JOURNAL OF ENGINEERING AND APPLIED SCIENCE, VOL. 67, NO. 8, DEC. 2020, PP. 2109-2127
FACULTY OF ENGINEERING, CAIRO UNIVERSITY

LIVING SKIN AS A TOOL FOR REGULATING INDOOR AIR TEMPERATURE AND COOLING LOADS INSIDE KINDERGARTEN CLASSES

N. TOULAN[1], E. ELSHAZLY[1], A. HASSAN[2], AND R. GAMAL[3]

ABSTRACT

Kindergarten classes highlight links between thermal comfort and energy consumption. Children spend up to one third of their day in classrooms, which makes class design a key objective to provide an adequate indoor environment and to help improving children's performance. Usage of mechanical systems for achieving required thermal conditions explore passive design solutions that can save energy as the excess usage of mechanical systems increases urban heat island phenomena. This paper aims to investigate the application of living skin as ecological solution integrated with kindergarten facades to regulate indoor air temperature and reduce consumed energy in space conditioning. Simulation is done by using Design Builder Software for a model (10×10 m^2) in two different climatic zones (Alexandria and Aswan) through the following cases (normal case, applying environmental code, applying green roof then applying living wall on each façade) to determine the most effective living wall reducing both indoor air temperature and cooling loads, then investigating the most effective air gap between living wall and class façade. Finally, it was found there is a decrease in the total cooling loads after applying green roof and living walls on certain facades with specific air gaps for kindergarten classes in each climatic zone.

KEYWORDS: Living walls, Green roof, Kindergarten classes, Indoor air temperature, Cooling loads, Urban heat island effect, Design builder simulation.

1. INTRODUCTION

It is a well-known fact that the built environment is a major contributor to global environmental problems, which are the primary reasons for climate change in our era. Buildings are accountable for 30 - 40% of the world's total energy consumption. The significance of kindergartens for energy efficiency may be questioned as they are small in area compared to other types of buildings like offices or residential buildings. The

[1] Associate Professor, Department of Architecture, Faculty of Engineering, Cairo University, Giza, Egypt.
[2] Professor, Department of Architecture, Faculty of Engineering, Cairo University, Giza, Egypt.
[3] Ph. D. Candidate, Department of Architecture, Faculty of Engineering, Cairo University, Giza, Egypt, rania.gamal@akam.com.eg

specific role of thermal comfort is less well studied in kindergarten buildings even though they are major energy consumers, both for heating and cooling to provide acceptable thermal comfort conditions. Most of new educational buildings have been constructed without considering students' thermal comfort though they spend up nearly one third of the day in their classrooms, so, a good indoor environment can help in optimizing conditions for their performance and productivity [1].

Children are less resistant to different environmental conditions compared to adults and many researches show that when temperature increases above 26°C, it affects their performance [2].

The use of mechanical systems for achieving thermal comfort for children inside kindergarten classes, dictates the importance of exploring new passive design strategies, as the excess in the usage of these mechanical systems causes increase in the Urban Heat Island, UHI effect. UHI is one of the major problems the world is facing, and many countries are giving alerts to overcome this. In December 2015, the Paris Agreement aimed to strengthen the global response to the threat of climate change by keeping a global temperature rise this century below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase.

For achieving both, thermal comfort and saving energy, it is essential to find integrated solutions that can regulate indoor air temperature and reduce consumed energy needed for space conditioning. Through this paper, the use of vegetation is highlighted as an ecological solution whether by application of living walls or green roofs in two kindergarten classes in two different climatic zones. Based on the results of the study, it was found that these applications are effective in the thermal performance of kindergarten buildings and can have a major effect in decreasing the energy consumed in cooling loads in both climatic zones.

2. RESEARCH PROBLEM

Indoor spaces in kindergarten classes have been rarely studied for a complete thermal performance compared to other buildings, like offices and residential buildings. Few studies were presented that can give optimized integrated solutions which may contribute to decreasing the indoor air temperature consequently, minimizing the energy consumed in cooling loads.

3. RESEARCH AIM

1. Evaluating the impact of applying green roof and living walls on both indoor air temperature and cooling loads inside a kindergarten class in different climatic zones.
2. Strengthening the bond between the children - in the early age - and the nature by improving, not only the physical side through decreasing the indoor temperature but also enhancing the psychological (non-physical) side by the greening of the children's surroundings.

