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THE EFFECT OF TRADITIONAL STRUCTURAL ELEMENTS OF PARTITION WALLS IN RESIDENTIAL BUILDINGS ON THE QUALITY OF THE USE OF THE PREMISES

WPŁYW CHARAKTERYSTYCZNYCH ELEMENTÓW KONSTRUKCJI PRZEGRÓD BUDYNKÓW MIESZKALNYCH NA JAKOŚĆ UŻYTKOWANIA POMIESZCZEŃ

A b s t r a c t

This paper describes the phenomenon of mould growth on the inner surface of partition walls of multi-block constructed residential buildings. An assessment was undertaken of the impact of the resulting damage, in terms of health and safety of residential premises.

Keywords: *humidity levels in partitions*, *industrialized construction*, *thermal quality*

S t r e s z c z e n i e

W artykule opisano zjawisko występowania pleśni na powierzchni wewnętrznej przegród budynków mieszkalnych, wykonanych w technologii wielkoblokowej. Wykonano ocenę wpływu występujących uszkodzeń w aspekcie bezpiecznego użytkowania lokali mieszkalnych.

Słowa kluczowe: *zawilgocenia przegród*, *budownictwo uprzemysłowione*, *jakość cieplna*

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1. Introduction

The phenomenon of mould growth on the surfaces of partitioned walls in residential premises occurs in buildings with different material and structural characteristics. Among other building types, it affects properties built in the 1970's and 1980's. Nowadays, residents in these housing estates report problems associated with poor level insulation of partition walls and instances of mould spore corrosion. Maintaining an indoor climate (temperature and humidity) at a certain level is not an insignificant factor in terms of health and safety in these dwellings.

This paper analyses the results of research into surface condensation, using humidity measurements taken on site.

2. Research subject and scope

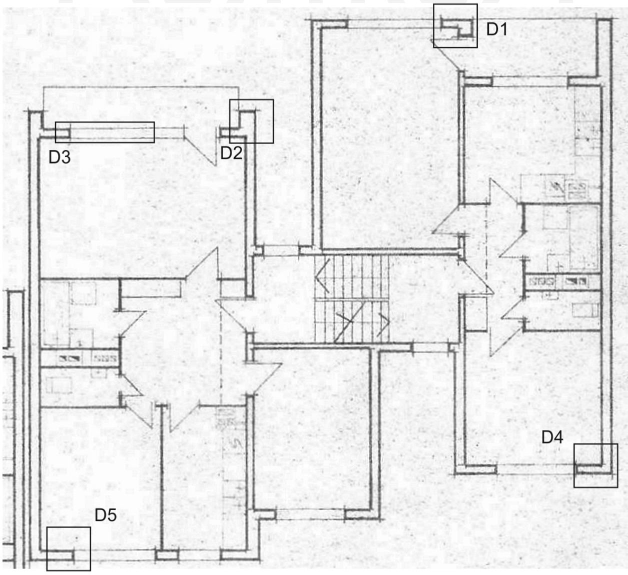
The study focused on one of the buildings of the Bytom housing estate. The selected property is a multi-block technology construction, using the WBS system – Big Silesian Block. The external construction walls are comprised of light-coloured concrete blocks, 32 cm thick, and are insulated with 12 cm PGS cladding. The curtain walls and canopy hooded walls of the vented flat roof were fortified with PGS blocks with a thickness of 24 and 19 cm. During its period of use, the building has been insulated with 5 cm thick mineral fibre panels and exterior wooden panels have been coated with asbestos-cement.

Fig. 1, 2. Bytom, view of the surveyed building, north-west elevation (1) and south-east elevation (2)

In June 2013, the building was subject to a visual inspection, in response to residents reporting a problem with mould affecting partition walls in part of the premises. The surveys confirmed that mould had affected the inner surfaces of the walls and small areas next to ceilings. Spores were located in corner positions, at the juncture of the curtain walls and external structural walls, mostly next to loggias (recessed balconies on the south-east elevation), but also on the north-west elevation.

At locations where mould had appeared, humidity readings were carried out (17 locations in all) using a TESTO 635-2 tool with a probe to measure actual humidity (manufacturer's calibration protocol No. 02356831). Moisture values were given as a percentage value expressed in relation to dry material mass. The level of humidity present on the inner surfaces where mould damage had occurred, ranged between 1.3% to 2.8%. An increase in humidity of 3.2% to 5.4% was recorded at the north-west side on the second and fourth floors.

