ASOCIAȚIA INGINERILOR DE INSTALAȚII DIN ROMÂNIA
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UNIVERSITATEA "POLITEHNICA" DIN TIMIŞOARA
Departamentul de Construcții Civile şi Instalații

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CUVÂNT ÎNAINTE

Calitatea mediului ambiant din clădiri este un domeniu de mare importanţă pentru sănătatea oamenilor. Larga arie de investigare referitoare la confortul termic, ventilare – climatizare şi calitatea aerului, efectul pozitiv/negativ al apei, sănătatea şi siguranţa ocupanţilor/clădirilor, modelarea şi monitorizarea, toate în dinamica schimbărilor climatice şi ţinând seama de sustenabilitatea soluţiilor, precum şi de dezvoltarea socioeconomică, conduce, pe lângă colaborarea cu alte specialităţi, la necesitatea/obligativitatea schimburilor de experienţă a celor ce s-au dedicat ştiinţei instalaţiilor pentru construcţii. Dorinţa de mai bine, experienţa anterioară izvorâtă din dictonul « Homo sanus in domo pulchra » şi din paradigma interdisciplinarităţii, înţelegerea holistică a multitudinii de factori/vectori care influenţează confortul, efectele care rezultă asupra oamenilor şi clădirilor, ne-au determinat şi ne motivează să continuăm. Să continuăm a dezvolta şi motiva teorii, în a oferi soluţii şi tehologii, dar şi în a le impune (aceasta însemnând continuarea solicitării sprijinului legislativ/politic, la toate nivelurile – ca exemplu pozitiv, deşi nu ne aparţine nouă, românilor, menţionăm restricţiile referitoare la fumat). Să continuăm : a căuta soluţii care să răspundă dezvoltării sustenabile ; provocărilor date la schimbările climatice ; a găsi tehnologii şi materiale nepoluante care să protejeze consumatorii ; să promovăm energiile curate/neconvenţionale ; să asigurăm flexibilitatea funcţională a instalaţiilor ; să punem OMUL înaintea altor interese.

În concluzie, continuarea înseamnă aprofundarea cunoştinţelor şi diversificarea preocupărilor, respectiv, ca alternativă, lucru în echipe interdisciplinare, înseamnă oportunităţi şi atragerea de noi specialişti talentaţi, dar şi rezolvarea nevoilor sociale (sau măcar răspunsuri pentru acestea) ; înseamnă a acorda atenţie OMULUI prin confortul ambiental, a-l susţine prin a-i asigura noi surse/resurse de energie, prin a-l sprijini să îmbunătăţească/protejeze mediul înconjurător, prin a-i oferi, gradual, educaţia care să-l îndreptăţescă a se considera stăpân pe toate.

Pentru toate acestea, instalatorii în colaborare cu toţi cei care îşi doresc o viaţă mai bună, dată de confort, siguranţă, performanţă, şi-au unit eforturile (inspirate) în elaborarea a 58 lucrări valoroase, repere pentru activităţile viitoare. Aducem călduroase mulţumiri celor 107 autori/coautori care au înţeles importanţa cuvântului scris în împărtăşirea experienţei.

Prof. Adrian RETEZAN

only when the reflector is left in EWGα plane and right in NSGα plane relative to the collector. For other reflector-collector positions the rules from Table 3 given in [6].

3. Conclusion

In this paper the mathematical model for determining the irradiated area of the LAS of the BFPC, when the impact of the LCE is included, is presented. The LCE are the integral part of every flat-plate solar collector. It means that they will always affect the formation of the irradiated area of the LAS. Because of that, the size of the irradiated area is always less then the size of the same area when the impact of the LCE is neglected. It should be noted that the impact of the LCE increases when the dimensions of the collector decrease if the dimensions of the LCE do not change.