4. RESEARCH QUESTIONS

1. Does the application of living walls and green roof for kindergarten classes decrease indoor air temperature and cooling loads?
2. What are the most efficient facades for living wall applications with green roof that can decrease both, indoor air temperature and consumed energy in the cooling loads?
3. Could the air gap between living wall and class façade influence decreasing indoor air temperature and cooling loads?

5. RESEARCH OBJECTIVES

1. Building two models of kindergarten classes in two different climatic zones.
2. Making a comparison through simulation for the kindergarten class along different cases, first: normal case, second: applying environmental code requirements, third: applying green roof to the normal case, and fourth: applying green roof, living wall on each façade orientation to the normal case.
3. Recording the indoor air temperature and the cooling loads inside the two kindergarten classes.
4. Monitoring the most efficient air gap between living wall and kindergarten class façade.

6. METHODOLOGY

Through the study, the literature review discusses the impact of thermal comfort inside kindergarten class on the children's performance accordingly, the study explains how the application of living skin, as an ecological solution, can regulate indoor air temperature and reduce the consumed energy in air-conditioning. The simulation is done by using Design Builder Software to determine the most efficient orientation for living wall application with the most appropriate air gap that can decrease the consumed cooling loads.

7. LITERATURE REVIEW

Through the literature review, there is an illustration for the publications that discussed topics concerning educational buildings like, how to achieve energy efficiency inside these buildings, children performance and productivity and the thermal comfort and how it can be monitored and achieved.

7.1 Thermal Comfort

The term "Comfort" appeared in the paper published by Stankovic et al., [3]**,** they discussed that preschool children should be provided by physical facilities like Space Comfort, Light Comfort, Aesthetic comfort, but for the thermal comfort importance, it was not highlighted.

Mohidin et al., [4], aimed to examine the effectiveness of kindergarten design in promoting early childhood development in Malaysia. Children categorization was birth to 2 years are infants, (3-6 years) are preschool children, (7-12) years are primary school children, (13-18 years) are secondary school children. The paper focused on: movement, and competence. In this paper, there was no focus on the thermal comfort contribution.

Some papers focused on evaluating the thermal environment in preschool buildings as published by Ismail et al., [5]. The result showed that the air temperature in two preschool buildings exceeded the standard suggested by ASHRAE, but for relative humidity it was within the standards. In this paper there is no proposed solution for decreasing the temperature inside building.

Šenitková, [6], presents results of users' satisfaction to thermal comfort and environment quality through a questionnaire in 21 school building rooms. Results showed that about 80% of users were satisfied with thermal comfort in only 11% of the buildings. Air quality scores were 26% of buildings having 80% of users' satisfaction. The paper recommended that thermal comfort should be considered by designers.

7.2 Achieve Low Energy Performance and Energy Efficiency

There are papers that discussed energy performance in kindergartens like; Hammad et al. [7]. This paper illustrates the case of an existing kindergarten in Amman that was redesigned to achieve low energy performance by; light saving lamps and wall thermal insulation. But this paper did not mention the impact of applying new materials that might regulate temperature inside classes accordingly.

The objective of Ramli et al. [8]**,** was to identify the design elements of Malaysian school towards a green sustainable building. A committee was held between: US Environmental Protection Agency, EPA, Collaborative for High Performance Schools, CHPS and US Green Building Council LEED for Schools, to reach the suitable internal temperature and relative humidity for the different educational levels. It was found that: for temperature, kindergarten and primary-grade students were most comfortable when the air temperature was 65°F to 68°F (18.3 to 20 degree Celsius), compared to elder students who were better at 68°F (20 degree Celsius).

For the energy efficiency in kindergarten buildings, Stankovic et al. [1] they focused on a methodology of energy efficiency through: exterior wall insulation and changing the windows and outside doors. The objective of the reconstruction is to improve energy efficiency and reduce energy consumption.

Šuman et al. [9] have presented a comprehensive renovation strategy for existing preschool buildings in Slovenia for energy and economic efficiency. It was done by replacement of (floor slab and external walls) by new layers including thermal insulation. The paper focused on finding ways for energy saving.

Gajić et al. [10]**,** focused on the fact that the measurement of thermal performance of buildings' envelopes is an appropriate parameter in the calculation of kindergartens' energy performance. Indoor air temperature is the only parameter to determine thermal comfort, and energy needed for heating. The paper recommended introducing some modifications to the policies for building energy efficiency.

