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Glazed building wall as a solar thermal collector

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A good chance to separate thermal and living functions of the building shell appears in indirect passive systems, where absorption and accumulation of the transmitted solar energy takes place close to the wall glazing. A wall of this kind, that transmits, absorbs and accumulates solar energy becomes for a building solar thermal collector. In the whole building scale heating demand reduction, due to this passive solar system may reach 14%. Some further reduction of heating but also cooling demand will be possible when internal air exchange between distinguished thermal zones is considered. Total amount of the useful solar gains from well designed indirect system (windows) is very close to the gains attainable form large indirect system (collecting and accumulating wall). But a major advantage of the indirect system consists in significantly reduced overheating risk in winter and summer. Unfortunately, comparison of the direct solar system and collecting wall, based on combined energy use and investment costs criterion, indicates application of rationally designed passive direct systems.

Keywords: *low energy building, passive solar use, building simulation*

1. Introduction

The requirements imposed in recent years on buildings and their elements have been changing rapidly. On one hand it was a result of an intense worldwide pressure on energy saving, on the other hand it was connected with growing user expectations regarding thermal comfort conditions within the building space. Although, various aspects of low energy building have been present in Polish research and publications for many years, it would be difficult now to find explicit and reliable designing rules useful for practitioners.

1.1. Thermal balance of a low energy building

Due to increased thermal resistance of the external building shell and significant reduction of the ventilation losses, the relations between the major factors of energy balance of the modern buildings are now completely different than they were before. The averaged energy balance structure of the of 15 International Energy Agency experimental low energy buildings is shown in Figure 1 [1]. Although technical design and details of those buildings were different and some of them were located in radically different climatic conditions, important general observations may be formulated:

- solar energy is a dominant part of the balance,
- significant contribution to the balance of internal gains and heat recovery,
- reduced importance of conventional heating.

For example, in case of a German building, that was located in climatic conditions similar to Polish, conventional heating covered 25% of the total energy demand while passively gained solar energy share was 43% [1]. In case of the very well insulated Norwegian row house, located in the most disadvantageous climate (above 60ºN), heating system covered only 11% of the total demand while heat recovery 56%, internal gains 15% and sun 10%. Average structure of the energy balance and given examples show quite well an importance of the gains, that were of marginal significance before and also indicate the main directions of a further development.

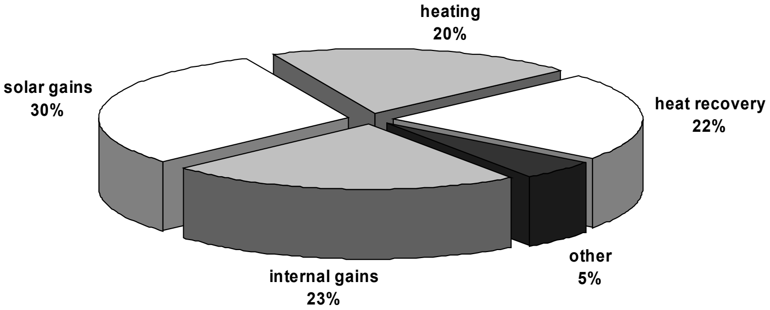

Fig. 1. Heat balance structure of the low energy IEA buildings [186]

Due to the major decrease of energy consumption, that is a result of high thermal resistance of building shell and ventilation air heat recovery, it is possible to meet considerable or even dominant portion of the heating demand with solar energy and internal gains.

1.2. Heat gains usability

Intensive solar radiation that enters highly glazed building on a sunny day or large internal gains in public use buildings does not mean that conventional heating demand will be significantly reduced. Unfortunately, a big part of these gains results in unnecessary internal temperature growth and increased heat losses [2]. Large temporary heat gains cause unacceptable space overheating and finally induce intensified ventilation or space cooling. Hence, only a fraction of the accessible thermal gains will be efficiently used to reduce heating demand.

The simplified designing tools do not consider this effect, so expected savings could be in this way overestimated and well insulated buildings would be overheated [3]. High capacity building envelope enables to store excessive internal energy gains or solar radiation for later use and reduce in this way conventional heating demand [4]. Energy storing process can be connected with temperature growth in standard massive materials, phase changing heat in PCM or reversible chemical reaction in TCM. Positive effects of heat accumulation concern not only heating energy savings but also space protection against overheating and high temperature fluctuations. Those aspects of building use are particularly important for the users and should be thoroughly considered by the designers.

In Polish standard PN-B-02025 [5] concerning heating demand calculation, monthly average value of gain utilization factor η depends only on the ratio of thermal gains and losses (*GLR*):

$$\eta = 1 - e^{-\frac{1}{GLR}}. \tag{1}$$

Calculated in this way η-factor value is equal to 100% when thermal gains are negligible, for *GLR* = 1.0 it is reduced to 63% and for *GLR* = 2.0 it is only 39%. Because η-factor value does not depend on space thermal capacity, it will be identical in case of lightweight wooden structures and massive concrete or brickwork structures. It may encourage inexperienced designer to increase unlimitedly glazed areas in order to maximize solar fraction, but in fact heating and cooling demand would grow significantly in this situation.

