Reconstruction of the Courtyard Spaces of the Historical Buildings of Saint-Petersburg with Creation of Atriums

Vera Murgul*

St. Petersburg State Polytechnical University, Politekhnicheskaya, 29, Saint-Petersburg, 195251, Russia

Abstract

The paper is dedicated to the creation of the atriums in the historical centre of Saint-Petersburg for improving the quality of courtyards. Since 19 century Saint-Petersburg was built mostly with brick buildings along the perimeter of allotments with founding one or several courtyards. "Well-like" courtyards of historical buildings of Saint-Petersburg have typically a lack of illumination and insolation, are badly ventilated and are often transformed into parking lots for inhabitants. Possibility of glassing of "well-like" courtyards is analyzed from the viewpoint of historical buildings protection regulation of Saint-Petersburg and norms of insolation and illumination of the dwelling buildings, basing on the actual experience in the creation of atriums in Saint-Petersburg.

1. Introduction

In the period from 1800 to 1860 in Saint-Petersburg was built mostly with brick buildings along the perimeter of allotments with founding one or several courtyards. In the context of mass reconstruction and restoration of historical buildings in Saint-Petersburg an issue of searching for the ways to improve the quality of internal yards...
environment is considered to be an up-to-date one. An existing low solar exposure and daylight level regarding the lower floors of building wings, which normally form a secluded yard, give causes for concern. Poor natural airing is dramatized by parking construction inside courtyards creating a bad practice. There can be the following way to solve this problem: to turn courtyards into the ones with glass dome-like overlapping slabs (construction of atriums) and re-design dwelling floors while reconstruction of buildings. When it comes to contemporary terminology atrium should have the notion of internal courtyard made of glass.

2. Historical development of buildings with "well-like" courtyards in Saint-Petersburg

From the second half of the 20th century on the majority of construction sites of the city private sites were developed using brick buildings in the case of adjacent blocks perimetral system with one or more yards in the site arranged in order. Internal yards were constrained with the minimum dimensions (the width must have been not less than 10 'sagenes' (21.3 m)).

At the final stage of the commercial buildings development (1861 – 1890) a number of floors increased up to 5-6 floors resulting in formation of 3 and more secluded courtyards. The end of the 20th century can be featured with a range of commercial buildings’ complexes having sophisticated arrangement of the yards.

This period (1897-1917) is typical for large-size yard ensembles arranged in row, distinctive entrance arcs and the system of detached or joint building wings. The height of the buildings reaches 5-6 floors. Therefore the following features appeared when developing Saint-Petersburg: over-compacted adjacent residential blocks perimetral construction, increase of absolute dimensions of a facing wing due to additional floors construction in accordance with height restrictions. [1] Typical form layouts of historical buildings of Saint-Petersburg are given in the Figures 1 and 2.

![Fig. 1. Typical layouts of historical buildings with internal courtyards of Saint-Petersburg in the 19th century](image)
Glazing of internal yards can create extra comfortable space for dwellers, ensure protection from negative environmental impact having visual relation with the environment remained. Besides, it is necessary to secure duly daylight level, required level of air circulation and eliminate risk of having yard overheated in summer.

3. Atriums development history

Going back to the history atrium was like a large-size open space inside the building and was a feature of an ancient Roman dwelling where daylight and ventilation were secured. There was normally a swimming pool in the center of the atrium, which was embedded into a floor to gather rain water (Figure 3, a). But more often ancient atriums were like open internal yards where a heating stove and a dining room were arranged. And this explains the origins of the word. The notion of the word ‘atrium’ is taken from the Latin word *ater* — ‘smoky’, ‘black’. [2]

Ancient atriums were described in details in the works of Vitruvius and classified into 5 basic types depending on their constructions.

The Industrial Revolution of the 19th century resulted in considerable achievements in the field of iron and glass production. Open yards were covered with glass protecting internal space against bad weather what gave birth to contemporary design of atriums. Figure 3.

