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Modular Systems for Building Renovation

Tojiboev Ulugbek, Kamilova Marjona*

Samarkand State Architecture and Construction University

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*Correspondence: Kamilova Marjona
Email: marjonakamilova88@gmail.com

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Abstract: The article discusses the methodology and technology of installing a new facade system on the old facade of the building, improving the appearance of the building and protecting the old facade, including the prevention of many problems. This research employs an analytical descriptive approach by gathering information on the methodology and technology used in installing modular facade systems on existing buildings. Data is collected through literature review and case studies of successfully implemented building renovation projects. The analysis results indicate that the use of modular systems in building renovation provides numerous benefits, including improved construction efficiency, cost and time reduction, as well as enhanced durability and aesthetics of the building. Moreover, the use of modular systems enables more flexible design adjustments according to the existing architectural context. The utilization of modular systems in building renovation brings positive impacts in enhancing the building's appearance while safeguarding the original facade and preventing various construction issues. By providing more efficient and flexible solutions, modular systems unlock significant potential in sustainably and aesthetically renewing existing building structures.

Keywords: Facade, Renovation, Installation, Improvement, Modernization, Reconstruction

Introduction

This renovation option provides for the installation of a new facade system directly on the old facade and is fundamentally different from the "replacement of the facade system", which, as the name implies, provides for the replacement of the old facade with a new facade system. The installation of a new facade system on the old facade of the building is designed to provide the following advantages (Degirmenci, 2022; Tashakor, 2022; Tian, 2022; Yao, 2022; Yin, 2021).

Reduction of heat loss through the facade of the building and ensuring compliance with modern standards of thermal insulation; One of the primary benefits is the reduction of heat loss through the building facade, ensuring compliance with modern thermal insulation standards. By installing a new facade system with improved insulation properties, energy efficiency is enhanced, leading to potential savings in heating and cooling costs (Gnanavel, 2021; Gong, 2021; Mykoniatis, 2021).

Improving the appearance of the building; Another advantage is the enhancement of the building's appearance. The installation of a new facade system allows for architectural updates and aesthetic enhancements, rejuvenating the visual appeal of the structure and potentially increasing its market value (Arrano-Vargas, 2023; Mo, 2023; Thangavel, 2023; Jiang, 2022; Ming, 2022).

Protection of the old facade of the building, including prevention of water leakage; The new facade system serves as a protective layer for the old facade, shielding it from weather elements and preventing issues such as water leakage and deterioration. This helps preserve the integrity of the building envelope and extends the lifespan of the structure (Dan-Adrian, 2022; Hussein, 2022; Sabioni, 2022; Wang, 2022; Yu, 2022).

Minimal discomfort for residents during renovation. Residents experience minimal inconvenience during the renovation process compared to complete facade replacement. Since the existing facade remains intact during installation, disruptions to occupants are reduced, and the renovation process may be completed more efficiently (Li, 2022; Wu, 2022).

In the new facade system installed on the old facade of the building, various materials can be used, including composite panels (or sandwich panels) and metal cassette panels. Thermal insulation is placed behind the new facade system and attached to the wall of the building using the necessary means of protection from weather influences.

The installation of a new facade system onto the existing facade of a building offers a cost-effective, energy-efficient, and aesthetically pleasing solution to address thermal performance, aesthetic, and protective concerns, while minimizing disruption to occupants during renovation activities.

Methodology

As a rule, a new facade system involves the installation of an additional frame, which is attached either directly to the old facade, or, preferably, to the floor slabs or load-bearing elements of the building structure. This is better than attaching the frame of a new facade system to a potentially weak old facade. The height of the frame modules is taken from the calculation of the height of the building floor and when installed on the building, the necessary adjustment is made in place, taking into account the irregularities of the existing facade (Lawson et al., 1999).

New metal facade systems have already been installed on many residential and commercial buildings, as well as buildings of educational institutions, in particular in the UK and Scandinavia, according to this principle. Usually, the renovation of the building is carried out in a comprehensive manner and simultaneously with the installation of a new facade system on the old facade of the building, the roof is reconstructed. New windows are also being installed in the building, which significantly increases overall energy savings (Healer et al., 1999).