In European standard EN ISO 13790 [6] utilization factor depends not only on *GLR* but also on envelope thermal capacity expressed by means of time constant τ:

$$\tau = \frac{C}{H}, \tag{2}$$

where:

C – internal heat capacity,

H – heat loss coefficient.

Although improved algorithms better describe thermal characteristic they can not substitute specialized designing procedures or tools that allow undertaking reasonable decisions and optimizing passive solar system in a simple but efficient way. According to Hastings [3] old procedures of building design, developed even twenty years ago, when insulation standards, user expectations and technical measures were completely different than nowadays, are still in use.

According to author's intention, below presented results should be a simple tool for energy aware designer of indirect passive solar system.

2. Collecting and accumulating solar wall

Greenhouse effect, based on the spectrally differentiated radiation transmittance of the glass, is the background of the building solar gains. Energy collecting aspect may clash with the basic living functions of the building space and its thermal comfort. This conclusion especially concerns the passive direct systems (large window areas), in which the users are exposed to large temperature fluctuations and over lighting conditions [2]. Direct and diffused solar radiation, absorbed by the clothes or human skin may result even in 10 K increase of operative temperature [7].

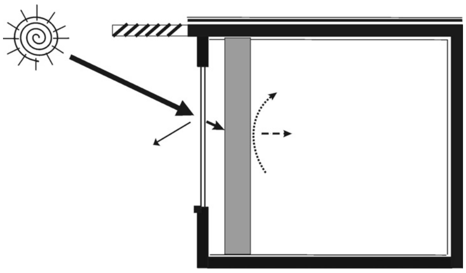

Fig. 2. Scheme of the solar energy gains in indirect passive solar system

A good chance to separate energy and living functions of the building shell appears in indirect passive systems, where absorption and accumulation of the transmitted solar energy takes place close to the wall glazing. A wall of this kind, that becomes a solar thermal collector for a building, will be further shortly called CASW (Collecting and Accumulating Solar Wall).This system is often called Trombe wall, after the first designer [2].

Thermal efficiency of the indirect system is usually lower than that of the direct system [8]. But due to the increased use inconvenience in spaces with the large glazed openings, window area must be limited, while Trombe wall area may be kept pretty large. More efficient solar energy use is achieved when heat from the indirect system is evenly distributed throughout the building space or when the more complicated hybrid systems is introduced.

2.1. Dynamic simulation model

Finite differences method and electric network analogue have been used to create a simple dynamic CASW simulation model. The derivatives used in basic differential heat transfer equation are here replaced with differences of the respective quantities in the defined time steps. Wall materials are replaced with a discrete network consisting of the nodes without thermal capacity (surface nodes) and with thermal capacity (internal nodes). Heat exchange between the nodes takes place via the material or surface resistances. Nodal temperature is a result of the balance of incoming and outcoming heat fluxes, i.e. heat exchange between the neighboring nodes, solar radiation in case of the surface nodes and accumulated heat flux in case of the node with thermal capacity.

Because the initial temperatures are not known usually, so calculations are being repeated long enough to achieve fully repeatable and independent of the initial values cycles.

Temperature of the node i that belongs to one dimensional network and at the moment $p+1$ may be derived from general Equation [7]:

$$T_{i,p+1} = \frac{\Delta t}{C_i} \cdot \left(q_i + \sum_j \frac{T_{j,p} - T_{i,p}}{R_{i,j}} \right) + T_{i,p}, \tag{3}$$

where:

Δt – time step,

C_i – i-node thermal capacity, equal to the product of density, specific heat and volume,

q_i – heat flux density (e.g. solar radiation),

T_{jp} – j-node temperature at the moment p, node j is in thermal contact with node i,

R_{ij} – thermal resistance between nodes i and j,

Convergent solution in explicit computational diagram will be found when time step meets the following condition [9]:

$$\Delta t \le \min \left[C_i \cdot \left(\sum_j \frac{1}{R_{i,j}} \right)^{-1} \right]. \tag{4}$$

Physical sense of expression in parenthesis corresponds with the time constant of capacity C_i.

2.2. Computational wall diagram

The analyzed wall has been divided into four layers: two thin layers at the edges and two thick internal layers of the same thickness. It was assumed that glazing has no thermal capacity but only thermal resistance. There is a closed air gap between glazing and accumulating wall. Internal air temperature is being kept at the same level, external environment conditions (ambient air temperature and solar radiation) are combined in equivalent solar temperature T_{eq}. Momentary equivalent solar temperature value is calculated as the sum of ambient air temperature harmonic function and positive values of solar radiation harmonic function. The values of the glazing solar transmission coefficient, insulation and airspace thermal resistances and solar radiation absorption are constant.