![Figure 2: Typical form layouts of secluded courtyards in the context of historical buildings of Saint-Petersburg](image)

![Figure 3: Atriums development](image)

Fig. 2. Typical form layouts of secluded courtyards in the context of historical buildings of Saint-Petersburg

Fig. 3. Atriums development a) Ancient atrium layout (Corinth atrium) b) Atrium of Victoria Hall in Halifax Town Hall, 1863 [2]
4. Practice of atrium construction in Saint-Petersburg

Referring to the history practice of internal yards glazing was not widely spread in Saint-Petersburg. The Zinger House can be one of such rare examples (Nevski pr. 28? Saint-Petersburg). Figure 4.

![Zinger House](image)

Fig. 4. The Zinger House in Saint-Petersburg. A Photograph of 1904.

In the beginning of 20th century the German company Zinger – the largest manufacturer of sewing-machines – bought a land plot at the corner of Nevski prospect and Yekateriniskiy Canal. A sky-scraper was assumed to be built on the site of the demolished building. But there was a Decree about height restrictions up to 1905 in Saint-Petersburg. It was forbidden to build houses higher than Winter Palace’s eave (11 sagenes – about 23.5 meters) according to this Decree.

An architect Suzor P.U. solved this problem by making the design of the building under the height requirements with a high dome. The building was equipped with state-of-the-art facilities including modern elevators and self-maintained removing of snow from the roof. It was the first experience in the history of the Russian architecture when a frame structure was used by Suzor what made it possible to place large-size windows on the face building. Also it was the first time when an internal yard was covered with glass. View of a contemporary internal covered with glass is shown in the Figure 5.

![Zinger House](image)

Fig. 5. The Zinger House in Saint-Petersburg. Contemporary state, internal courtyard.

Another example might be the Passage in St Petersburg. St.Petersburg’s Passage opened on May 9 (22), 1848 (architect R.A. Zeljazevic). In 1900 - reconstruction by adding the floor by architeect S.S.Kozlov, Figures 6-8. [3]
5. Contemporary practice to arrange atriums, Saint-Petersburg

Nowadays there are only atriums in commercial non-dwelling buildings of Saint-Petersburg. A commercial apartment building, which belonged to I.V. von Besser, can be assumed as one of such examples. Today it is known
as ‘Vladimirovsky Passage’ (Figure 9). This house was built in 1900-1901 (architect Shulman K.A.). Reconstruction of the building was performed in 2002-2003 (chief architect Vladimir Gorbunov), and practical use of this building was also changed into a shopping and hotel complex ‘Vladimirovsky Passage’.

Fig. 9. A commercial apartment building belonged to I.V. fon Besser, Saint-Petersburg. Photograph of 1930 and contemporary view.

While reconstruction an internal courtyard was covered with a glass dome (Figure 10).

Fig. 10. A commercial apartment building belonged to I.V. fon Besser, Saint-Petersburg. An internal courtyard under reconstruction and its contemporary view.

6. An analysis of the regimes for areas to be protected in the context of possible courtyards glazing

Reconstruction and restoration activities for historical buildings are executed in accordance with the existing standards for conservation of historical and cultural monuments. Constraints for any changes in certain building exteriors are stated in the Law of Saint-Petersburg «On the boundaries of protection areas of objects of cultural heritage and on the conditions of using the land in the above boundaries and on the introduction of changes into the law of Saint-Petersburg “On the master plan of Saint-Petersburg and on the boundaries of the protection areas of
cultural heritage in the region of Saint-Petersburg]. [4]

Protection area is the area to be protected with particular regulations developed to constraint city-planning and economic activities. These measures are taken to secure actual preservation of cultural and historical heritage.

The majority of the buildings in the historical center of Saint-Petersburg are considered to be historical and cultural monuments under protection. City protection authorities are mainly focused on the ensembles in the historical center and cultural suburbs of Saint-Petersburg enlisted into the UNESCO World Heritage Center. The most significant assets of value in the cultural and historical context, their object-based content and regimes for use are determined. Stiff constraints for Innovative Technologies in Development of Construction Industry reconstruction of the valuable objects in the cultural and historical context (buildings, front facades, squares) have been imposed within these areas. The rest part of combined areas is subject to differential constraint regimes allowing construction and more radical reconstruction without changing structure layouts (traffic networks, residential blocks layouts), basic environmental features, and certain cultural heritage-listed objects. In the majority of cases it is allowed to cover secluded courtyards; change the heights of certain courtyard blocks (not higher than a front block located in front of the object under reconstruction); change architectural solution of the walls facing the courtyards in accordance with the statement decision of the cultural and historical heritage-enlisted objects protection authorities. It is not allowed to change architectural solution in the front facades, engineering and technical equipment placement in particular.