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OPTIMISATION OF THE DEPTHS OF HORIZONTAL ROOF OVERHANGS DURING A COOLING SEASON

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Abstract

This paper presents the simultaneous optimization of the depths of the horizontal roof overhangs for the retrofit of a residential house for house operation during cooling season. The overhangs are made by using reinforced concrete. The optimization objective is to minimize the sum of the primary operative energy consumption during the overhang lifecycle and the embodied energy in the roof overhangs. The house is located in Belgrade, Serbia. The overhangs face north, south, east, and west. For the optimization, Hooke-Jeeves method is used with GenOpt code. The EnergyPlus software is used to simulate energy behaviour of the house.

The depths for east and west facing optimized overhangs are longer than that for the south facing optimized overhang. The north facing overhang almost does not exist. The optimized overhangs during the cooling season may achieve savings in the total energy consumption by 3.20% when compared to the custom overhangs.

Rezumat

În această lucrare se prezintă optimizarea lățimii consolei orizontale a acoperișului pentru reabilitarea clădirilor rezidențiale pentru perioada rece. Consola este realizată din beton armat. Optimizarea obiectivă este de a minimiza consumurile primare de energie operative pe *perioada ciclului de viață la console și energia înmagazinată în consola acoperișului. Casa este situată în Belgrad, Serbia. Console sunt pe fața nord, sud, est și vest. Pentru optimizare, s-a utilizat metoda Hooke - Jeeves cu ajutorul softului GenOpt. Programul EnergyPlus este utilizat pentru simularea comportării energiei a locuinței.*

Lățimea optimă a consolei pe fațada dintre est și vest este mai lungă decât cea de pe fațada sud. Consola de pe fațada nord aproape că nu există. Optimizarea consolei pe perioada sezonului rece poate asigura reducerea consumului de energie cu 3,20% în comparație cu consola acoperișului tradițională.

Key words: roof overhangs, optimization, embodied energy, GenOpt, EnergyPlus, retrofit

1. Introduction

The buildings require large amounts of energy both for cooling and heating. The cooling loads due to solar heat gains represent about a half of the cooling loads for residential and non-residential buildings [1]. It is very important to decrease cooling loads in order to conserve energy.

Overhangs block direct solar radiation from entering a window during certain times of the day or the year. They may reduce the cooling loads and avoid uncomfortable lighting in perimeter rooms. In the northern hemisphere, they are more effective on south-facing windows. In literature, there is research about the application of overhangs of the prescribed depth during cooling. In research of Raeissi and Taheri, the application of the overhangs achieved 12.7% in energy saving for cooling [2]. Using overhangs of the south orientation of the buildings in Athens achieved the energy saving of 7.2% [3]. Also, Kim et al. achieved the energy saving of 11% by using overhangs (1.53 m in the depth) facing south [4]. Huang et al. [5] investigated the energy and CO2 emission payback periods of external overhang shading in a university campus in Hong Kong. Also, they took into account embodied energy of applied overhangs. After application of the overhangs on the west and east facade, with depth of 1.2 m, the annual space cooling load was reduced by 44.1%. But, due to requirements of structural strength of overhang under typhoons, the energy and CO2 emission payback periods of the project are still unrealistically long. Ebrahimpour and Maerefat [6] studied the shading effect of advanced glazing and overhangs on the solar energy

transmitted into or lost from the room through the fenestration areas for typical residential buildings in Tehran. Using EnergyPlus software, it was found that appropriate overhangs or side fins in the south, west and east windows would lead to the optimal reduction of the annual energy transferred into the buildings. As one of seven passive measures, the effect of the overhangs depth was investigated in 25 cities in China [7]. It was found that the overhang depth of 1.8 m on the south orientation could reduce the thermal load by 10%. Lee and Tavil [8] conducted a study on energy performance and visual comfort using a combination of electrochromic window and overhangs. The study was conducted for south-facing private office in Huston and Chicago, USA. They used four overhang depths of 0.85, 1.0, 1.3, and 1.5m. They concluded that the electrochromic windows with overhangs can significantly reduce the average annual daylight glare index (DGI) and deliver significant annual energy use savings if the window area is large. Using the highest the overhangs depth of 1.5m, the total primary annual energy use was decreased by 10% in Chicago and 5% in Houston for large-area windows. The peak electric demand can be reduced by 7–8% for moderate-area windows and by 14–16% for large-area windows in either climate. Pietila et al [9] investigated the possibility to eliminate taking electricity from grid by a house during the grid electricity peaks. It was found that 41%-51% of the goal of eliminating electricity consumption during the summer Ontario on-peak period could be achieved through a combination of architectural, control, efficiency, and occupant behavior measures. The roof overhang (depth of 0.5m and 1.0m) was used as one of architectural measures in combination with other measures. However, there is no research to optimize the dimensions of the roof overhangs regarding the minimal primary energy consumption for cooling and embodied energy during the life cycle of the overhangs.