The software modeling was highlighted in the paper of Faggal [11]. The main objective is evaluating the annual thermal performance of a classroom in Cairo, Egypt to monitor the thermal comfort criteria and number of discomfort hours through a whole academic year. Simulation results that 45% of the working hours are exceeding the maximum limit of comfort temperature and accordingly high annual cooling loads. These findings indicate the importance of integrating passive cooling strategies to achieve the students' thermal comfort.

7.3 Children Health and Productivity

Mainka et al. [12] focused on children's exposure to air pollutants and that attention should be directed to preschools because younger children are more affected by air pollution than higher grade ones. The objective is to improve ventilation and reduce the occupancy per room to decrease high CO_2 levels. This paper focused on the improvement of indoor air quality and there was no highlight for thermal comfort.

7.4 Environmental Sustainability

Some papers have discussed the environmental behaviors of children, like Tucker and Izadpanahi [13]. They aimed to compare the environmental behaviors of children attending sustainable primary schools with others' behaviors in conventional ones. The findings indicate that children attending sustainable schools had more pro-environmental attitudes. The paper focuses on that school designers should integrate sustainability features to strengthen the bond between children and their surrounding environment.

Kindergarten buildings can improve environmental sustainability, that appeared in Stankovic et al. [14] it illustrates that school building should provide three principles; Sustainable Design, Economy of Resources and Life Cycle. Green facades are one of the discussed solutions. The paper focused on their benefits, like producing oxygen, improving microclimate, collecting dust particles, and reducing both air flow and humidity.

After illustrating the papers through the literature review, some papers discussed the term “comfort”, few have highlighted the thermal comfort importance in spite of being one of the main aspects that have a great impact on children’s performance and productivity.

8. GREEN ROOF AND LIVING WALL BENEFITS

Green roofs have many environmental benefits like, reducing air pollution and urban heat island phenomena in the highly populated dense areas and providing better ecological habitat for urban life [15]. It also provides protection from ultra violet radiation rays and improves the lifespan of roof and buildings [16] as shown in Fig.1.

As for living walls can improve the quality of the surrounding environment, it has become a key design considered in modern building developments, not only for an aesthetic goal but also as a means of providing environmental services, such as regulating indoor air temperature as shown in Fig. 2, natural air cooling, reducing greenhouse effect and reducing solar gain through the envelope [17].

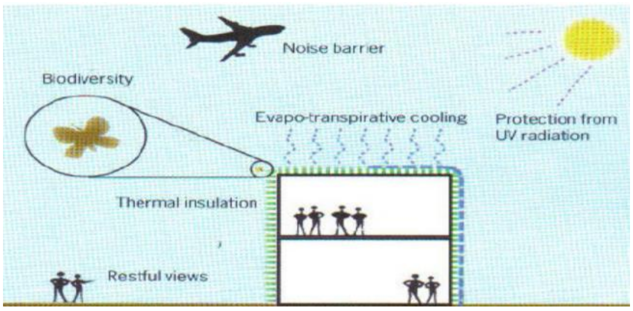

Fig. 1. Green roof environmental benefits [16].

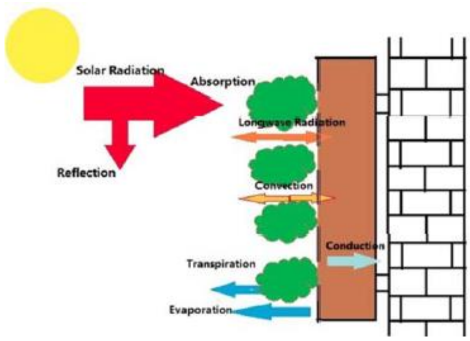

Fig. 2. Processes regulating indoor temperature [18].

Generally, the building envelope is the most influential parameter that has a great impact on indoor thermal comfort [19].

9. SIMULATION

The integration of living skin within kindergarten classes is monitored through simulation to observe the impact on indoor air temperature and total cooling loads.

9.1 Methods and Tools

To conduct the study, a quantitative measurement is done by energy simulation software, Design Builder version 4.5. It is a comprehensive user interface to the Energy Plus thermal insulation engine, developed by Design Builder Ltd. for generating performance data, allowing the calculations of heating and cooling loads by adopting the ASHRAE method [20]. It is worth noting that the Design Builder software has been used [21, 22] to calculate all building energy, lighting, carbon, and comfort performance analyses.

9.2 Simulation Parameters

The study passes through the following stages for each kindergarten class in two different climatic zones (Alexandria and Aswan) as shown in Fig. 3.

