The Impact of Extending the Loggia of a Precast Panel Building on Daylight and Insolation of the Apartments

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***Abstract*—Extending the loggias is currently a very popular way to increase user comfort and the market value of apartments in precast panel houses. Construction companies offer several designs, enabling expansion ranging from 20 centimetres to 2.5 meters.**

The aim of our research is to examine the impact of this adaptation on the apartments' interior lighting conditions and to determine the limit width of the loggia, which does not prevent the fulfilment of the requirements for insolation and daylighting of residential buildings. The evaluated factors are, relating to the valid legislation in the Czech Republic, the sunlight duration on 1.3. and the daylighting factor D.

In this article, we examine the possibilities of loggia extension on a specific example of an apartment house in Prague; build in the standard system VVU ETA. This building is located in practically ideal conditions, with a southern orientation of the loggias and without any shading obstacles. This enables us to find the ultimate limit of the loggia width, which will then be modified according to specific shading conditions.

Keywords—precast panel buildings, loggia extension, daylighting, insolation

I. INTRODUCTION

After the end of the Second World War, the construction of a new residential building began. Emphasis was placed primarily on the usable area per inhabitant and hygienic requirements, which included the insolation and daylight.

Due to the higher efficiency, the Czech Republic is primarily occupied by blocks of flats rather than family houses and terraced houses. Along with this trend, residential dwellers lose direct contact with the outside environment. The solution was an addition of a loggia or a balcony to the apartment unit. This was postponed due to higher financial costs for construction in the post-war period. Nevertheless, with the progressive development of prefabrication and expansion of panel construction, this trend is changing. According to standardized buildings plans prepared by the typing institutes, almost every apartment has balcony or a loggia since 1963 [1].

One of the functions that balconies and loggias should provide is a residential function. In 1964, Rajisa and Ilja Kvasnička stated that this area should be at least 1800 x 1250 mm for two persons and 1900 x 1500 mm for four people.[1] According to O. Nečas and the team, this area is even 2050 x 1550 mm for two persons and 2400 x 1600 for four people. [2] Taking into account the valid standard ČSN 73 4305: Furnishing of flats, the area of the balcony required to provide a residential function is 2500 x 1500 mm for two persons and 2900 x 1700 mm for four persons. [3] Most apartments made of prefabricated panels have a balcony or loggia depth of 1200 mm, which does not allow the occupancy of two persons.

One way to increase user comfort and the market value of flats in houses is to extend existing loggia. Several companies are engaged in this type of renovation on the Czech market. The construction options offered by the suppliers are mainly the following:

- welded metal structure, mounted on loggia (extension 200 mm - insulation compensation)[4]
- insertion of an additional balcony structure on the loggia (extension of 800 mm)[4], [5]
- a metal structure fitted in front of an existing balcony structure and anchored to the construction of an existing balcony (extension of 1500 mm) [5]
- a steel construction consisting of four columns that carry the floor of the added balcony (extension from 2000 to 2500 mm) [5]

As a model example, a panel house built at the Prague housing estate of Řepy was chosen. This house was built in the VVU ETA system with a six-meter span, which is one of the most frequently used construction systems on the territory of the Czech Republic.

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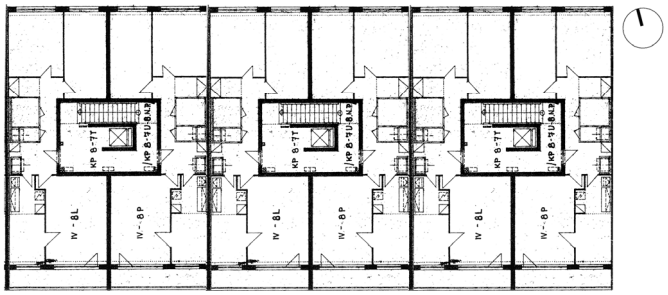

Fig. 1. Floor plan of the examined object

At the same time, it is a construction system that has been undergoing reconstructions in recent years due to failures on the facade and on balcony constructions. This raises the question of how to maintain the comfort of the loggia when placing the insulation on the outside of the facade and whether it is possible to increase usable comfort with the reconstruction.

The house consists of three row sections with two apartments of size 3 + 1 on the section. The thickness of the external wall panels of the VVU ETA is 240 mm (this is a variant of the cladding panels used for Prague after the industrial inspection of Průmstav in 1983). [6]

For the purposes of this article, a thermal insulation of 150 mm thickness is added on the faced. The clear height of the loggia is 2550 mm. The rail is solid with a wire mesh paneling and a height of 1100 mm.

The partitions between the loggias of individual flats are considered to be opaque, 50 mm thick, to the full height of the loggia, located in the axis of the walls between the flats. In all variants, it is contemplated to use plastic euro-windows double-glazed with clear glass.