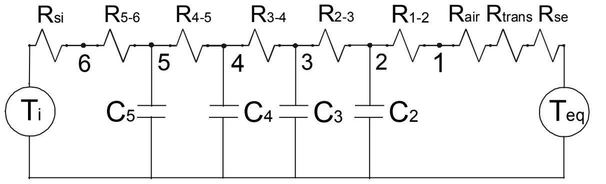

Fig. 3. The simulation diagram of the wall [7]

$$R_{e-1} = R_{se} + R_{\text{trans}} + R_{\text{air}}, \tag{5}$$

where:

R_{se} – external surface resistance,
R_{trans} – glazing thermal resistance,
R_{air} – airspace thermal resistance.

$$R_{e-2} = R_{e-1} + R_{1-2},$$

$$R_{i-5} = R_{5-6} + R_{si},$$

where:

R_{si} – internal surface resistance,
R_{i-j} – thermal resistance between nodes i and j, equal to quotient of the material thickness between nodes i and j and its thermal conductivity.

Nodal temperatures are determined by the following Equations [7]:

$$T_{2,i+1} = \frac{\Delta t}{C_2}\left(\frac{T_{eq}(i\cdot\Delta t) - T_{2,i}}{R_{e-2}} + \frac{T_{3,i} - T_{2,i}}{R_{2-3}}\right) + T_{2,i},$$

$$T_{3,i+1} = \frac{\Delta t}{C_3}\left(\frac{T_{2,i} - T_{3,i}}{R_{2-3}} + \frac{T_{4,i} - T_{3,i}}{R_{3-4}}\right) + T_{3,i},$$

$$T_{4,i+1} = \frac{\Delta t}{C_4}\left(\frac{T_{3,i} - T_{4,i}}{R_{3-4}} + \frac{T_{5,i} - T_{4,i}}{R_{4-5}}\right) + T_{4,i},$$

$$T_{5,i+1} = \frac{\Delta t}{C_5}\left(\frac{T_{4,i} - T_{5,i}}{R_{4-5}} + \frac{T_i - T_{5,i}}{R_{i-5}}\right) + T_{5,i}, \tag{6}$$

$$T_{6,i} = T_i + R_i\left(\frac{T_{5,i} - T_i}{R_{i-5}}\right),$$

$$T_{1,i} = T_{2,i} + R_{1-2}\left(\frac{T_{eq}(i\cdot\Delta t) - T_{2,i}}{R_{e-2}}\right).$$

Simulated Trombe wall consists of:

- double standard glass with solar transmission coefficient equal to 0.710,
- concrete accumulating mass 23.5 cm thick; concrete density 2400 kg/m^3, specific heat 1000 J/(kgK), thermal conductivity 2.0 W/(mK), solar absorption coefficient 0.95.

Concrete accumulating mass was divided in two surface layers, each 3 cm thick and two internal layers, each 8.75 cm thick. It was proved that simulation results are not very sensitive to wall division. Modification of the edge layer thickness within the range of 1 cm to 8 cm and constant total wall thickness did not result in any significant heat balance change.

The smallest time constant of the single layer capacity is 1746 s, while time step used in simulations is ca. 3 times shorter and equal to 600 s.

Ambient air temperature is a sinus function with mean temperature –3 °C and oscillation amplitude 6 °C, solar radiation intensity is also a sinus function with mean value 0 W/m^2 and amplitude 550 W/m^2. Internal air temperature is constant and equal to +20 °C.

Temperature distribution during the sunny winter day within the CAW section with standard double glazing is shown in Figure 4. Presented data were preceded by the 5 day simulation period to achieve fully repeatable results.

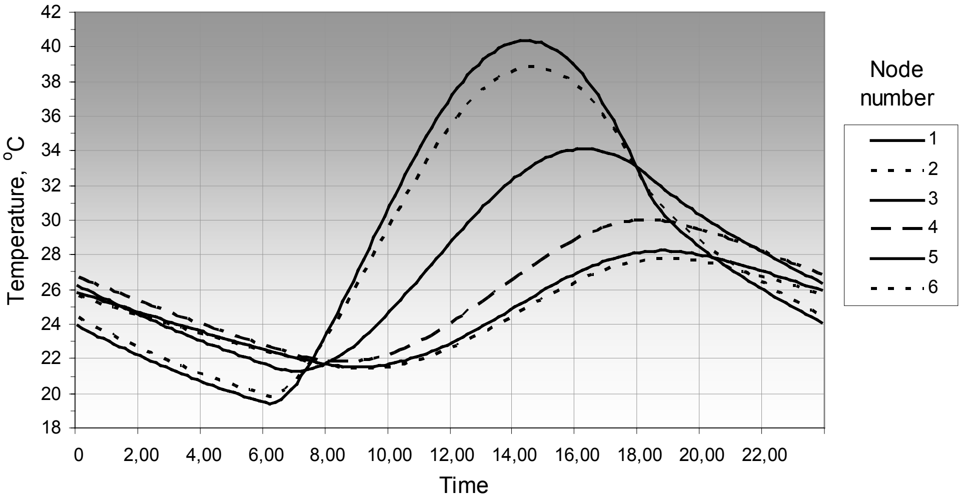

Fig. 4. Temperature distribution within the wall section during the sunny winter day, standard double glazing

External equivalent temperature wave (node 1) is gradually damped, smoothed out and shifted within the concrete wall. Internal surface temperature curve is fully sinusoidal.