The structure of protection areas for cultural heritage of historically developed central districts of Saint-Petersburg is presented in the Fig. 11.

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**Fig. 11. Structure of protection areas for cultural heritage of historically developed central districts of Saint-Petersburg.**
As an example the following basic constraints and permits within the protection area1 (O3 1) can be listed. The following is acceptable:

- local changes in the architecture of the facing facades of the historical buildings, structures and constructions at the ground and first-floor levels without violating general architectural solution, window cases;
- mansards to be built on the facing buildings without changes in roof constructions (it is accessible to rise a roof ridge up to 1 m), and on the buildings in the yards with partial change in roof constructions;
- slabs in enclosed yard spaces;
- changes in the heights of certain yard buildings (not higher than facing buildings located in front of the object under construction);
- changes in architectural solution of yard facades in accordance with the decision of the state cultural heritage protection authorities.

Changes in architectural solution of the front facades (placement of engineering equipment in particular) are not accessible.

Such constraints entail targeted and individual approach to a project solution for each certain case. Saint-Petersburg is a developing metropolitan city which cannot be conserved. For this reason coming to an agreement about city development and reconstruction plans with the state cultural heritage protection authorities is an up-to-date issue. [4]

7. Turning a courtyard into an atrium

Two basic schemes are suggested to be used:

- load transfer to existent building wings (external water disposal)
- load transfer directly to foundation soil (internal sewage).

A cover structure model designed for a courtyard under the scheme of load transfer to foundation soil with an internal sewage is shown in the Figure 12.

Fig. 12. A cover structure model designed for a courtyard under the scheme of load transfer to foundation soil with an internal sewage.
It should be noted that making a cover over a courtyard can inevitably lead to decrease of solar exposure level which is already insufficient. Lower floors of the courtyards do not normally receive initial direct sunlight.

8. Solar exposure of courtyards

According to the existing ‘Hygienic requirements for solar exposure and sunlight protection of dwelling houses and public buildings and areas’ [5] solar exposure is the exposure of surfaces and spaces to direct sun beams radiation. Saint-Petersburg is the northeast city with population more than 1 million. Coordinates of center are 59°57’ N 30°19’ E. Standard duration of solar exposure is determined for fixed calendar intervals with due account for geographical latitude. The interval starting from April, 22 to August, 22 is determined for the Northern zone (further north than 58° N) and correspondingly for Saint-Petersburg. Standard duration of on-going solar exposure for dwelling building in the Northern zone is specified not less than 2.5 hours a day starting from April, 22 to August, 22. Besides, duration of solar exposure for dwelling buildings should be ensured at least for one-room in 1-3-room apartments and for two rooms in 4-room (and more) apartments. These requirements for solar exposure can be achieved provided buildings are arranged and oriented to the horizon, and accurate 3-D design concept is elaborated. [5]

Courtyard cover can decrease solar exposure level of the higher floors directly striking by sun beams. However, it is more important to safeguard working area of the courtyard against atmospheric precipitation and increase light level of lower floors. Provided 3-D designs of apartments are changed an estimated solar exposure at the level not lower than existing one can be achieved.

Generally, it would be rational if homeowners association could take a decision whether to cover a courtyard. 3-D concepts of apartments and floors should be changed anyway in order to increase an estimated solar exposure level to the maximum and ensure potential possibilities to cover courtyards in future.

9. Daylight levels of courtyards

Lack of daylight is an urgent issue for court-yards of Saint-Petersburg. A daylight is the light secured for rooms and spaces by sky light (direct or reflected) which penetrates into light area openings in external building enclosures. There are natural side-light (daylight through light areas in exterior walls) and natural top-light (daylight using street lamps, light areas in the walls with respect to height differential areas of a building), and also combined light (combination of side and top ones). Daylight factor (DLF) is a ratio of daylight produced by sky light (direct or reflected) at a certain point of the room’s plane given to simultaneous external horizontal light totally produced by the light of open sky fall; it is expressed as a percentage. [6]

The requirements for daylight of dwelling buildings (standard DLF indicators expressed as a percentage) are specified in SanPin 2.2.1/2.1.1.1278-03 (Sanitary Regulations and Standards). When there is one-side light in dwelling houses a standard DLF value should be achieved at an estimated point located at the intersection of a vertical plane of a certain room in section and floor plane at a distance of 1 km from the wall the farthest removed from light areas: in one room for 1-, 2- and 3-room apartments and in two rooms for 4-room and more apartments. In the case of the rest rooms in multi-room apartments and in kitchens a standard DLF value should be achieved at an estimated point located in the center of a room on the floor plane. [7]

It is possible to meet the daylight requirements for courtyards provided beam guides are used.

