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AIR-SHAFTS IN THE INTERWAR PERIOD BUILDINGS AS A PROTOTYPE IDEA OF THE GROUND HEAT EXCHANGER

SZYBY WENTYLACYJNE W BUDYNKACH MIĘDZYWOJENNYCH JAKO PROTOTYP IDEI GRUNTOWEGO WYMIENNIKA CIEPŁA

Abstract

In was common practice in the inter-war years of the twentieth century, for special large cross-section ducts to be included in residential buildings, in addition to the common ventilation and plumbing shafts, as well as, in the chimneys. In residential houses, such shafts were fitted with small windows that could be opened for inspection and access. These technical features provide identical physical and thermal dynamics and effects to the core principles of a high-tech ground heat exchanger, as used in today's modern passive houses. Ventilation shaft windows located in the individual apartments in these earlier buildings were designed to provide cool air flow in the hot summer season and warm air throughout the winter months.

Keywords: air-shafts, ground heat exchanger, passive houses

Streszczenie

W okresie dwudziestolecia międzywojennego ubiegłego wieku w budynkach mieszkalnych, oprócz pionów wentylacyjnych, kominowych i instalacyjnych, dość często projektowano szyby wentylacyjne o znacznym przekroju. W mieszkaniach szyby te zaopatrywano w nieduże otwieralne okna. Zapomniane rozwiązanie techniczne wykorzystywało te same zjawiska fizyczno-termiczne, które stanęły u podstaw współczesnej zaawansowanej technologii gruntowego wymiennika ciepła, stosowanego w domach pasywnych. Okna szybów wentylacyjnych znajdujące się w mieszkaniach miały za zadanie dostarczać chłodne powietrze w sezonie upalnym, a cieplejsze z otoczenia w okresie chłodów.

Słowa kluczowe: szyby wentylacyjne, gruntowy wymiennik ciepła, domy pasywne

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1. Introduction

In the last few decades of the twentieth century, scientists and the industry became increasingly aware of the importance of the need for energy economizing, as a result of the world's dwindling natural resources, the increase in demand and the consequent higher costs of power generation and supply. This work is ongoing. It covers all areas of human activity, including the construction industry. This paper deals with one aspect of the construction process: steps to reduce energy consumption by, at the same time, maintaining stable temperature conditions in residential premises. In view of the extensive range of materials used for the fabric and insulation of the building, etc., this paper takes a narrower focus on the question of obtaining savings on heating and cooling units.

In tracing the recent history of the development of house building, we note that the latest techniques used in the construction of a passive house, rely (consciously or unconsciously) on historically-proven methods which are largely overlooked in the technical literature of today. An article by Tadeusz Niedzielski[1] in a 1914 edition of Architect Magazine [2], a monthly magazine for professionals, examined the construction of new buildings and attitudes towards the art and design of the time, and stated that the advances made in terms of knowledge and safety around the globe had led to a realization that: "health and hygiene had a psychological, as well as, a physical dimension. (...) This provides us with a fresh perspective of the Construction Act, and an important new principle: maximum sunlight and air (...) The provision of proper ventilation and modern lighting provides for most of what is known as the rear building line to a distance equal to half the height of the building, (...) In addition, we should ask whether there should be a minimum volume of air in homes. The minimum volume for an adult should not fall below 16 cubic meters. For a child under 14 years, the amount is 12 cubic meters. (...) The Progressive Building Act is a legal guide to sanitation and construction standards, and should be regarded as an ABC guide to building use by all and sundry. Such an example is provided by the London Act, which runs to some 300 pages including a number of pictures. The equivalent statute for New York is a technical masterpiece, and even small townships have extensive and comprehensive local laws restricting the licensing of contractors in the sanitation and construction industries (...).Wrote Tadeusz Niedzielski[2]. Therefore, this paper compares the cost-effectiveness and efficiency of a typical ventilation shaft, coupled with vent risers and used in the buildings of the interwar period, with the output of a modern geothermal heat exchanger, as used in passive houses and increasingly deployed in other less sophisticated buildings, in which the same physical and thermal dynamics are present.

