value air permeability measurements were made. Then, on the basis of the obtained data, the air permeability values of the window at different Δp were calculated (Fig. 8 and Table 2).

As a result of the conducted surveys of historical translucent structures, it became obvious that they do not comply with the current requirements, neither on heat transfer resistance nor on air permeability. In case of preservation of metal window frames (according to the requirements of the law on protec-

Table 2. Air Permeability of Translucent Cladding at Positive Pressure Differential Δp

Δp, Pa	Volume air flow, m³/h	Mass air flow, G_a, kg/h	Air permeability	
			by volume, m³ / (h · m²)	by mass, kg / (h · m²)
15	16	19.1	2.7	3.3
20	18	21.5	3.1	3.7
25	20	23.9	3.4	4.1
30	23	27.5	3.9	4.7
35	33	39.5	5.7	6.8
40	33	39.5	5.7	6.8
45	35	41.9	6.0	7.2
50	40	47.8	6.9	8.2
55	44	52.6	7.5	9.0
60	47	56.2	8.1	9.6

tion of cultural heritage sites) the large-scale computer calculations should be performed to determine the best ways of window restoration.

The authors express deep gratitude to the staff of the NIISPh (A. Verkhovsky, S. Potapov, V. Bryzgalin and E. Dalichik) and GC ROBITEX, LLC (N. Rumyantsev and I. Istomina) for assistance in carrying out field surveys of historical translucent structures of the Pushkin State Museum of Fine Arts.

REFERENCES

1. Replacement of windows in architectural monuments. // Oknamedia, publication 27.01.2017.

1. Zamena okon v pamiatneykakh arhitektury'. // Oknamedia, publikatciia 27.01.2017.

2. Shestov A. Windows as the core element of the historical building. // ARDIS, No. 2 (54), 2013.

2. Shestov A. Okna kak vazhnei'shii' e'lement istoricheskogo zdaniia. // ARDIS, No. 2 (54), 2013.)

3. "Complex reconstruction, restoration and adaptation to modern museum technologies of the major building of the Pushkin State Museum of Fine Arts (Moscow, Volkhonka Str., 12)" [Documentation prepared by FSUE Central Scientific and Restoration Design Workshops].

3. "Kompleksnaia rekonstruktciia, restavratciia i prisposoblenie pod sovremenny'e muzei'ny'e tekhnologii glavnogo zdaniia Gosudarstvennogo muzeia izobrazitel'ny'kh iskusstv imeni A.S. Pushkina (g. Moskva, ul. Volhonka, d. 12)" [Dokumentatciia podgotovlena FGUP "Central'ny'e nauchno-restavratcionny'e proektny'e masterskie"]

4. GOST R54852–2011 "Buildings and structures. The technique of thermal imaging quality control of thermal insulation of cladding".

4. GOST R54852–2011 "Zdaniia i sooruzheniia. Metod teplovizionnogo kontrolia kachestva teploizoliatcii ograzhdaiushchikh konstruktcii'".

5. Levin, E.V., Okunev, A. Yu., Umnyakova, N.P., Shubin, I.L. Fundamentals of Modern Construction Thermography/ Edited by I.L. Shubin. M.: NIISPh of RAACS, 2012, 176 p.

5. Levin E.V., Okunev A. Iu., Umniakova N.P., Shubin I.L. Osnovy' sovremennoi' stroitel'noi' termografii / Pod obshch. red. I.L. Shubina. M.: NIISF RAASN, 2012, 176 p.

6. GOST 26602.1–99 "Window and door blocks. Test methods for heat transfer resistance" and GOST R54853–2011 "Buildings and structures. Test method for heat transfer resistance of cladding by means of a heat meter".

6. GOST 26602.1–99 "Bloki okonny'e i dverny'e. Metody' opredeleniia soprotivleniia teploperedache" i GOST R54853–2011 "Zdaniia i sooruzheniia. Metod opredeleniia sopro-tivleniia teploperedache ograzhdaiushchikh konstruktcii' s pomoshch'iu teplomera".

7. GOST 31937–2011 "Buildings and structures. Test methods for air permeability of cladding in field conditions".

7. GOST 31167–2009 "Zdaniia i sooruzheniia. Metody' opredeleniia vozduhopronitcae-mosti ograzhdaiushchikh konstruktcii' v naturny'kh usloviiakh".

Alexander V. Spiridonov,
Ph.D. in Technical Sciences, graduated from the Moscow Power Institute (MPEI) in 1975, majoring in "Lighting and light sources". At present, he is the Chief Research Fellow of the NIISPh of RAACS, President of the Association of Manufacturers of Energy Efficient Windows (APROK), Laureate of the RF Government Prize in Science and Technology

Nina P. Umnyakova,
Ph.D. in Technical Sciences, Associate Professor. graduated from the Moscow Civil Engineering Institute. At present, she is Deputy Director of the NIISPh of the RAACS. Her research interests are thermal protection of buildings, energy saving, evaluation of thermal protection qualities of cladding in the presence of reflective thermal insulation