10. Daylight system based on beam guides

A daylight system based on beam guides can be represented by single-point roof lights with light-conducting pits. High performance capacity of modern beam guides makes it possible to reflect up to 88% of light. Light is effectively transferred at a distance up to 25 from a dome. It is suggested herein to use guide beams to meet daylight requirements. Beam guides do not ensure solar exposure of courtyards since mainly reflected sun beams are used in
this system.

11. Use of atriums to increase energy performance of buildings

Provided a glass cover can keep heat contribution of a glazing space into general heat balance of a building can be significant. Translucent cover constructions are the most urgent areas of problem dealing with building enclosures nowadays in the matter of high heat losses in winter time.

A module façade system «Qbiss Air» (Slovenia) can be considered to be a positive example.

The glass modular façade system «Qbiss Air» is the multilayer insulation façade system with the following parameters [8]:

- the heat transfer factor of the structural module with seven layers: \( U = 0.19 \text{ W/(m}^2\text{C)} \);
- the heat transfer factor of the translucent structure (including boundaries, profile systems and horizontal systems): \( U = 0.27-0.45 \text{ W/(m}^2\text{C)} \);
- an assumed heat transfer factor for the façade glazing: \( U = 0.4 \text{ W/(m}^2\text{C)} \);
- an assumed heat transfer factor for the roof glazing: \( U = 0.32 \text{ W/(m}^2\text{C)} \).

On top of that an amount of glazing should be reduced in summer time in order to avoid overheating of a courtyard space. A cover over courtyard may reduce power consumption for heating to a considerable extent in winter time.

Secluded courtyards of historical buildings in Saint-Petersburg significantly differ from each other by their forms and yard area to volume space ratio. Consequently, initial conditions for microclimatic regime modeling with reference to secluded courtyards can differ. There is a need for individual solution for each certain building. Natural microclimate in secluded courtyards directly depends on external atmospheric conditions (sun and wind), and modeling should be implemented on a monthly basis.

12. Conclusions

An accurate glazing of a courtyard can:

- improve maintenance specifications and quality of a courtyard space in general;
- improve daylight performance in courtyard (based on guide beams);
- improve airing of a courtyard by means of mechanically induced air circulation in summer time when there is a lack of natural ventilation;
- reduce general power consumption of a building;
- increase commercial attractiveness and, consequently, market value of a building. Courtyard area can be included into non-residential gross floor area with significant reduction factors (for instance, relatively to ordinary and recessed balconies taken from total general apartment area) in the long run;
- increase socialization and interaction of dwellers;
- psychological relations with natural environment. A glazed courtyard can ensure protection from negative environmental impact having visual relation with the environment remained.

References

[4] Law of Saint-Petersburg «On the boundaries of protection areas of objects of cultural heritage and on the conditions of using the land in the above boundaries and on the introduction of changes into the law of Saint-Petersburg “On the master plan of Saint-Petersburg and on the boundaries of the protection areas of cultural heritage in the region of Saint-Petersburg».
[5] Regulatory document 2.2.1/2.1.1.1076-01 "Gigiyenicheskie trebovaniya k insolyatsii i solntsezashchite pomeshcheniy zhilykh i obshchestvennykh zdaniy i territoriy" [Hygienic requirements for solar exposure and sunlight protection of dwelling houses and public buildings and areas].


[7] Regulatory document 2.2.1/2.1.1.1278-03 "Gigiyenicheskie trebovaniya k yestestvennomu, iskusstvennomu i sovmeshchennomu osveshcheniyu zhilykh i obshchestvennykh zdaniy" [Hygienic requirements for natural, artificial and combined illumination residential and public buildings].