9.2.1 First stage of simulation

Applying the normal case, then the Environmental Code, Applying green roof to normal case, then Applying green roof and living walls to normal case on each façade orientations to identify the most efficient one in regulating both, indoor air temperature and total cooling loads.

9.2.2 Second stage of simulation

A simulation is applied to identify the most efficient air gap between living wall and kindergarten façade (5 -15- 25 cm).

9.3 Location and Case Studies

The case study is a single kindergarten classroom 10×10 m^2 as shown in Figs. 4, and 5. The case study is tested in two different climatic zones, Alexandria, and Aswan.

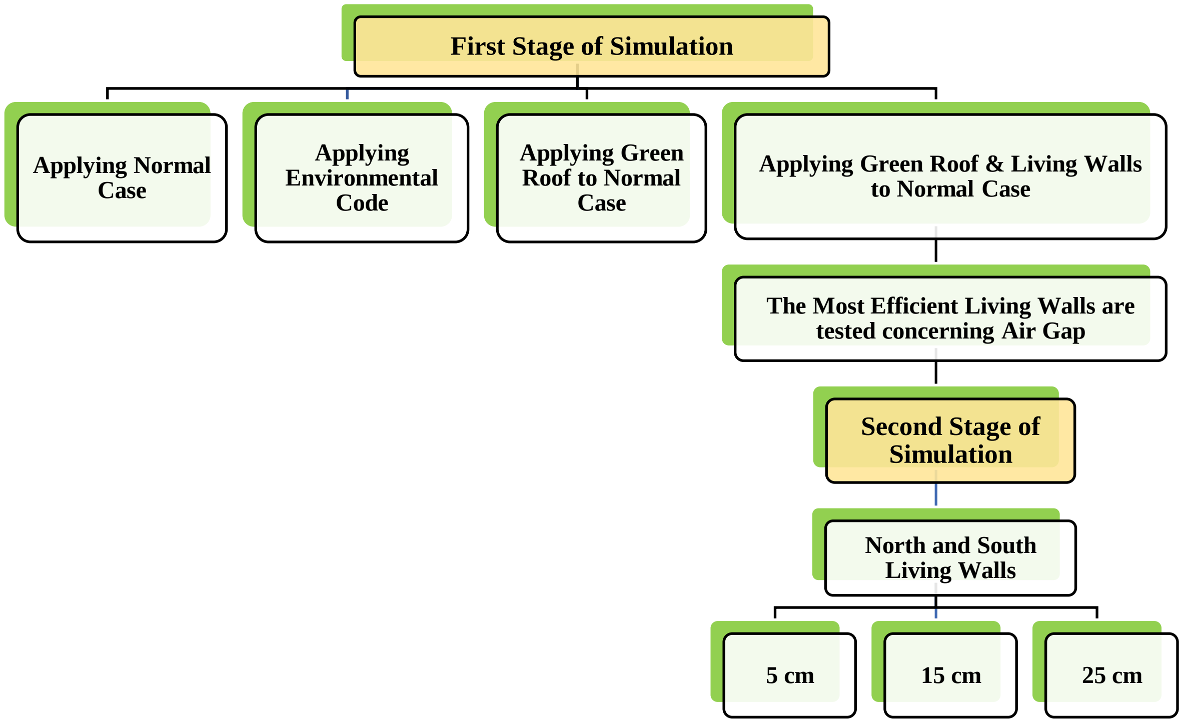

Fig. 3. Simulation stages.

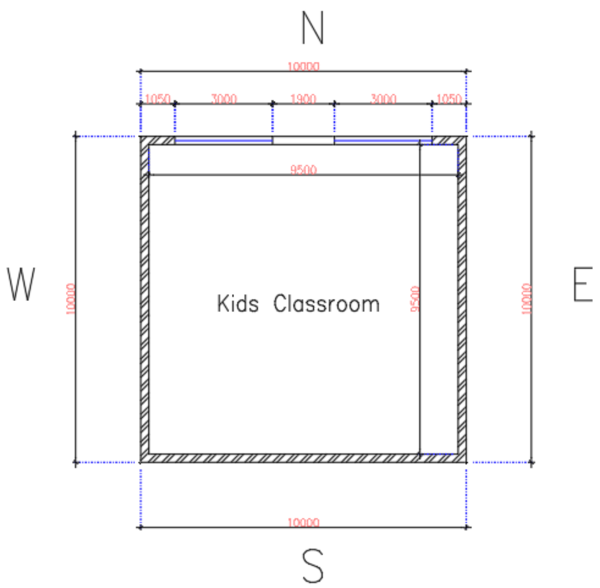

Fig. 4. Alexandria case study.

