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Extension of multi-family buildings

Rozbudowa budynków wielorodzinnych

Review paper (Artykuł przeglądowy)

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Abstract. This paper presents an example of enlarging the usable floor space of a residential building by adding on winter gardens (conservatories). Considering that there has been a growing interest in this subject, a load-bearing construction adapted to the climatic conditions prevailing in Poland is proposed. Static strength analyses have shown a self-supporting steel frame construction independent of the structure of the existing building to be most advantageous.

Keywords: modernization; multi-family buildings; winter gardens; add-on construction.

Streszczenie. . W artykule przedstawiono przykład zwiększenia powierzchni użytkowej obiektu przez dobudowę ogrodów zimowych. Z uwagi na prognozowany wzrost zainteresowania poruszaną tematyką, zaproponowano rozwiązanie konstrukcji nośnej dostosowane do warunków klimatycznych panujących w Polsce. Na podstawie rezultatów otrzymanych z analiz statyczno-wytrzymałościowych, za korzystne uznano wykorzystanie samonośnej stalowej konstrukcji szkieletowej, niezależnej od konstrukcji istniejącego obiektu.

Słowa kluczowe: modernizacja; budynki wielorodzinne; ogrody zimowe; konstrukcja dostawna.

As the built-up area of cities increases and land prices rise, the construction of high-rise buildings becomes a necessity. For this reason such buildings have been increasingly built in Poland since the middle of the 20th century [1]. Considering that the construction business contributes to nearly 40% of the greenhouse gas emissions [2], and so greatly affects the state of the natural environment, a special focus should be given to seeking innovative solutions making possible the rational use of the natural resources and the land development area. According to GUS (Central Statistical Office of Poland) data [3], the average size of new flats in Poland has remained at the same level in recent years. In 2019 it amounted to 88.6 m^2. The statistics on new buildings indicate that the size of flats in Poland does not differ from the European standards (the average size of a flat in EU is 80 m^2). However, an analysis of all the occupied dwellings reveals a somewhat less positive picture of the situation. Taking into account the fact that a considerable part of the dwellings are large panel blocks of flats, the average size of a flat in Poland amounts to about 50 m^2, and 36% of the dwellers live in overcrowded conditions. Eurostat statistics show that in this respect Poland is in the fourth place in the EU, after Romania, Latvia and Bulgaria. Even though increasingly more people would like to move out of a block of flats to a newer higher-standard apartment building, because of the high prices of such apartments and their insufficient number, there has been a growing interest in acquiring a suburban single-family house rather than an apartment in a multi-family building. This results in urban sprawl, and so in long commutes generating costs and greenhouse gas emissions. Therefore it seems reasonable to rekindle interest in older dwellings, located in the centres of cities, with good accessibility to public services. As these dwellings often do not meet their occupants' current requirements, they lose their function. At the same time in a considerable number of cases they are still structurally sound.

It seems that the simplest solution in a case when a building no longer performs its function is to pull it down and in its place erect a new building meeting the contemporary requirements. From the legal point of view (the dweller's right to the property) and considering the environmental aspects and the rational use of resources, this approach is unacceptable. A solution can be to modernize the existing residential buildings and thereby improve the standard of the dwellings. This approach is being adopted in West European countries, where there has been a growing interest in this issue. Projects were undertaken as part of which whole single-family housing estates were upgraded to meet the dwelling needs. The measures taken to restore the function of residential buildings focus on increasing their usable floor space by, e.g., joining flats together or adding on the so-called winter gardens (conservatories) to the building whereby the residents gain additional space which can be used for, e.g., storage, growing plants, spending free time, resting, or for meetings.

Examples of enlarging living space of flats

The best known example of the extension of a residential building is the project consisting in the remodelling of 530 flats in the Grand Parc complex in Bordeaux, France. The task was to remodel modernistic communal blocks of flats dating from the early 1960s. It was decided to add on a prefabricated reinforced concrete construction so that each of the flats would gain more space and light (photo 1). Thanks to this structure sufficiently large and fully functional private outdoor space was added (photo 2). The project designed by

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A. Lacaton, J.P. Vassal (Pritzker prize 2021 winners) and F. Druot and Ch. Hutin was awarded the EU Mies van der Rohe prize in contemporary architecture in 2019.