The operational necessity of installing a new facade system on the old facade is largely dictated by the need to significantly increase the thermal insulation of the building, prevent water from entering and removing moisture from the building or the old façade (Sidikovna & Erkinovna, 2023).

Figure 1. Examples of installing new facade systems on old facades of buildings with concrete wall panels. The new facade systems consist of horizontal metal panels

The construction of superstructures and the reconstruction of the roof."Roof reconstruction" is the creation of a new roof structure on an existing building (Abdiyev, 2022). Most often, the reasons for the reconstruction of roofs are the poor performance of the existing roof (for example, water leaks) and the desire to use the space under the roof, for example, for utilities or new apartments (Yuldasheva & Kamilova, 2023). The design of the new roof is largely determined by the purpose of the space under it, i.e. whether it will be residential or not. The benefits of having a new space in a building often pay off all the costs of organizing it. During the reconstruction of the roof, lightweight steel frames can be used in the following variants:

1. Often (closely) located trusses (rafters) between the facade walls;
2. Rarely located trusses (rafters) between the facade walls and girders resting directly on them;
3. portal frames or other stable systems supported by columns around the perimeter;
4. lightweight steel structure supported by a grillage of steel beams supported by individual columns at the bottom.

Farms can be simple pitched (such as Fink or Prat) or attic, giving more usable space. For the construction of superstructures on a building, it is usually best to use lightweight steel structures supported by steel beams that overlap the existing flat or slightly pitched roof as shown in Figure. 2.

Figure 2. Two-storey superstructure made of light steel frame on an existing building, Rotterdam

Modular systems for building renovation. Superstructures on buildings can be easily erected using modular or "volumetric" systems. These systems are self-supporting vertically, but are supported by the existing structure on the sides. As a rule, the modules of these systems have a width of up to 3.6 m, so they are easily transported without special escort and also easily climb buildings. The cladding on the modules can be installed in advance or on site. The best results from the use of such modular systems for building renovation have been achieved in Scandinavia. The popularity of modular systems for building superstructures is steadily growing in the UK and recent examples include medium-sized hotels and social housing projects.

Result and Discussion

The installation of a new facade system on the old facade assumes very accurate results of the inspection of the exterior walls of the building. This is necessary so that all parts fit exactly in size without the need for on-site refinement. Therefore, a study was conducted on the factors affecting the accuracy of laser scanning. As part of this study, it was necessary to confirm that laser scanning technology is capable of providing sufficient resolution and accuracy of measurement results for the design and production of assembly units of a steel facade system for installation on the old facade of a building. The existing steel facade systems designed for installation on old facades of buildings allow for a deviation in size at the attachment points within 5 mm in all directions. Accordingly, the technologies used to inspect the facade of the building must ensure compliance with these tolerances. The steel cladding panels of the facade system have a smooth, even surface, and any unevenness or curved seam between them will be immediately noticeable to the naked eye.

As a rule, buildings requiring renovation in the form of a new facade system are very tall, so manual inspection of their facades is fraught with great difficulties. This problem can be solved by laser scanning technology, which can provide the required accuracy of the results.

This technology allows you to perform three-dimensional measurements from a certain distance and, provided the results are accurate enough, can be an important tool for collecting data necessary for the design and production of parts of a prefabricated steel facade system for installation on old facades of large buildings.

The accuracy of a high-resolution laser scanning system is determined by a number of factors. Since the defining technical feature of the laser scanning system, which distinguishes it from traditional building inspection tools, is high detail, the following factors can be clearly identified:

1. Scanning density and spot size (or beam diameter);
2. Interference;
3. Edge effects (distortion at the edges);
4. Resolution;
5. Range accuracy;
6. Angular accuracy;
7. Surface reflectivity;
8. Environmental conditions.

Conclusion

The laser scanning system is capable of providing the required level of accuracy at a distance of up to 50 m. Therefore, only the most accurate laser scanning systems are suitable for the inspection of buildings, provided that the working procedure of the study is strictly followed. Scanning accuracy (for example, a grid pitch of 1.5 mm) and spot size (within 5 mm) are considered very important characteristics of the system. Measurement accuracy within 5 mm in all directions is considered sufficient for the design and production of prefabricated steel facade systems.

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