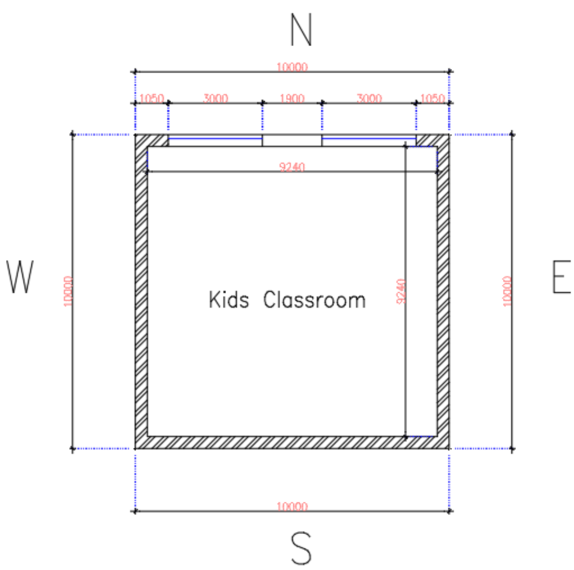

Fig. 5. Aswan case study.

Based on the climate consultant software, it is found out that the hottest day in Alexandria is 16 May as shown in Fig. 6 and in Aswan is 2 July as shown in Fig. 7 which are obtained from Climate Consultant Software.

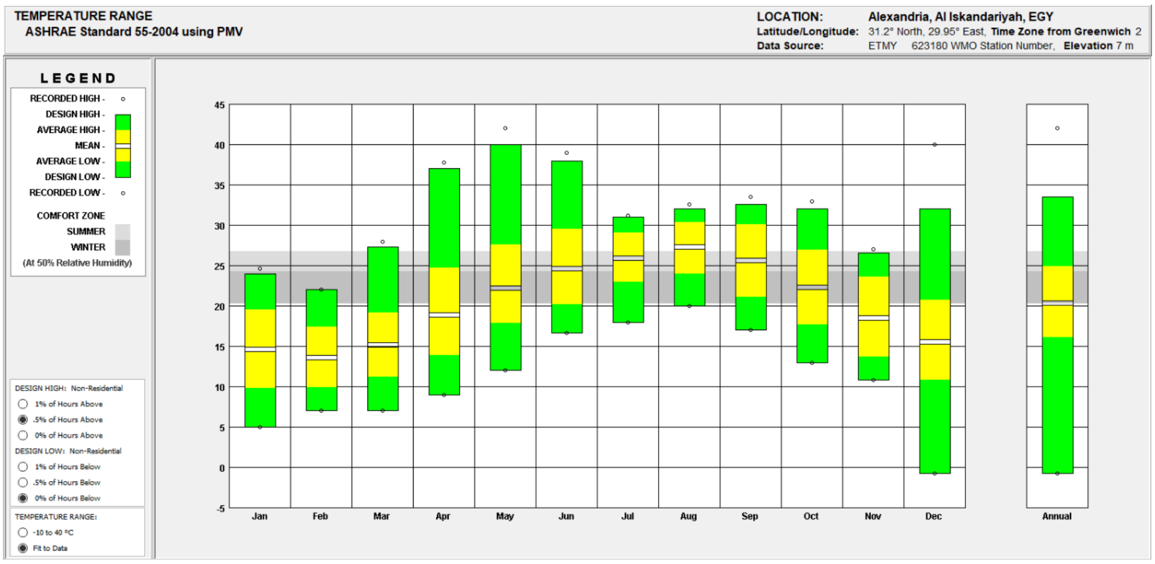

Fig. 6. Alexandria temperature range.