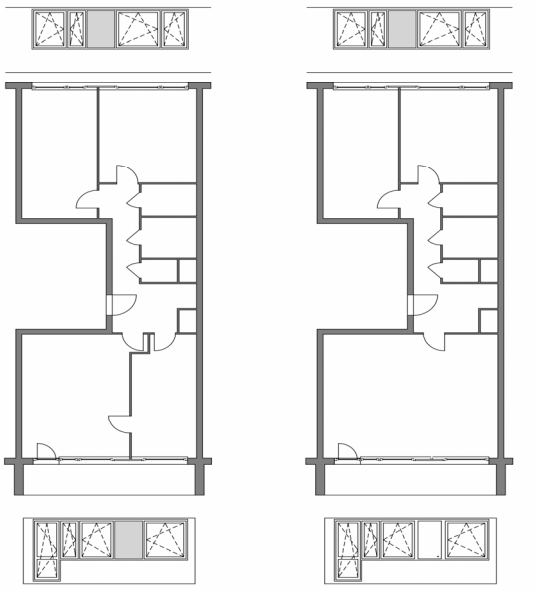

Fig. 2. Variant A (left), the kitchen is separate from the living room and there is an opaque window panel adjacent to the partition. In Variant B (right), the partition is removed and the opaque panel is replaced with a clear one.

Two variants of the calculation are considered. The first (option A) leaves the original floor plan with a kitchen separated from the living room by a partition (the kitchen has an area of 10.32 m2 and is not a room (living space) according to ČSN 73 4301 Residential building). [7] In this variant, the opaque panel, adjacent to the partition between the kitchen and the living room, is kept (replaced by a new opaque panel when replacing windows).

The second option (option B) is to remove the partition between the living room and the kitchen (change of disposition from 3 + 1 to 3 + kk). In this variant, the opaque part of the window padding is replaced by a non-openable window with a transparent glass fill.

For both variants, calculation of insolation and daylight is performed according to valid Czech legislation, for various loggia widths ranging from 200 mm to 1600 mm at intervals of 100 mm.

II. INSOLATION

The criterion for assessing the insolation of residential buildings is the sunshine duration. The sunlight duration was calculated using the Světlo+ software [8].

A. Legislative requierements for the insolation of residential buildings

The requirements of the norm ČSN 73 4301 Residential buildings for the insolation of residential buildings are, as follows:

The apartment is insolated if the total floor area of its insolated rooms is equal to at least one third of the total area of all its rooms.

A room is considered insolated if the following conditions are met simultaneously:

- *the horizontal angle of the sun's rays with the main line of the plane of the window opening must be at least 25° and the solar altitude at least 5 °;*
- *the openings, through which the sunlight enters the room are glazed with a transparent and non color distorting material, the total area of the openings is at least 10% of the room's floor area, while the smallest dimension of the opening is 900 mm;*
- *under a clear sky (clouds neglected) on March 1st and June 21st the duration of direct sunlight must more than 90 minutes.* [7]

B. Boundary parameters of the insolation calcutaion

In the house, the same 3+1 apartment layout is repeated, mirrored opposite each other. The calculation was therefore performed for both rotations of the apartment. The floor area of the bedroom is 12,88 m^2, the area of the children's room is 12,12 m^2. The area of the separate living room (Variant A) 18,34 m^2. The total area of all the rooms in Variant A is 43,35

m^2, one third of this area is 14,45 m^2 and it is therefore sufficient for the living room to be insolated to meet the conditions of ČSN 73 4301. The reference point is located horizontally in the center of the relevant part of the window and vertically 300 mm above the windowsill (1200 mm above the floor).

The area of the living room combined with the kitchen (Variant B) is 29 m^2. The total room area of Variant B is 54 m^2, one third of the area is 18 m^2. To meet the conditions of ČSN 73 4301, it is therefore sufficient that the living room is insolated. The reference point is horizontally located in the center of the entire window system. The apartment is located in Prague, the latitude 50.1 ° N, meridian convergence is therefore 7,8°.

C. *The results of the insolation calcutation*

TABLE I. TIME OF INSOLATION

Extension lenght [mm]	Time of insolation on the 1.3. [hours:minutes]			
	Variant A		*Variant B*	
	Appt.1	*Appt. 2*	*Appt. 1*	*Appt.2*
0	7:37	7:44	8:33	8:33
200	7:27	7:34	8:31	8:29
300	7:20	7:27	8:19	8:20
400	7:12	7:17	8:02	8:01
500	7:06	7:08	7:49	7:47
600	6:58	7:03	7:43	7:35
700	6:51	6:56	7:22	7:22
800	6:43	6:48	6:09	6:10
900	6:31	6:31	6:56	6:58
1000	**2:59**	**3:02**	3:29	3:03
1100	2:02	1:14	**1:34**	**1:34**
1200	1:26	0:24	0:39	0:46
1300	0:59	0:03	0:12	0:19
1400	0:39	0:00	0:00	0:00
1500	0:21	0:00	0:00	0:00
1600	0:05	0:00	0:00	0:00

In terms of insolation, the limit for extending the loggia is 1000 mm. With this extension, both variants meet the requirements of the norm with considerable margin. Variant B (connecting the living room with the kitchen) will meet the requirements of the standard even when the loggia extension is 1100 mm.