2.3. Glazing with improved thermal resistance

Former research works proved that standard glass with low thermal resistance is not suitable for the low energy systems. Glazing systems with enhanced insulating features were used in further research [10]:

- "LE" – double glazing with one low emissivity coating and xenon, *U* value equal to 1.082 W/(m^{2}K) and total solar transmittance 0.595,
- "LE+" – double glazing with two low emissivity coatings and xenon, *U* value equal to 0.915 W/(m^{2}K) and solar transmittance 0.516,
- "Therm" – triple glazing with double LE coating and crypton, *U* value equal to 0.627 W/(m^{2}K) and solar transmittance is 0.472.

Temperature fluctuations of the internal surface of the storage wall have been shown in Figure 5 for three types of glazing and two weather cases: sunny and cloudy winter day.

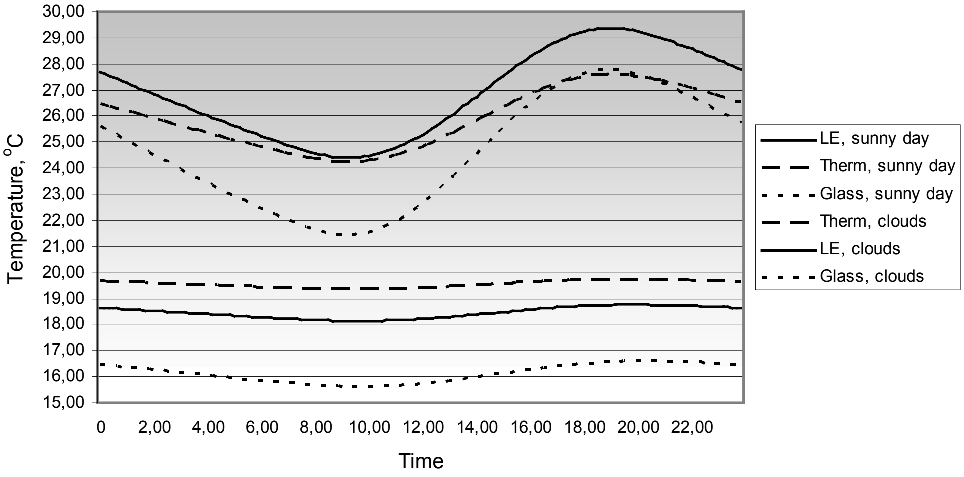

Fig. 5. Internal surface temperature during the sunny and cloudy winter day

Solar intensity amplitude on a sunny day, 550 W/m^2, is ten times bigger than that on a cloudy day. Due to the low insulating capability of the standard glazing, wall surface temperature is lower than in the other cases, in spite of high solar transmittance of "Glass" panes. "LE" glazing, with higher than "Therm" solar transmittance, enables to achieve better results on a sunny day, but on a cloudy day triple glazing outperforms the others.

To facilitate further comparisons it was assumed that wall performance will be described by the total surface heat flux balance for a sunny and cloudy day, Figure 6. In case of "LE" and "Therm" glazing heat balance difference was merely 3 ‰. It means that those two glazing systems are practically equivalent to each other in sense of energy saving but different in sense of investment cost.

During the highly advantageous sunny day conditions, in spite of the low ambient temperatures, heat balance is positive, i.e. gains are bigger than losses, for all investigated glazing systems. In these conditions CASW is a source of the net heat gains for a space. On a cloudy day heat balance is in every case negative, but distinctly diverse according to glazing insulating characteristic.

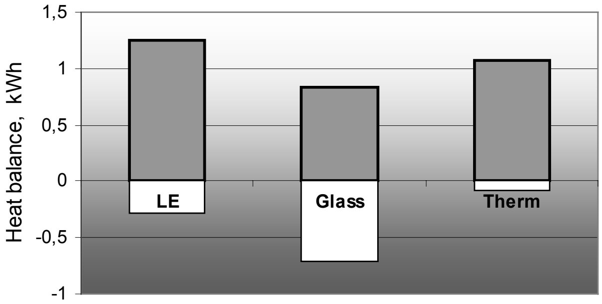

Fig. 6. Internal surface heat balance for a sunny (grey bar) and cloudy (white bar) day

Another, commonly used way of description of the resultant thermal performance of the wall is so called equivalent heat transfer coefficient U_{eq}, In the same way as above heat balance, it combines in one number heat gains and losses. Negative U_{eq} value responds to prevailing gains. Sunny day U_{eq} values for collecting and accumulating wall have been shown in Figure 7. The most beneficial sunny day results could be achieved in case of the wall with "LE" glazing (not "Therm"), as it was also shown before in Figure 6.