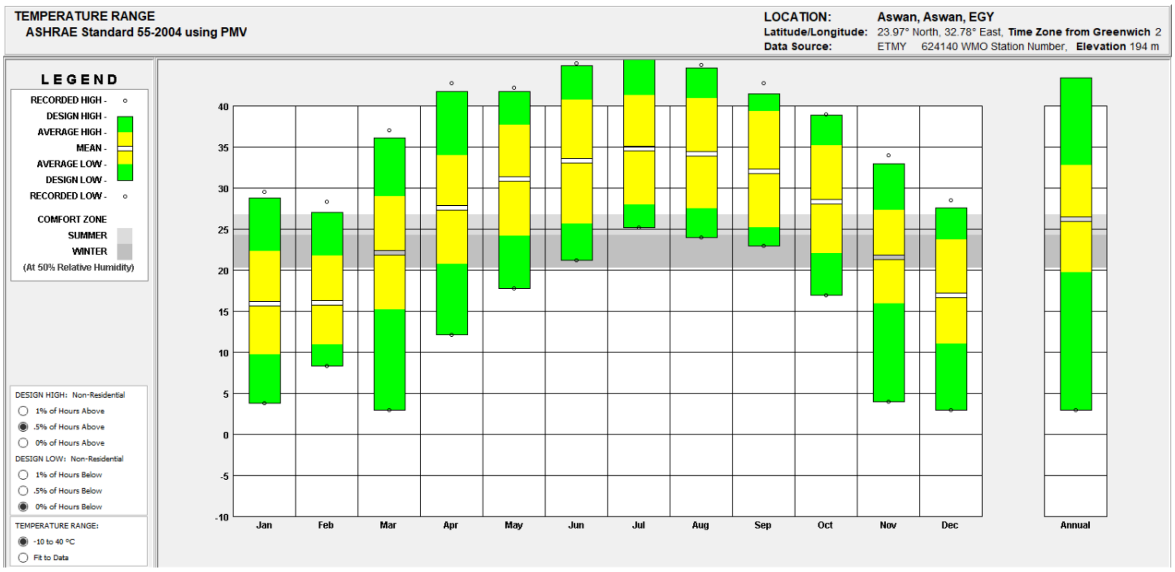

Fig. 7. Aswan temperature range.

9.4 Simulation of Alexandria Case Study

9.4.1 First stage of simulation

An illustration for the simulation cases is illustrated below. The simulation was applied on an Alexandria kindergarten class as shown in Table 1 and Figs. 8 - 12, which are obtained from Design Builder Software.

Table 1. Alexandria simulation case.

Cases	Walls	Roof	Openings
Normal Case	10 mm Paint + 20 mm Plaster + 250 mm Brick + 20 mm Plaster + 10 mm Paint as in Fig. 8.	10 mm Paint + 20 mm Plaster + 120 mm R. C. + 20 mm cement screed + 20 mm Bitumen + 50 mm. Polystyrene + 60 mm Sloped Concrete + 60 mm Sand + 20 mm Mortar + 20 mm Tiles as in Fig. 9	In Design Builder: The used is 20% glazing, single clear 3 mm, aluminum window frame with no shading devices. The openings are found only in North Façade.
Environmental Code	The R Value needed for East and West (0.6 $m^2/K/W$), North (0.4 $m^2/K/W$) and South Wall (0.5 $m^2/K/W$). This can be achieved for all walls by; 10 mm Paint + 20 mm Plaster+ 250 mm Brick + 20 mm Plaster + 10 mm Paint as in Fig. 8.	The R Value needed is (2.2 $m^2/K/W$) (2.35 $m^2/K/W$ in code). This is divided between (R of Building Materials 0.6 $m^2/K/W$ and R of Insulation Layer 1.75 $m^2/K/W$): 10 mm Acrylic Paint + 20 mm Plaster + 200 mm Hollow Block Concrete + 60 mm Polystyrene + 60 mm Sloped Concrete + 20 mm Bitumen + 60 mm Sand + 20 mm Mortar + 20 mm Tiles as in Fig. 10.	For South and North Walls: Required SHGC (0.8). For East and West Walls: Required SHGC (0.4). The value selected from Code is (0.78, fixed and aluminum frame). In Design Builder: The used is 20% glazing, single clear 3 mm, aluminum window frame. The openings are found only in North Façade.
Normal Case + Green Roof	Same as normal case.	Green Roof: 200 mm Plantation + 200 mm Perlite + 20 mm Membrane + 50 mm Wooden Box & supports + 50 mm Gravel + 60 mm Sloped Concrete + 50 mm Polystyrene + 20 mm Bitumen + 120 mm R. C. as in Fig. 11.	Same as normal case.
Normal Case + (East – West – South – North) Living Walls + Green Roof	The basic walls as normal case and for living walls: 200 mm Plantation + 100 mm Perlite + 5 mm Felt Layer + 40 mm Rockwool + 10 mm Plywood + 150 mm Air Gap + 20 mm Plaster+ 250 mm Brick + 20 mm Plaster + 10 mm Paint. as in Fig. 12.	Same as green roof layers.	Same as normal case, and the openings will be in the same façade of the living wall.