A ground heat exchanger, also known as a ground air heat exchanger, is a system that uses the natural or artificially-controlled temperature of the ground to assist in maintaining a steady and constant temperature in the building (so that it provides a cooling effect in the summer and a heating effect in winter). This system is mainly formed of pipes made of PVC, sunk a minimum 20 cm below the frost penetration level (underneath the building), in which air circulates after being heated or cooled by a process of ground temperature absorption and storage. Polish law requires that air intake should occur not lower than 2 meters above

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[1] *Braki i niedomagania naszych ustaw budowlanych*, [w:] Architekt, r. XV, kwiecień 1914, z. 4, s. 55-66.

[2] *Ibidem*, s. 55-66.

ground level. The combined use of the solar chimney (which has been known for centuries in ancient Rome and the Middle East [3, 4]) should guarantee no additional energy needs. The solar chimney works by a process of air convection and should be made of a material that absorbs solar radiation in a vacuum. It should be located on a south-facing wall and should extend above the roof level.

2. What is an air vent and how is it defined?

The Minister of Infrastructure issued a Regulation dated 12 April 2002 [5] concerning the technical requirements for buildings and also for locations. Part IV of the Regulation (as amended) addresses technical equipment to be installed in buildings. Section 6 sets out the conditions and standards to be met by ventilation and air conditioning systems. The current regulations and standards do not define the parameters of ventilation shafts. These only give details on what calculations are required for installation. The flow rate and other factors determine the dimensions for the cross-sectional area of the tube (or funnel) for manmade exhaust and (in the case of mechanical ventilation of air conditioning). The 1928 Building Regulation [6] required further protection against moisture and the negative effects of weathering and obliged builders to make provision for reasonable facilities for heating, ventilation and airing of all living units designed to accommodate people, as well as kitchen areas, servants' quarters and toilets. It was common practice to construct ventilation shafts to meet this statutory duty[3]. Thus, the ventilation shaft can be defined as a "functional interior space in a residential building that meets the statutory requirements for heating, ventilation and aeration."

3. Shafts in residential buildings in the early twentieth century

In addition to the flue ducts and pipes to expel exhaust gases, flues from gas boilers and coal furnaces were often fitted before windows were installed, and function as the equivalent of modern day "air-conditioning". These provided a natural means of regulating the temperature inside the building, offered a constant supply of fresh air into the room (isolated from the internal partition walls which housed the exterior windows) and, to a lesser extent, controlled the temperature in the living quarters.

The number of ventilation shafts required for these purposes depends on the number of living units on each floor in a typical residential building, as well as the number of multi-

[3] Rozp. Prez. Rp. z dn. 16.02.1928 r. o prawie budowlanem i zabud. osiedli, Rozdz. 10, Art. 241.
(1) Premises designed to accommodate people, particularly living rooms, dining areas, servants' rooms, classrooms, kitchens, offices, commercial premises, premises for meetings, etc., should be effectively protected from the negative effects of moisture and pollutants and have the proper equipment for heating and ventilation.
(2) These properties should be provided with a sufficient number of windows for interior open spaces and to ensure an adequate supply of lighting and proper ventilation of the rooms in question.
(3) In rooms designed to accommodate people, the total surface area of the windows should be at least one-tenth of the floorspace area, except in cases which are detailed in Art. 325.

storey buildings in the vicinity. In the twentieth century, much of this construction work in Krakow took place in the 1930s on both sides of the natural/urban belt that delineates the Second Ring Road, together with the Slovacki, Mickiewicz and Krasinski Avenues [1]. These buildings were typically between 3–4 storeys, except at certain locations, such as road junctions where buildings overlooking intersections were built to a different size and scale. Here, the priority in terms of the urban design was given over to the junction. In the larger triple storey houses, rooms were located away from the street along a dark and unlit corridor, with access halfway down the rear passage facing an interior courtyard enclosed block. Typically, various ancillary rooms were adjacent to the corridors running the length of the boundary walls, notably: a small service room, illuminated fanlights, a walker economy kitchen overlooking the courtyard, and sanitary facilities, designed either with the first modern-era toilet, or a bathroom with a cast iron bath. Pantries and small storage units were fitted adjacent in the rear.