Fig. 3, 4. The view on mould outbreaks on external walls: detail D1 (3) and D5 (4) in flats on second floor



Detail_1: connection of recessed balcony wall with curtain wall
Detail_2: connection of recessed balcony wall with curtain wall
Detail_3: connection of balcony panel with curtain wall
Detail_4: corner of wall (juncture of block wall and PGS block wall)
Detail_5: juncture of ceiling and curtain wall

Fig. 5. Sites of mould occurrence and details

This paper deals only with readings where further analysis was conducted.

Of all the spore-corroded sites, 5 construction joints were selected (Fig. 3) in order to check the likelihood of mould formation on the inner surfaces of the partition walls, using the PN-EN ISO 13788 [1] standard procedure. The temperature distribution across the surfaces/joints of the partition walls was calculated using a computer simulation, representing each of the joints. A temperature factor of f_{Rsi} was applied to calculate temperature values at the selected locations. In the simulated models, details were taken from archived project records as well as information available from the relevant standard and technical approvals.

The following thermal conductivity coefficient values were applied [1, 4]:

– Concrete blocks of light aggregate: 0.75 [W/mK],
– Gravel concrete: 1.45 [W/mK],
– Reinforced concrete: 2.20 [W/mK],
– PGS blocks 0.30 [W/mK],
– Swarf-cement panels 0,14 [W/mK],
– Cement-lime plaster 1.00 [W/mK].

Table 1

Measured moisture values, depicted by percentage weighting in relation to dry material mass

Detail	Site of occurrence	Floor	Humidity
D1	wall	1	1.8–1.9%
		3	1.9%
		4	1.7–1.8%
D2	wall	1	1.9–2.5%
		2	1.8–2.1%
		4	2.5–2.7%
D3	wall	1	1.6%
		2	1.3–1.8%
D4	wall	4	5.4%
D5	ceiling	2	5.0–5.2%

3. Measurement method

A computer program THERM 7.19 was used to assess the thermal-humidity at selected locations in the building. Temperature values for the cross-section of the partition in the joints were obtained, as were the total heat flux density and the heat transfer coefficient U (W/m^{2}K). The geometry and readings are shown in Table 2. The computer program readings were used to assign a temperature factor for the inner surface of the external wall: i.e. f_{Rsi}; in order to determine the risk of surface condensation. Calculations were made in accordance with [1]. This process was performed for two variants: for the first variant using data from

PN-82/B-02402 [2] and PN-82/B-02403 [3]; and for the second variant with local climate parameters used at the meteorological station in Katowice. The results were as follows:

– Outside air temperature: t_{e1} = –20°C; t_{e2} = –2.4°C (annual mean temperature for the coldest month);
– Internal air temperature: t_{i1} i t_{i2}= +20°C;
– Heat transfer coefficient h_e = 25 W/(m²K); h_i = 7,69 W/(m²K); providing the conditions for surface condensation 4.0 W(/m²K).

If we apply the relevant Technical Conditions [4] for a residential building with an internal temperature t_i = 20°C, and an average monthly relative 50% internal air humidity value, then we can adopt the required temperature factor value on the inner surface of external wall (of f_{Rsi}). This is equal to 0.72 and is acceptable. For the calculation of the condensation risk, an internal humidity level of 50% was adopted.