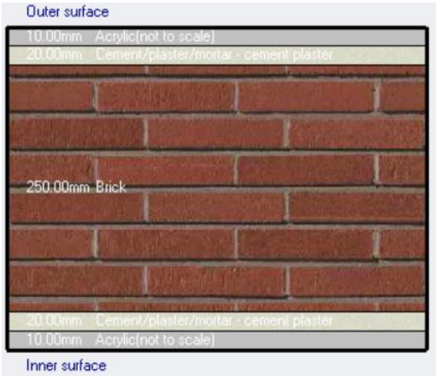

Fig. 8. Wall layers in normal case and according to environmental code.

Fig. 9. Roof layers in normal case.

Fig. 10. Roof layers according to environmental code.

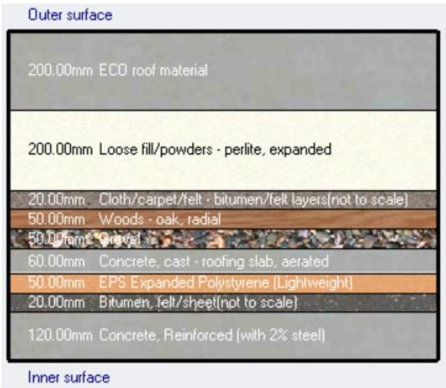

Fig. 11. Green roof layers.

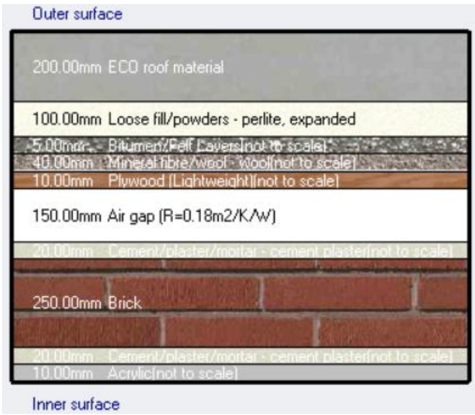

Fig. 12. Living wall layers.

9.4.2 Results of first stage of simulation

The two most efficient facades in decreasing both indoor air temperature and cooling loads, are north and south facades as summarized in Table 2.

9.4.3 Second Stage of simulation

Another simulation is done to find the most efficient air gap between living wall and building façade, for north and south living walls it is found that the 25 cm air gap has the most efficient impact on cooling loads as shown in Tables 3 and 4.

Table 2. Indoor air temperature and cooling loads in north and south facades.

CASES	Air Temp, C	Total Cooling Loads, kW
Normal Case	26.81	35.19
Environmental Code	26.76	34.63
Green Roof	26.67	33.45
East Living Wall + Green Roof	26.73	32.41
North Living Wall + Green Roof	26.67	31.82
South Living Wall + Green Roof	26.6	32.02
West Living Wall + Green Roof	26.75	33.48

Table 3. The most efficient air gap in north living wall.

Air Gap, cm	Air Temp., C	Total Cooling Loads, kW
5	26.67	32.09
15	26.67	31.82
25	26.66	31.56

Table 4. The most efficient air gap in south living wall.

Air Gap, cm	Air Temp., C	Total Cooling Loads, kW
5	26.6	32.29
15	26.6	32.02
25	26.6	31.76

9.5 Simulation of Aswan Case Study

9.5.1 First stage of simulation

An illustration for the simulation cases applied on Aswan kindergarten class is shown in Table 5 and Figs. 13 – 18, which are obtained from Design Builder.

Table 5. Aswan simulation case.

Cases	Walls	Roof	Openings
Normal Case	10 mm Paint + 20 mm Plaster+ 250 mm Brick + 20 mm Plaster + 10 mm Paint as in Fig. 13.	10 mm Paint + 20 mm Plaster + 120 mm R.C. + 20 mm cement screed + 20 mm Bitumen + 50 mm Polystyrene + 60 mm Sloped Concrete + 60 mm Sand + 20 mm Mortar + 20 mm Tiles as in Fig. 14.	In Design Builder: The used is 20% glazing, single clear 3 mm, aluminum window frame with no shading devices. The openings are found only in North Façade.

Table 5. Aswan simulation case, (Cont.).