III. DAYLIGHT

The principal comparative quantitative criterion for the daylight assessment is the total daylight factor D [%]:

$$D = Ds+De+Di \quad (1)$$

where: Ds[%]…sky component

De[%]…externally reflected component

Di[%]…internally reflected component [9]

The total daylight factor is assessed on a comparative plane, at a height of 850 mm above the floor under the assumption of the CIE winter sky overcast with a continuous layer of clouds and dark terrain.

The daylight calculations were performed in the software environment Building design using the computing module Wdls 5.0 – Daylight calculation [10].

A. *Legislative requierements for daylighting in residential buildings*

The requirements of ČSN 730580-2 Daylighting in buildings - Part 2: Daylighting in Residential Buildings are: In rooms with side-lighting, in two reference points in the middle of the room's depth, 1m from the interior surface of the side walls, the total daylight factor value must be at least 0.7% the furthest 3 m from the window and the mean value from both of these points must be at least 0.9%[11].

B. *Boundary parametres of the dayligt calculation*

For the calculation, the following parameters were used: the average reflection factor of internal surfaces $\rho m = 0.5$, the reflection factor of the surrounding terrain $\rho = 0.1$ for dark terrain.

The window openings are double-glazed with clear glass, the transmittance of window glass is $\tau s,nor = 0.846$. The frame of the plastic eurowindows occupies 33% of the total area of the opening, therefore $\tau k = 0.67$. The value of the pollution factor for internal pollution is $\tau zi = 0.95$ for a clean interior and for external pollution it is $\tau ze = 0.9$ for an area with average pollution.

Daylight was calculated for all the rooms in the apartment without additional thermal insulation (but already with new windows), then with 150 mm of thermal insulation on the façade. Then, daylight was calculated in the living room for different widths of extension of the loggia, ranging from 200 mm to 1600 mm.

C. *Results of daylight calculations*

In the bedroom without external insulation, the minimal value of the total daylight factor was Dmin=2,5% a and the mean value Dm=2,6%, with external thermal insulation Dmin=2,3% and Dm=2,3%. In the children's room without insulation, the value of Dmin=1,3% and Dm=1,3%, with external insulation Dmin=1,1% and Dm=1,1%. Both bedroom therefore meet the daylight requirements.

In the living room, the results of daylight calculation for Variant A and Variant B are listed in Table II.

TABLE II. DAYLIGHT FACTOR OF LIVING ROOM

Extension lenght [mm]	Daylight factor					
	Variant A			*Variant B*		
	A1	*A2*	*mean*	*B 1*	*B.2*	*mean*
0, no insulation	0,9%	0,9%	0,9%	1,1%	1,0%	1,1%
0, 1 50 mm insulation	0,9%	0,8%	0,9%	1,0%	1,0%	1,0%
200	0,8%	0,8%	0,8%	0,9%	1,0%	1,0%
300	0,8%	0,8%	0,8%	0,9%	1,0%	1,0%
400	0,8%	0,8%	0,8%	0,9%	1,0%	1,0%
500	0,8%	0,8%	0,8%	0,9%	1,0%	0,9%
600	0,8%	0,8%	0,8%	0,9%	1,0%	0,9%
700	0,8%	0,6%	0,7%	0,9%	0,9%	0,9%
800	0,7%	0,6%	0,6%	0,8%	0,9%	0,9%
900	0,7%	0,6%	0,6%	**0,8%**	**0,9%**	**0,9%**
1000	0,7%	0,6%	0,6%	0,8%	0,9%	0,8%
1100	0,6%	0,5%	0,5%	0,6%	0,6%	0,6%
1200	0,6%	0,5%	0,6%	0,6%	0,6%	0,6%
1300	0,6%	0,5%	0,6%	0,6%	0,6%	0,6%
1400	0,6%	0,5%	0,6%	0,6%	0,6%	0,6%
1500	0,5%	0,5%	0,5%	0,6%	0,6%	0,6%
1600	0,5%	0,5%	0,5%	0,6%	0,6%	0,6%

For Variant A (living room separated from the kitchen), it was not possible to extend the loggia while meeting the daylight requirements. The limit values were already reached by adding the 150 mm of thermal insulation on the facade.

For Variant B, the limit width of extending the loggia was 900 mm.

IV. CONCLUSION

Leaving the original layout of apartments (Option A) does not allow extension of the loggia while complying with the requirements of the Czech legislation on daylighting in residential buildings.

Modifying the layout by removing the partition between the kitchen and the living room and replacing the opaque part of the window with clear glazing (Option B) allows the loggia to be expanded by 900 mm without compromising the requirements for daylighting and insolation of residential buildings.

It is therefore possible to extend the loggia to a total depth of 2100 mm. This size allows a residential function for four persons (the space for four persons according to ČSN 73 4305 is 2900x1700 mm). This expansion of the loggia therefore leads to a significant improvement in the user comfort of the apartment.

From a structural point of view, the expansion of the loggia by 900 mm is, after an assessment of the particular case by the structural engineer, possible by inserting the balcony construction onto the existing loggia without the need to mount another supporting structure [5].

This limit width can be achieved in this particular example when the object is located in near ideal conditions - there are no shading obstacles and the loggias are oriented to the south. Therefore, it can be assumed that in a contiguous urban structure with shading obstacles the limit extension of the loggia will be lower.

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