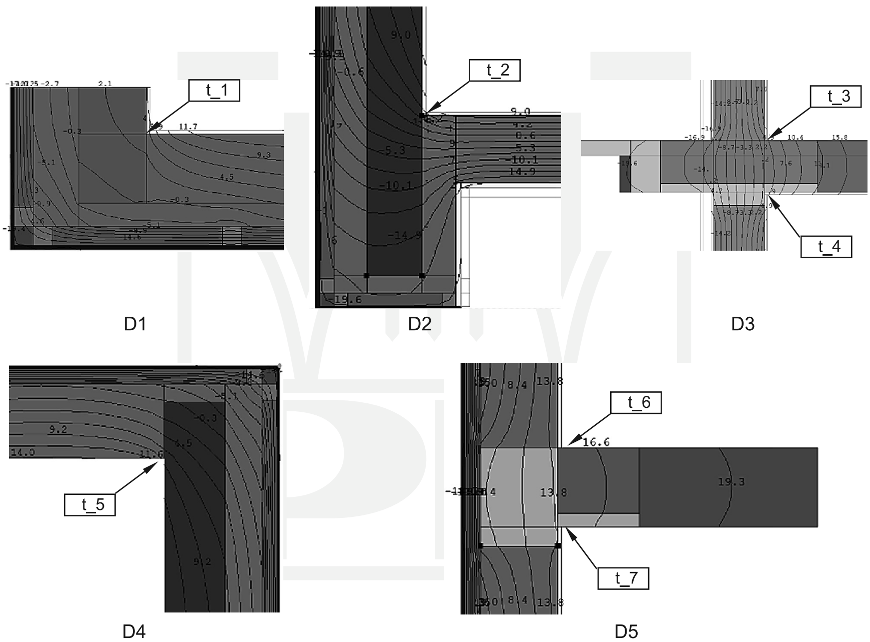


Fig. 6. Geometric models of details and locations of temperature readings

The minimum value of the temperature coefficient $f_{Rsi,\min}$ was calculated using the formula *j*:

$$f_{Rsi,\min} = \frac{\theta_{si,\min} - \theta_e}{\theta_i - \theta_e} \tag{1}$$

where:

$\theta_{si,\min}$ – minimum temperature value of the inner surface of the partition walls,
θ – external temperature,
θ_e – internal temperature.

4. Summary and results analysis

The values of the minimum temperatures in the selected joints, and the calculated temperature factors, are shown in Table 2.

Table 2

Summary of calculation results

Scheme	Surface temperature determination method	Temperature in joint [°C]		Temperature factor f_{Rsi}	
		Variant_1 $t_i = 20°C$ $t_e = –20°C$	Variant_2 $t_i = 20°C$ $t_e = –2.4°C$	Variant_1 $t_i = 20°C$ $t_e = –20°C$	Variant_2 $t_i = 20°C$ $t_e = –2.4°C$
Detail D1	t_1	4.8	11.5	0.62	0.62
Detail D2	t_2	6.7	12.4	0.66	0.66
Detail D3	t_3	4.5	11.2	0.61	0.60
	t_4	3.7	10.8	0.59	0.58
Detail D4	t_5	8.6	13.6	0.71	0.72
Detail D5	t_6	14.7	17.0	0.86	0.86
	t_7	14.4	16.6	0.86	0.84

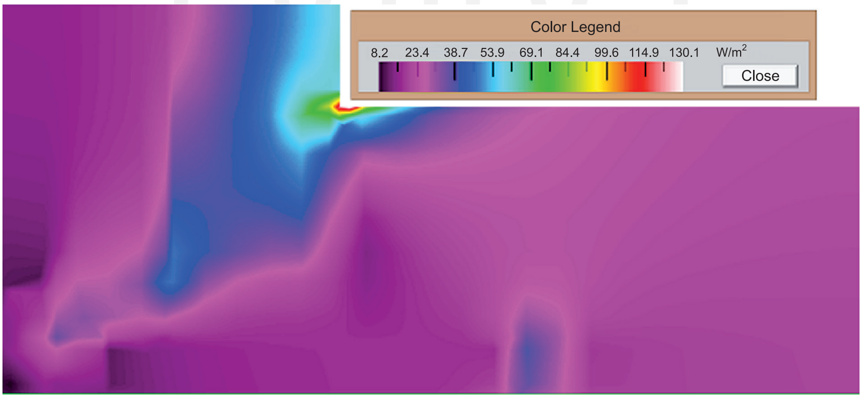


Fig. 7. An example of the heat flux density distribution in the cross-section – Detail D_1

The calculation results indicate there is a risk of surface condensation and of the formation of mould in both of the computed variants, in the joints marked D_1, D_2, and D_3. These partitions have complex material elements and characteristics. A concrete (class B20 according to the old marking) core joint, reinforced with plain bars, with favourable thermal parameters (shown in details D_1 and D_3), is in place alongside the light concrete elements of the wall. In comparison to the temperature reading of the D_1 structural wall and curtain wall combination (i.e. wall blocks with PGS blocks but without a column in the corner), the temperature at the joint was almost 2°C higher. The beneficial impact on the thermal parameters of the joint, by using gravel concrete at the juncture of the balcony panel and the external wall (detail D_5), is also apparent.