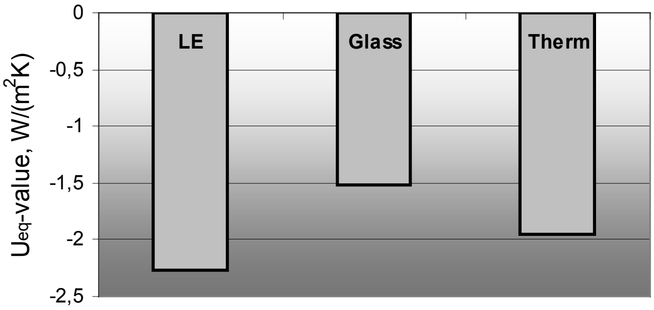

Fig. 7. Equivalent sunny day *U*-value

3. Long term simulation in EnergyPlus

The simple simulation model that was described in former section allowed to analyze only energy performance of a separate wall fraction in the selected boundary conditions. However the most important information for a user or designer concern usable heat gains in a whole space or even building, during the whole heating season and in real weather conditions.

One of the largest and newest simulation programs nowadays, is an American program called EnergyPlus. It was released by the American Department of Energy, its agencies and other partnering institutions, it enables dynamic simulation of a whole building and its installations [11, 12].

A geometrical outline of the portion of the building that was simulated in Energy Plus is shown in Figure 8.

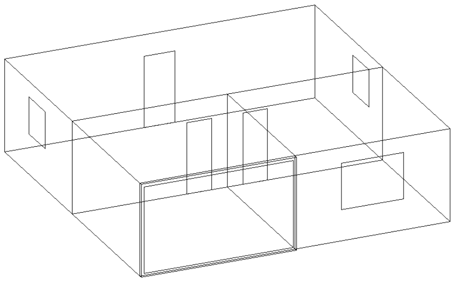

Fig. 8. Collecting and accumulating wall in south-west zone of the simulated building

It may be a storey of a single-family building or, after slight modifications a repeatable unit of a multi-storey residential or office building. Although the dimensions of the entire floor area of the unit are 10 by 10 by 3 m, the main object of the simulation reported in this paper is the unit's south-west part only (modeled as a separate thermal zone), with horizontal dimensions 5 by 5 m and a height of 3 m. Thermal insulation thickness of external walls is 20 cm and roof 25 cm. Minimum internal air temperature during the heating season is constant and equal to +20 °C. When air temperature tends to exceed +25 °C cooling system will be switched on. Ventilation rate is kept at the fixed level of 0.6 h^{-1} with seasonal average heat recovery efficiency equal to 50%. Index *E*, equal to ratio of the seasonal heat demand and floor area is a measure of heating demand and corresponding index *EC* is a unit measure of seasonal cooling demand.

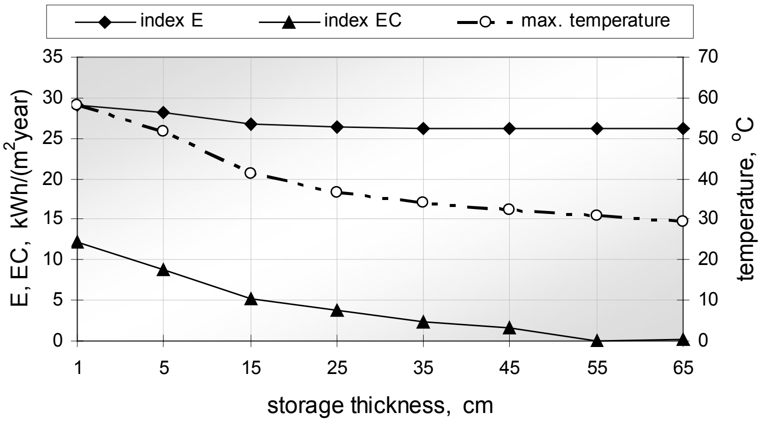

Fig. 9. Index *E*, *EC* and maximum temperature of internal CAW surface *vs*. the concrete storage thickness, "LE" glazing system

Relationship between indexes *E* and *EC* and concrete storage thickness has been shown in Figure 9. The third dashed line in Figure 9 is maximum temperature of the accumulator internal surface (right vertical axis). A 25 cm thick concrete storage is practically sufficient to minimize seasonal heating demand of the analyzed space. Further increase of the concrete thickness would only reduce space overheating (*EC* index) and maximum temperature of the surface.

Total heating demand reduction due to massive concrete storage is not very significant, ca. 10% of initial value. Essential importance of accumulator thermal capacity consists in distribution of the solar gain flux beyond sunshine period and maximum temperature decrease.

Further results of CASW modifications are collected in Table.