In this paper, the optimal depths of four roof overhangs are simultaneously found. They each face different direction (north, south, west and east). The optimization objective is to minimize the sum of the consumption of the primary energy for cooling and the embodied energy in the roof overhangs during their life cycle. These depths are obtained by using Hooke&Jeves optimization algorithm. Through the comparison, the energy consumption is studied for retrofit of the house. For the retrofit of the house, the energy consumption of the house with optimized overhangs is compared to the energy consumption of the house with the custom-depth overhangs, and the energy consumption of the house with optimized overhangs is compared to the energy consumption of the house without any overhangs.

2. Mathematical model

2.1 House description

Electricity consumption for cooling is simulated for four residential houses that only differ in overhangs (see Fig.1). The first, second, and third house has four roof overhangs made of reinforced concrete each facing north, south, east, and west direction. The overhangs of the first and second house have the optimized different depths. The third house has the roof overhangs with the same customary depth of 1m. The fourth house does not have any overhangs. The third and fourth house serves as the base houses for comparison.

The first house has the overhangs depths determined by the optimization program for the entire cooling season. The second house has the overhangs depths determined by the optimization program for the partial cooling season.

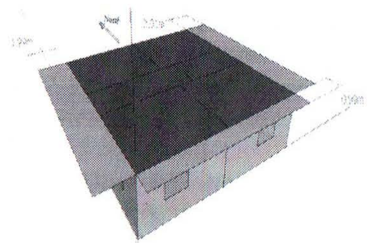

Fig. 1 The residential house with the with optimal overhangs depths (left) and cross section of the analysed house (right)

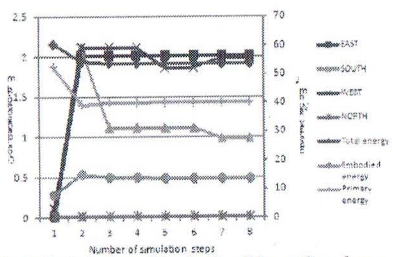

Fig. 2 Optimization of the depths of the roof overhangs

The investigated houses are located in Belgrade, Serbia. Each house has the plane roof. It is used by one family, and has the living area of 190 m^2. The house has 4 air-conditioned rooms. Each air-conditioned room has the exterior walls, external windows, interior walls, ceilings, and floors of the same size and composition. In each room, all windows are set to the identical geometrical position relative to the boundaries of room. The exterior walls are made (from inside to the outside) by using 0.02 m of plaster, 0.19 m of porous brick, 0.05m of polystyrene as thermal insulating layer, and 0.02m of plaster. They have U-value of 0.57 W/(m^2K). The windows are double glazed with the air gap of 15mm having U-value of 2.72 W/(m^2K). The overall area ratio of the windows to the entire envelope

walls is 0.14, where the total area of the envelope is 112 m^2 and the total area of the windows 19 m^2. The interior walls are made by using 0.02 of plaster, 0.19 m of porous brick, and 0.02 m of plaster. The roof is made (from top to bottom) by using 0.08 m of mineral wool as a thermal insulation layer, 0.04 m of cement screed, 0.16 m of porous brick, and 0.015m of plaster. It has a U-value of 0.40 W/(m^2K). The floor is made (from outside to the inside) by using 0.1 m of unreinforced concrete, 0.15 m of ferroconcrete, and 0.001m of hydroinsulation, 0.04 m of polystyrene as a thermal insulation layer, 0.04 m of cement screed and 0.015 m of ceramic tiles. It has a U-value of 0.47 W/(m^2K). The installed windows and doors on the building envelope provide the infiltration of 0.5 ach.