4. The location and construction of ventilation shafts in the structure of a residential building

The ventilation shaft was placed so that it was accessible through a small glass window (Fig. 1). Possible locations were the kitchen, bathroom and storage room. It was normal for two inspection windows to be fitted in, and one inspection window in a smaller spaced room lacking a pantry. Different types of shafts and ducts were installed in these buildings partly because of limited opportunities for ventilation. There was no other method of providing rapid exchange or air to keep the air fresh inside the property, and to maintain a ground temperature of around 8–10°C – given the Polish climate.

Fig. 1. Interior apartment view of the window

One house located in Szlak street 14B in Krowodrza district provides us with a working example. In 2005, a study was conducted into the technical infrastructure of this property, which by twenty-first century standards is well preserved. In addition to the ventilation and chimney stacks, three vertical shafts were installed each with a surface area of 0.50 m², covered by a skylight on top of the roof. These conduits provided an important source of ventilation for the bathroom, toilet and maid's room and also enabled natural light emanating from the kitchen window to illuminate the property. Subsequent repair works resulted in the removal of several windows, which may be evident of a desire on the part of the owners to extend the living space. Over time, smaller windows were bricked up, reducing the prospect of additional ventilation into more secluded rooms. This work may have allowed for additional installations to be fitted. The ground floor plan of the larger residential building units shows of the presence of two shafts (Fig. 2A, B) and a service shaft located in the corner of the courtyard balcony to bring coal from the basement up to the kitchen. We also note that there is one window in the kitchen in the smaller two-bedroom apartments.

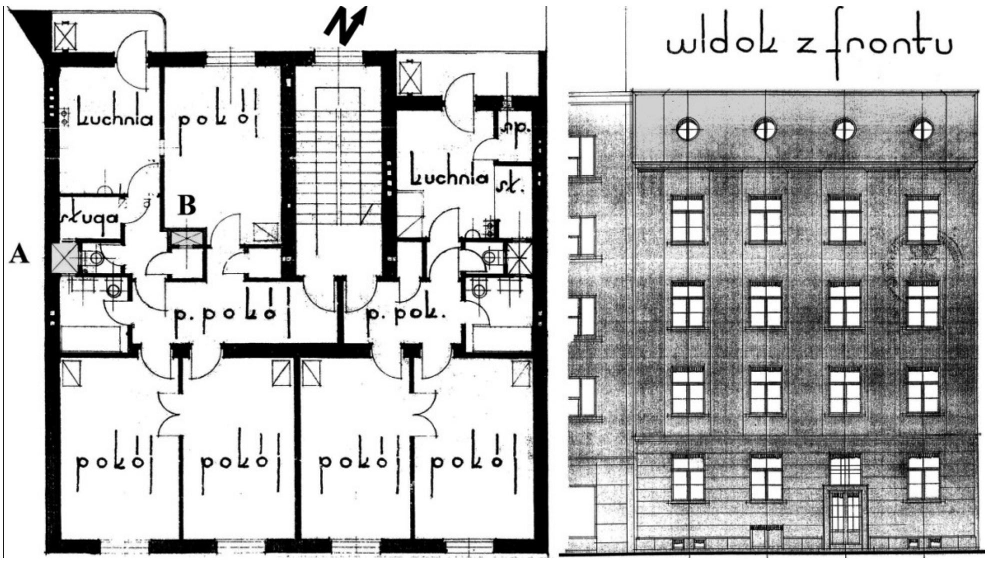

Fig. 2. Location of the air-shafts in the selected town house, 14B Szlak Street, Kraków

Shaft A, located in the western boundary wall, has three small rectangular single- framed windows opening into the bathroom, toilet and a small maid's room adjacent to the kitchen. These provide additional temperature control and ventilation capacity, as well as illumination into an otherwise dark room which has no windows in the exterior wall of the building.

Shaft B is located in the central part of the property and is serviced by two small single-rectangular windows. One of these vents is located in a small hallway connecting the kitchen to a more spacious internal central corridor. The second vent is designed to enable cool air to flow from the basement to keep the pantry at a stable temperature. The pantry is accessed from the hallway adjacent to the kitchen and the living room at the rear of the property.