Table. Influence of glazing system features on CAW heat gains

Glazing	Maximum temperature of concrete external surface	Maximum temperature of concrete internal surface	Seasonal heating index E	Average heating power	Seasonal cooling index EC
	^{o}C	^{o}C	kWh/(m^{2}year)	W	kWh/(m^{2}year)
Glass	65.59	34.76	41.01	176	2.68
LE	60.51	34.14	26.26	113	2.48
LE+	55.16	32.65	27.07	116	1.39
Therm	56.73	33.61	19.46	83	2.86

Although increased thermal resistance of the glazing is usually combined with decreasing solar radiation transmittance, seasonal heating index is significantly reduced. Exchange of standard glazing Glass for three panes Therm glazing results in 53% reduction of the space heating demand. In case of commonly used nowadays glazing “LE” reduction is 36% of the initial value and in case of “LE+” 34%. The best protection against overheating may be achieved by means of “LE+” glazing (reduced solar transmittance due to double “LE” coating). Considering combined criterion of energy performance (heating + cooling), the most advantageous is “Therm” glazing, followed by “LE+” and “LE”. Because in simulation model neither solar shading nor increased ventilation and internal air mixing between zones have been introduced as protection against overheating, with those measures it will be possible to avoid completely overheating shown in last column of Table.

Thermal efficiency is an important parameter of the passive solar system. Sound information regarding system's efficiency would allow even inexperienced designer to evaluate heat balance of the designed space without detailed simulation. Thermal efficiency of a collecting and accumulating wall was defined in a following way:

$$\eta = \frac{Q_{loss} - Q_{heat}}{J_{vert}}, \tag{7}$$

where:

Q_{loss} – total heat losses,

Q_{heat} – conventional heating demand of the space (overheating excluded),

J_{vert} – solar radiation intensity on vertical south-oriented surface.

The efficiency lines of the direct passive systems (windows) and indirect passive system (CASW) have been presented in Figure 10. Thermal efficiency η is shown as a function of the ratio of solar intensity J_{abs} and temperature difference T_i and T_e. Efficiency values were calculated in monthly steps and finally correlated. For the all analyzed cases linear correlation was very strong ($R^2 > 0.91$).

It may be easily observed, that solar gain use for space heating is distinctly differentiated throughout the year. In transition periods, with relatively high ambient temperatures and intense solar radiation, system's efficiency is usually low. On the other hand, low supply of solar radiation is usually connected with high system's efficiency. Because of this variation designing calculations should be repeated on a monthly basis [4].

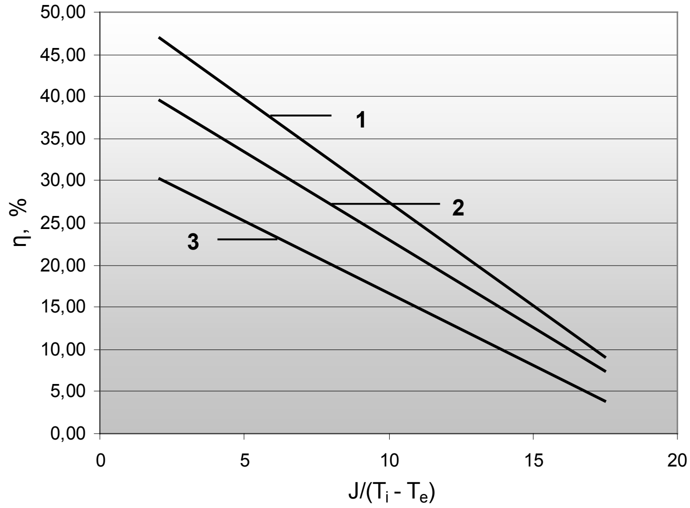

Fig. 10. Thermal efficiency vs. solar intensity and temperature difference ratio, 1: 6 m^2 window with "LE" glazing and massive building shell, 2: 6 m^2 window with "LE" glazing and lightweight building shell, 3: collecting and accumulating wall with "LE" glazing

Data presented in Figure 10 confirm that direct system thermal efficiency is higher than in case of indirect one. Discrepancy between lines 1 and 3 is particularly big in conditions of low solar radiation supply. Lines 1 and 2 show also influence of building shell thermal capacity on direct system efficiency.

Efficiency lines shown in Figure 10 may be used as a simple but very convenient designing tool for passive solar systems.

4. An example of practical modification of the indirect passive system

Passive solar systems are often modified in practical implementation because of thermal, technical or esthetic reasons. Introduced modifications may result in a hybrid system that is a combination of the features and advantages of the direct and indirect systems.

In world literature it is easy to find for example a rough description of the system in which continuous brickwork storage wall was substituted with water columns or horizontal water tanks with solar gaps between them [13]. In the other examples diode water tanks or hybrid solutions with forced air flow inside of the brickwork accumulator were used [14]. But detailed technical reports covering system specification or energy performance are usually not available.

An example of the simple indirect system modification is shown in Figure 11.