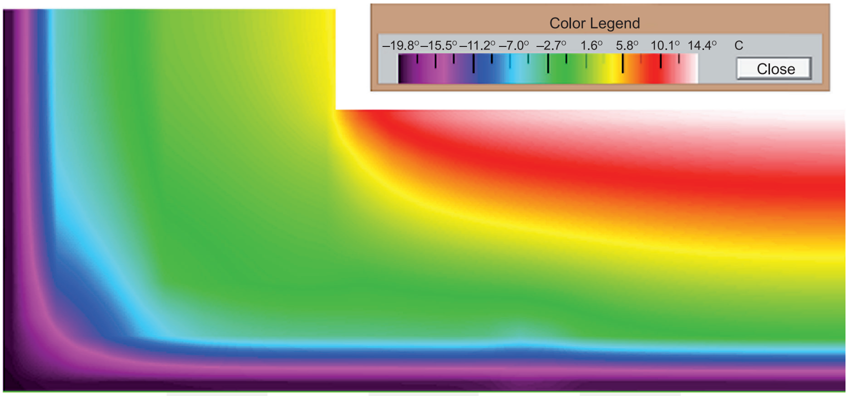


Fig. 8. An example of the field temperature distribution in the cross-section – Detail D_1

However, regardless of the theoretical computer-generated results obtained for all of the analyzed fragments of the partition walls, mould corrosion outbreaks were observed, and in the case of D_4 and D_5 ($f_{Rsi} > f_{Rsi,\max}$), humidity levels were greater on the partition wall's surface (up to 5.4%). Such high humidity levels on partition walls indicate considerable proclivity to exceptional humidity levels in the winter months when the heating system is fully functional and a lack of opportunity for drying out in the spring and summer. Operating conditions in domestic properties during these periods may differ significantly from those indicated in these calculations. This means that temperatures inside residential properties may be lower than 20°C and operating humidity levels may be higher than 50%.

The effect of partition wall design features on the quality of use of the premises, becomes more noticeable during short-term or long-term periods where relatively adverse air humidity levels are present in flats and apartments. It may also result from a lack of effective drainage of hot water vapour generated by users (e.g. due to an insufficient or inadequate air ventilation supply or a lack of a proper air outlet from the premises).

The computer model forecasts indicate that the minimum temperature factor, calculated for the local weather conditions, may reach values far higher than 0.72. As far as average monthly temperatures are concerned, the most adverse conditions occur in February, according to the meteorological station in Katowice. The temperature factor $f_{Rsi,\max}$ reaches a value of 0.832 in this period. For the D_4 building joint, such conditions favour the development of mould on the inner surface of a partition wall.

The joints most prone to humidity are located at the north-west elevation, and this may also indicate that weather conditions (rainfall and lack of sunlight) have a physical impact on the partition wall due to gaps, cracks and leaks in the building facade.

5. Conclusions

The inner surfaces of partition walls in the premises inspected suffer local and irregular occurrences of mould and excess humidity levels, which may be the result of:
– low thermal insulation of external walls;
– ineffective insulation of joints or the lack of insulation;
– adverse operational conditions at the premises, including operational temperatures lower than 20°C and relative air humidity levels inside the premises at levels higher than 50%;
– a lack of effective ventilation in the premises;
– cracks, leaks and gaps in the partition walls at the north-west elevation.

Material and structural features of partition walls can affect the quality of use of the premises. The accumulation of negative factors is most unfavourable. Residential construction works carried out in the 1970's and 1980's saw insufficient thermal insulation of external walls. This (coupled with utility factors associated with occupants' individual activities in, and use of, the premises) has encouraged the formation of mould.

References

[1] PN-EN ISO 13788 Cieplno-wilgotnościowe właściwości komponentów budowlanych i elementów budynku. Temperatura powierzchni wewnętrznej dla uniknięcia krytycznej wilgotności powierzchni i kondensacji międzywarstwowej.
[2] PN-82/B-02402: Temperatury ogrzewanych pomieszczeń w budynkach.
[3] PN-82/B-02403; Temperatury obliczeniowe zewnętrzne.
[4] Rozporządzenie Ministra Infrastruktury z dnia 12 kwietnia 2002 r. w sprawie warunków technicznych, jakim powinny odpowiadać budynki i ich usytuowanie, wraz z późniejszymi zmianami.