Any removal of the remaining access ducts for the kitchen, bathroom and pantry by current users or buyers would be detrimental to the property. Refurbishment work was carried out and some of the original ventilation ducts were dismantled which could undermine the building.

In the process of renovating the apartment on the ground floor, builders removed the excellent and cost-effective ventilation windows, cutting the rooftop units from the apartment with the result that functionality was lost. Ventilation was reduced in bathrooms, and the lack of sufficient natural ventilation pipes in the chimney shafts of the perimeter wall caused a gradual build up of moisture in the bathrooms, toilet, maid's rooms, kitchen, pantry and hallways on all floors of the residential property. The effect is the same whether or not the shaft is plastered or is left as an exposed masonry brick wall (Fig. 3).

Fig. 3. Interior view of the air-shafts

Extensive plaster on the surface of the normative[4] is visible from the foundation level, although a hole may have been drilled in the ceiling of the basement. If so, it was located about 1 metre above the apex of the side window aperture, covered by a rooftile or glass skylight.

5. Conclusions

The inter-war construction of these shafts can now be regarded as a precursor and as a prototype for today's ground heat exchangers. This conclusion follows a comparison of operating principles, purposes and economic considerations. The shafts were sunk into the ground, using techniques and materials whose capabilities were well-known before the outbreak of World War II. The system fulfilled a similar role to the previous practice of drawing air at ground-level temperatures from the basement and into the building, but without the need for advanced technologies and materials. This simple air conditioning system was, and still remains, safe and reliable. The construction industry of today still drills wells into the ground which can be an affordable practical solution to the problem of ventilating and heating low-cost social housing, especially as the alternatives can be costly.

Air conditioning or mechanical air cooling in residential buildings occurred sporadically across Poland before 1989. This was a result of economic backwardness and the high cost of such devices. After the fall of Communism and the re-modelling of the economy, despite

[4] Rozp. Prez. Rp. z dn. 16 .02.1928 r. o prawie budowlanem i zabud. osiedli, Rozdz. 8, Art. 217-218. Art. 217. Premises not intended to accommodate people like pantry, hall, corridors, stairs, passages rinsed with water and the like, can also be lit by skylights.
Art. 218. (1) Horizontal cross-section of the skylight, where the skylight is not intended to illuminate steps should be at least 4 square meters, and the distance of opposite walls – at least 2 meters.

the rapid progress in catching up to more economically-developed countries, improvements in the standards of living did not result in modern air conditioning systems becoming as widespread as might be expected. For example, we can compare two cities with similar climate conditions: Chicago in the U.S.A. and Kraków in Poland. In Chicago, it is common for simple air conditioners to be fitted in properties in poorer neighbourhoods. In Kraków, this is rarer. The reason is the price of electricity in each country: it is twice as expensive in Poland than in the U.S.A.

If financial resources are scarce, the use of ventilation shafts presents a more affordable alternative to modern energy-intensive systems. Many people currently occupying the inter-war apartment blocks in Poland may not be aware of the purpose and benefits of the shafts. In the best case scenario, the windows were simply bricked up. In the worst case scenario, the walls were demolished and less efficient glass ceilings were installed in an attempt to gain extra living space. This practice not only led to the other occupants of the building being denied the benefits of additional ventilation from the shafts but, in the worst case scenario, exposed them to the risk of a weakened construction (eg cracking walls above the ceilings, which became evident as a result of widespread scratching scraping of the ceiling).

In view of the fact that this practice was carried out on a large scale, it is important that we remind administrators and officials that before any permissions are granted for conversion or renovation works to buildings where there is no information presented about shafts in walls rather than in partitions, checks and surveys should be carried out to analyse the impact of proposed work on the safety of the building.

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[6] Rozporządzenie Prezydenta Rzeczypospolitej z dnia 16 lutego 1928 r. o prawie budowlanem i zabudowie osiedli, Rozdz. 10, Art. 241, Dz.U. Nr 34, poz. 216.