Fig. 11. Hybrid version of the modified CASW, external view on the left side, internal view on the right side

The narrow vertical element, that is a fireplace chimney shaft, was located closely to the large south window as in a typical indirect system. But the 35 cm airspace between the standard double glazing and the brickwork accumulator is fully opened to the attached room. Brickwork surface is painted dark green to enhance absorption of the solar radiation.

To investigate and illustrate heat accumulation process in the brickwork shaft, a short monitoring of the surface temperature and heat flux has been conducted.

Brickwork surface temperature and heat flux values during the 24 h sunny period are shown in Figure 12.

Surface temperature stratification at three points may be easily noticed during the early hours, when the temperatures are heading toward daily minimum, Figure 12a.

During the next few sunshine hours all the temperatures are practically equal until partial wall shading caused by the external structural elements takes place. During the sunny day surface temperatures are higher than internal air temperature but shortly after the sunset they fall down below air temperature due to the intensive long wave radiation exchange with standard glazing. As expected, accumulator location close to the poorly insulted glazing surface is connected with increased heat losses, comparing with heat accumulation in internal building shell.

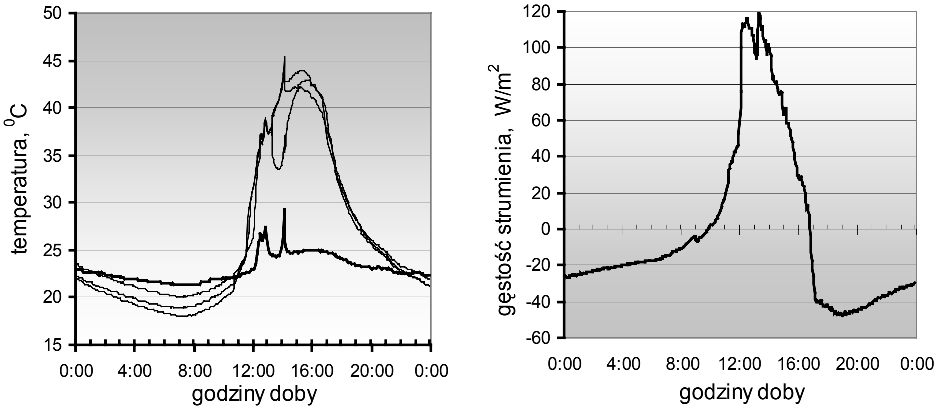

Fig. 12. a) internal air and brickwork accumulator surface temperatures, b) heat flux density

Time shift of the heat flux and temperature waves, connected with the brickwork surface thermal admittance, is equal to 2.5 h and matches the calculation results for 14 cm wall (12 cm brick and 2 cm plaster) at harmonic boundary conditions well [15].

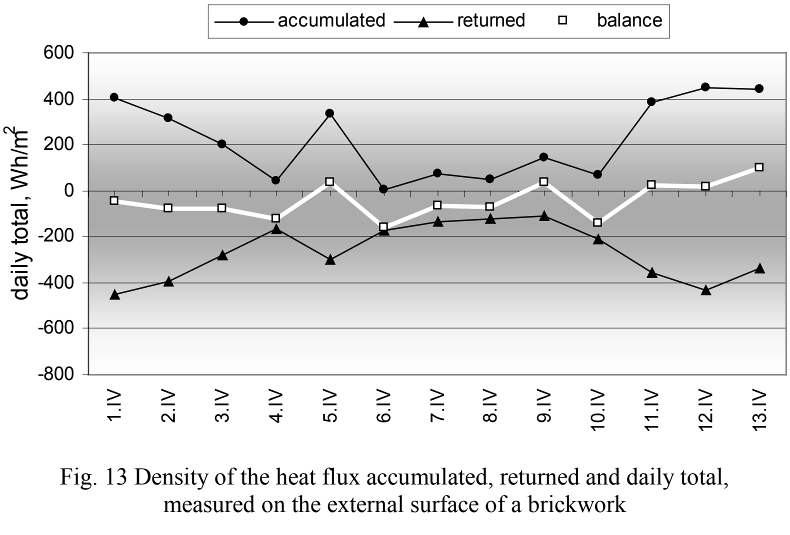

Fig. 13 Density of the heat flux accumulated, returned and daily total, measured on the external surface of a brickwork

Thermal capacity of the brickwork accumulator exposed to the 24 h harmonic oscillations (compatible with Balcomb's *dhc* value [4]) was calculated as a ratio of measured flux density and daily temperature amplitude. Calculated dynamic capacity value 55.47 kJ/(m^{2}K) was close to the number given for brickwork walls by Kossecka [16].

There is no full symmetry of the flux density accumulated and released from the brickwork storage surface, Figure 13. Thermal balance of the whole monitoring period was negative, i.e. accumulator heat losses were bigger than the absorbed solar radiation.