The cooling season runs from June 1 to August 31. During the cooling season, the temperature of indoor air is maintained at 24°C by using window air conditioners powered by electricity. The capacity of air-conditioners is the same 3.5 kW in each room. Each room has the same internal heat load (people, lighting, and electrical equipment), infiltration rates, and ventilation rates. Two persons reside in each room. In the each room, the traditional hanging lamps are used for lighting with incandescent bulbs of 200W. In each room, the classical electrical household devices are used (stoves, refrigerators, TVs, radios, washing machines, freezers, and microwaves) of 700W. The schedule of people presence in rooms, using of lighting in rooms, and using of electric equipment in rooms are given in table 1. The house ventilation is not provided. Air conditioners maintain the set temperature (24°C) all the time during each day.

Table 1. Schedules of the people presence, use of the instilled light, and use of the instilled electric equipment.

	The hours in a day									
	00:00 07:00	07:00 09:00	09:00 10:00	10:00 11:00	11:00 15:00	15:00 16:00	16:00 19:00	19:00 20:00	20:00 22:00	22:00 24:00
People presence, %	0	70	70	70	30	30	60	60	100	100
Using of lights, %	0	70	40	0	0	30	30	60	60	30
Using of electric equipment, %	0	20	20	30	30	30	30	30	50	0

2.2Weather and location

The investigated buildings are located in Belgrade. Belgrade is the capital city of Serbia. Its average elevation is 132 m, latitude 44°48 N, and longitude 20°28 E. The city has a moderate continental climate with four distinct seasons (winter, spring, summer, and autumn). The weather file used in the simulation is obtained by measurements at the Belgrade weather station.

2.3 Software

To simulate a thermal behaviour of these houses, the EnergyPlus software is used. This software is a very useful tool for modelling of energy and environmental behaviour of buildings. The program is initially developed by Lawrence Berkeley National Laboratory, U.S. Army Construction Engineering Laboratory, and the University of Illinois [11]. In the software, it is possible to input how people use building during its space cooling. In this direction, the complex schedules of cooling can be defined together with the schedules for use of lighting, internal energy devices and occupancy in the building.

In this study, the GenOpt code is used to program the optimization of the depths of the roof overhangs. GenOpt code is devised to help connection of an optimization routine and external simulation programs. The cost function to be minimized is programmed by using GenOpt code. The variables in this function are by external simulation programs [12]. The GenOpt code has been developed for optimization problems where the cost function is computationally expensive and its derivatives are not available or may not even exist.

In these investigations, the GenOpt code is programmed for the appropriate objective function and use of Hook Jeeves optimization method. Hooke-Jeeves algorithm is a direct search and derivative free optimization algorithm [13]. In Hooke Jeeves algorithm, only the objective function and the constraint values are used to guide the search strategy.

2.4 Primary energy consumption for cooling

After the simulation in EnergyPlus, a calculation output is the electricity consumption of window air conditioners ($E_{el,c}$) per cooling season. The primary energy consumption per cooling season by the air conditioners is calculated as:

$$E_{pry} = E_{el,c}\, R. \qquad (1)$$

Here, R stands for the equivalent of the primary energy consumption. This equivalent represents the primary energy used to generate the unit of electric energy. For the Serbian energy mix for electricity production, R = 3.01 [14]. In Serbia, the primary energy for electricity production is that of energy resources such as hydro, coal, oil, and natural gas.

2.5 Embodied energy in roof overhangs

The embodied energy of applied roof overhangs represents the primary energy consumed to produce the roof overhang material, to install the roof overhangs on the house, and to dispose the roof overhangs at the end of their life cycle [15]. Here, the energy to install, and despose them is assumed to be negligible. The annual embodied energy of applied roof overhangs is calculated by using the following equation:

$$E_{emb} = \rho\, l\, \delta\, h\, S_{emb} \,/\, f. \qquad (2)$$

Here, ρ stands for the specific density of the roof overhang material, l stands for the depth of the roof overhangs, δ stands for the thickness of the roof overhangs, h stands for the length of the roof overhangs, S_{emb} stands for the specific embodied energy of the roof overhangs, and f stands for the lifecycle of the roof overhangs. The characteristics of the roof overhangs are given in Table 3.