The current trends and the projects completed in Europe indicate that this direction will be followed also in Poland. The fact that there are many large panel blocks of flats, comprising about 4 million dwellings, in Poland contributes to the interest in this issue [6].

Photo 1. Grand Parc housing estate buildings after alteration [4]
Fot. 1. Budynki osiedla Grand Parc po przebudowie [4]

Photo 2. Added winter gardens [5]
Fot. 2. Dobudowane ogrody zimowe [5]

Design of lightweight add-on steel frame construction

In order to assess the possibility of adopting the above European ideas and trends in Poland, static strength analyses of the add-on steel frame construction were carried out in accordance with the governing standards [7 – 9]. The aim was to create a design fitting a typical large panel apartment building being in sufficiently good condition to attach a conservatory construction to it. The following assumptions concerning the add-on construction were made: total width – 30 m, total height – 18 m, front-to-back distance – 3.5 m and number of floors above ground – 6. An analysis of various material options showed that the a lightweight steel frame construction, made as self-supporting or as fixed to the existing building, would be most advantageous. The structural components were to be constructed of hot rolled sections made of steel S235JR. The other members of the conservatory were to be 15 cm thick prefabricated reinforced concrete slabs constituting the structure of the floors, and facade elements in the form of glass balustrades and user-foldable accordion glazings. As regards fire safety requirements, the construction was classified as human occupancy class ZL IV and fire resistance class C. The particular structural components were assumed to meet the requirements of the classes: R60 – the load-bearing structure, REI60 – the floors, and EI30 – the facade. Two designs of the winter garden construction were created. In design 1 the constructionis self-supporting and consists of two rows of columns: one at the construction's outer edge and the other at the building's wall (fig. 2). The construction is secured in the ground by means of spot footings and it is independent of the existing residential building structure. In design 2 there is only one row of columns erected at the construction's outer edge. Instead of using another row of columns, the construction is fixed to the residential buildingby means of transverse beams. The transverse beams are between the columns and the wall and at halfspan between the longitudinal beams situated in the horizontal plane between the columns.

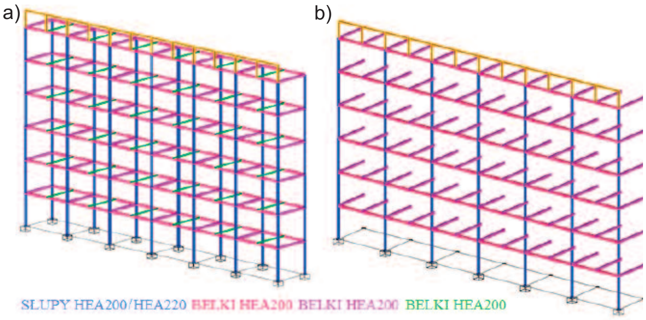

Fig. 1. Structural designs of winter gardens: a) design 1; b) design 2
Rys. 1. Warianty konstrukcji ogrodów zimowych: a) wariant 1; b) wariant 2

Results of structural analyses

Structural analyses of the two designs of the add-on construction were carried out to determine the cross sections of its components, and so the quantity of the materials used. The action of climatic loads (snow, wind), permanent loads and operational loads was taken into account in accordance with the provisions of standards [10 – 13]. The quantity of the steel used was determined to amount to 47.24 kg/m^2 for design 1 and to 26 kg/m^2 for design 2. In both designs HEA220 steel sections were used for the columns on the three lowest stories and HEA200 steel sections for the columns on the other stories and for the transverse and longitudinal beams, as well as for the bracings made of round bars PO42. The steel consumption is lower in the case of design 2 because there is one row of columns less and the add-on construction is joined directly to the existing building.