Short time monitoring data does not allow to answer the important questions regarding the system's long-range results and usefulness. Considering the manner of operation, this kind of design may be treated as a transition version between internal storage, fully enclosed in building space and typical CASW system with air gap separated from the building interior.

5. Summary

5.1. Energy gains

The thickness of the accumulating wall and its thermal capacity affects not only solar heating fraction but also a large extent protection of the space against overheating. On the grounds of conducted simulation it may be determined that 35 cm is a rational maximum concrete storage thickness.

Since standard glass use without selective coating is not reasonable here, highly insulating glazing systems are advised. Glazing thermal resistance has a significant positive influence on space heating demand. Because higher thermal resistance of a glazing is usually connected with decreased solar radiation transmittance, so overheating load is practically not rising. Two-chamber and triple-pane glazing Therm would reduce heating demand of adjacent space by 58% comparing to opaque well insulated wall and by 53% comparing to CASW with standard glazing system. In the whole building scale heating demand reduction may reach 14%. Further reduction of heating but also cooling demand will be possible when internal air exchange between distinguished thermal zones is considered.

Total amount of the useful solar gains from a well designed indirect system (windows) is very close to the gains attainable from a large indirect system (collecting and accumulating wall). The major advantage of the indirect system consists in significantly reduced overheating risk in winter and summer. This statement concerns systems with and without external shading elements.

5.2. Economic aspects of CASW use

Analysis presented above allows to compare the solar systems on energy basis and introduce thermal evaluation of the detailed solutions. But in fact potential investors are concerned not only in energy performance characteristic but mostly in economic aspects of their investments.

Indirect system in form of a collecting and accumulating solar wall, which is composed of large area glazing with thick and heavy storage, is doubtlessly much more expensive than regular window with 50% smaller area. Extra investment cost would be connected not only with the cost of the massive wall construction but also with the floor area covered by the storage [17]. There are no fully convincing reasons to justify high extra costs with small energy savings and improved protection against overheating. Payback period of this kind of investment would be higher than 20 years and not encouraging for a potential user.

Combined criterion comparison of direct solar system and CASW, regarding energy use and investment costs, indicates application of rationally designed direct system which would minimize space heating demand and ensure thermal comfort in summer.

Nevertheless, collecting and accumulating solar wall can be an important alternative for modern high quality buildings with big glazing area. Well designed wall offers energy efficiency and high standard thermal comfort, very important in public, commercial or exhibition buildings.

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Przeszklona ściana jako kolektor energii słonecznej dla budynku

Mniej uciążliwym dla użytkowników niż okno, źródłem zysków słonecznych jest masywna przegroda nieprzeźroczysta, od zewnątrz osłonięta zestawem szyb, nazywana przegrodą kolektorowo-akumulacyjną. W artykule sprawdzano jej przydatność w naszym klimacie i poszukiwano rozwiązań gwarantujących najlepsze rezultaty energetyczne. W skrótowy jedynie sposób przedstawiono wyniki analiz, m.in. wykresy, pozwalające na określenie sprawności cieplnej tej przegrody, a w efekcie udziału energii słonecznej w pokrywaniu zapotrzebowania na ogrzewanie. Wykresy tego typu mogą stanowić prostą pomoc we wstępnych analizach projektowych.

Uzyskane wyniki obliczeń symulacyjnych przekreślają praktycznie sens stosowania przegrody kolektorowo-akumulacyjnej ze zwykłym oszkleniem i bez izolacji termicznej. Istotną poprawę właściwości tej przegrody można uzyskać dopiero po zastosowaniu izolacyjnych zestawów szybowych.

Biorąc pod uwagę łącznie ogrzewanie i przegrzewanie wnętrza, najbardziej korzystną kombinację właściwości mają zestawy szyb o najwyższej izolacyjności termicznej. Wykazane w obliczeniach przy bardzo niekorzystnych założeniach, ograniczone przegrzewanie wnętrza w obiektach prawidłowo zaprojektowanych, może być w praktyce usunięte poprzez intensywniejszą wentylację lub wewnętrzną wymianę ciepła w budynku.

Główną zaletą przegród kolektorowo-akumulacyjnych jest ochrona warunków termicznych we wnętrzu, poprzez wygładzanie wahań pozyskiwanego strumienia energii słonecznej. Jednak związane z tym oszczędności eksploatacyjne nie uzasadniają w przekonywujący sposób znacznych różnic inwestycyjnych. Porównanie PKA z oknami, w oparciu o łączne kryteria energetyczne i inwestycyjne, sugeruje, więc raczej stosowanie okien o precyzyjnie dobranej i mniejszej niż przegroda kolektorowa powierzchni, gwarantującej niskie zapotrzebowanie na ogrzewanie i poprawne warunki termiczne w okresie lata. Przegroda kolektorowo-akumulacyjna może stanowić natomiast uzupełnienie czy nawet alternatywę dla obficie przeszklonych wnętrz, zwłaszcza w wysokiej jakości budynkach użyteczności publicznej, handlowych, wystawienniczych itp.