Table 3.The characteristics of the applied roof overhangs

Characteristics		Characteristics	
Material	Concrete	Specific density[&], ρ	2150 kg/m^3
Thickness, δ	0.18 m	Length, h	10.8 m
Height[*]	0.2 m	Depth, l	Optimized
Lifecycle, f	20 a	Specific embodied energy[&], S_{emb}	1.92 MJ/kg

[&] *Data for ρ, S_{emb} are taken from [16].*
[*] *Distance between the top of the window and the overhang.*

2.6 The objective function - the primary energy consumption of the system

The objective function is the total primary energy consumption that has to be minimized. The total primary energy consumption of the house is defined as the sum of the primary energy consumption by the air conditioners and the embodied energy of the applied roof overhangs:

$$E_{TOT} = E_{pry} + E_{emb}. \qquad (3)$$

2.7 The comparison indicators

The total primary energy saving per the unit of the embodied energy in the optimally applied roof overhangs in relation to the house without roof overhangs is given as $E_{ratio,0}$. The total primary energy saving per unit of embodied energy in the optimally applied roof overhangs in relation to the house with custom roof overhangs is given as $E_{ratio,\ cm}$. $E_{ratio,0}$ and $E_{ratio,\ cm}$ are given by the following equations:

$$E_{ratio,0}=((E_{TOT,opt} - E_{TOT,0})/E_{emb}),\ E_{ratio,\ cm}=((E_{TOT,opt} - E_{TOT,cm})/E_{emb}) \quad (4)$$

Here: $E_{TOT,opt}$ stands for the consumed total energy for cooling in the house with optimized applied roof overhangs, $E_{TOT,0}$ stands for the consumed total energy for cooling in the house without applied roof overhangs, and $E_{TOT,cm}$ stands for the consumed total energy for cooling in the house with customary roof overhang depths.

2.8 Simulation and optimization

To show how the optimization procedure operates, Fig.2 presents the depths of the four overhangs as a function of the number of the optimization steps for the case when air is cooled during three months. This shows that the optimization procedure is rather fast to yield to the optimal solution.

3. Results and discussion

3.1 Overhang depths

This paper reports the simultaneous optimization of the depths of four roof overhangs, each facing one cardinal direction. There are one optimization case: when the air is cooled during (1) three months, and during (see Table 4). Three months optimisation is performed when window air conditioners operate during June, July, and August. The depths for east and west facing roof overhangs are longer than that for the south and north facing roof overhangs. The north facing overhang almost does not exist.

Table 4. Overhang depths (m) for the investigated houses

House			East	West	South	North
First	Optimized for	June, July, August	2.01	1.99	0.99	0.01
Second	Non-optimized	(common depth)	1.00	1.00	1.00	0.00
Third	Non-optimized	(basic-no overhangs)	0.00	0.00	0.00	0.00

3.2 Retrofit of the house

To access the influence of the retrofit of the house to energy consumption, Fig.3 shows the primary and total energy savings for three cases: (1) the house using overhangs with the optimal depths compared to the house without overhangs, (2) the house using overhangs with the customary depths compared to the house without overhangs, and (3) the house using overhangs with the optimal depths compared to the house using overhangs with the customary depths. The optimal depths of the

overhangs are obtained for three months of cooling. It is found that the house with the optimized roof overhangs compared to the house without overhangs achieves the primary and total energy savings of 24.49% and 13.09%, respectively. However, the house with the customary overhangs when compared to the house without overhangs achieves the primary and total energy savings of 19.47% and 10.64%, respectively. Additionally, the house with optimal overhang depth compared to the house with customary overhangs has higher primary and total energy saving of 6.23% and 2.74 %, respectively.