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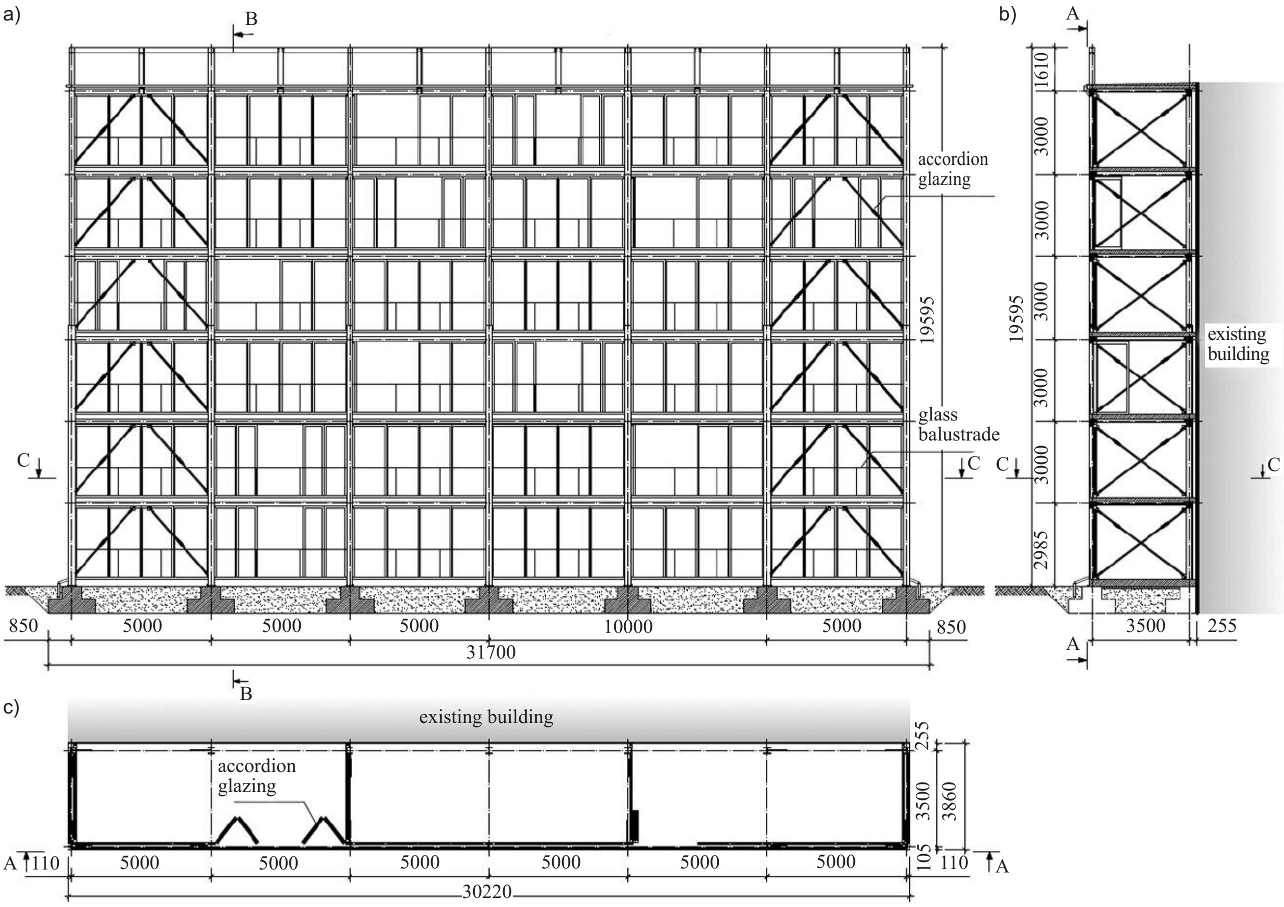

Fig. 2. Winter gardens structure design 1: a) view of front facade A-A; b) section B-B; section C-C
Rys. 2 Projektowana konstrukcja ogrodów zimowych – wariant 1: a) widok – elewacja frontowa A-A; b) przekrój B-B; c) przekroj C-C

However, one should bear in mind that this design, besides its lower material consumption advantage, has many disadvantages, such as the necessity of providing proper thermal insulation in the places of connection with the existing building in order to avoid thermal bridges (the connection between the steel members and the existing building's concrete). This design also generates complications at the construction stage. In design 1 there is no need to make many holes to attach the add-on construction to the existing building as it is the case in design 2. The latter is also disadvantageous as regards structural reliability as it requires a large number of connections with the existing building whose current technical condition may limit the attachment of the additional load-bearing construction.

Conclusion

The structural calculations have shown that in Poland it is possible to enlarge the usable floor space of flats by adding on winter garden constructions. Despite the greater consumption of materials, the self-supporting lightweight steel construction (design 1) was found to be more advantageous as it is easy to build, less failure-prone, better as regards the building's thermal performance (no thermal bridges) and its erection has no adverse affect on the existing building.

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