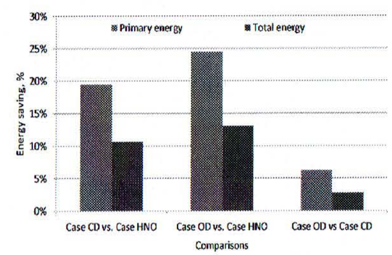

Fig.3 Primary and total energy saving (Case OD=house with optimal overhang depths. Case CD=house with customary overhang depths. Case HNO= house without overhangs)

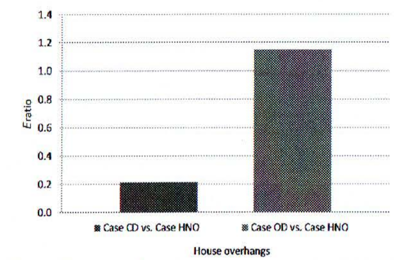

Fig. 4 The ratio of total energy saving and embodied energy in applied roof overhangs (Case OD=house with optimal overhang depths, Case CD=house with customary overhang depths, Case HNO= house without overhangs)

Figure 4 presents the total energy saving per the unit value of embodied energy during one three-month cooling season. The results are shown for two houses (1) the house using the optimized overhangs and (2) the house using customary overhangs. From Fig.4, using optimal roof overhang depth the ratio of total energy saving and embodied energy of roof overhangs is 1.15. Also, that ratio for house with customary roof overhang depth is 0.24. This means that this value for the overhangs with optimized depths is much higher than that with the customary depths.

3.3 Validation of the results

The primary energy consumption during cooling season for the house without overhangs is found to be around 49.6kW/m^2. This value is approximately equal to the average primary energy consumption of about 49.3kWh/m^2 given by local distributer of air-conditioners in Serbia [17].

4. Conclusions

Optimization of the roof overhangs depth that minimize the sum of the primary energy consumption of cooling system and the embodied energy of erected overhangs is achieved by using EnergyPlus, Genopt and Hooke-Jeeves algorithm. This is the simultaneous optimization of the depths of four roof overhangs, each facing one cardinal direction. It is found that the depths for east and west facing roof overhangs are longer than that for the south and north facing roof overhangs. The north facing overhang almost does not exist. The depths of east and west facing overhangs increase with lower optimal use time of the house.

The largest savings of the primary energy for the building with the optimal roof overhang depths is around 24%. The annual total energy saving is around 13%. The refurbishment with the optimized overhangs yields the benefit to the environment also when the embodied energy is taken into account. The house with the customary overhangs achieves the primary and total energy savings lot lower than that of the house with optimized overhangs. Using optimal roof overhang depth the ratio of total energy saving and embodied energy of roof overhangs is high as 1.15.

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REDUCEREA PIERDERILOR DE APĂ POTABILĂ PRIN MONITORIZAREA ON-LINE A PARAMETRILOR FIZICO-CHIMICI

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Rezumat

Reţeaua de distribuţie a apei reprezintă partea cea mai costisitoare a unui sistem de alimentare cu apă potabilă a centrelor populate. Pentru eficientizarea exploatării se impune monitorizarea următorilor parametri: presiune, pH, conductivitate, temperatura, turbiditate, debitul de apă.

Toate informaţiile sunt stocate pe baza cărora sunt realizate rapoarte şi grafice cu evoluţia parametrilor înregistraţi.

Abstract

The water distribution network is the most expensive water supply system of populated centers. For efficient operation the following parameters should be monitored: pressure, pH, conductivity, temperature, turbidity, water flow.

All information is stored and generates reports and charts with the evolution of the parameters registered.

1. Generalităţi

Reţeaua de distribuţie a apei reprezintă partea cea mai costisitoare a unui sistem de alimentare cu apă potabilă a centrelor populate (50-70% din costul total al instalaţiei), datorită atât lungimii sale mari (1-2 m/ locuitor), cât şi a faptului că reţelele au fost executate în mare parte din tuburi din otel si azbociment. Reţeaua de distribuţie trebuie să funcţioneze sigur şi fără