Cases	Walls	Roof	Openings
Environmental Code	The R Value needed for East, West & South (1.4 m^2/K/W), for North (1.3 m^2/K/W). This can be achieved for all walls by; 10 mm Acrylic Paint + 20 mm Plaster+ 30 mm Expanded Polystyrene + 380 mm Brick + 20 mm Plaster + 10 mm Paint as in Fig. 15.	The R Value needed is (3.4 m^2/K/W) (2.95 m^2/K/W in code). This is divided between (R of Building Materials 0.6 m^2/K/W and R of Insulation Layer 2.35 m^2/K/W): 10 mm Acrylic Paint + 20 mm Plaster + 200 mm Hollow Block Concrete + 100 mm Polystyrene + 80 mm Sloped Concrete + 20 mm bitumen + 60 mm Sand + 20 mm Mortar + 20 mm Tiles as in Fig. 16.	For South & North Walls required SHGC can be (0.7). For East & West Walls: Required SHGC (0.3). The value selected from Code is (0.78, fixed and aluminum frame). In Design Builder: The used is 20% glazing, single clear 3 mm, aluminum window frame. The openings are found only in North Façade.
Normal Case + Green Roof	Same as normal case.	Green Roof: 200 mm Plantation + 200 mm Perlite + 20 m Membrane + 50 mm Wooden Box & Supports + 50 mm Gravel + 60 mm Sloped Concrete + 50 mm Polystyrene + 20 mm Bitumen + 120 mm R. C. as in Fig. 17.	Same as normal case.
Normal Case + (East – West – South – North) Living Walls + Green Roof	The basic walls as normal case and for living walls: 200 mm Plantation + 100 mm Perlite + 5 mm Felt Layer + 40 mm Rockwool + 10 mm Plywood + 150 mm Air Gap + 20 mm Plaster+ 250 mm Brick + 20 mm Plaster + 10 mm Paint. as in Fig. 18.	Same as green roof layers.	Same as normal case, and the openings will be in the same façade of the living wall.

Fig. 15. Wall layers according to environmental code.

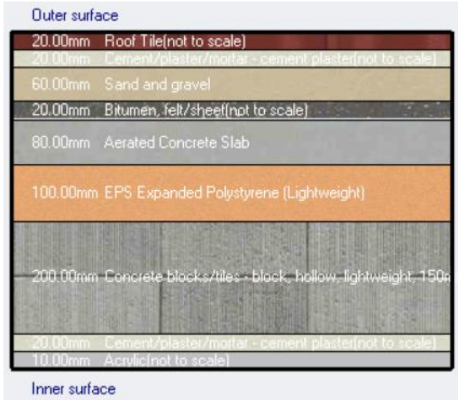

Fig. 16. Roof layers according to environmental code.

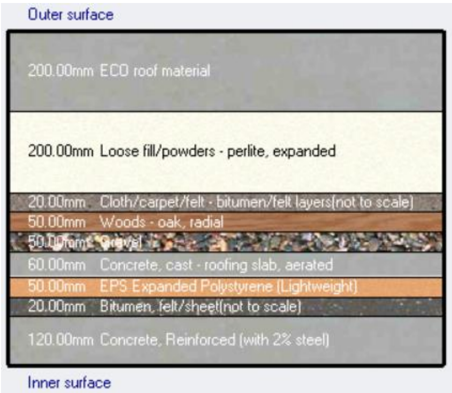

Fig. 17. Green roof layers.

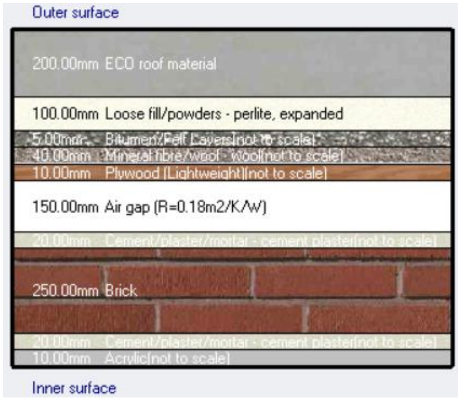

Fig. 18. Living wall layers.

9.5.2 Results of first stage of simulation

The two most efficient facades in decreasing both indoor air temperature and cooling loads, are north and south facades as in Table 6.

9.5.3 Second stage of simulation

Another simulation is done to find the most efficient air gap between living wall & building facade, for north and south living walls it is found that the 25 cm air gap has the most efficient impact on cooling loads as shown in Tables 7 - 8.

Table 6. Indoor air temperature and cooling loads in north and south facades.

CASES	Air Temp, C	Total Cooling Loads, kW
Normal Case	27.02	47.7
Environmental Code	26.77	45.04
Green Roof	26.79	46.94
East Living Wall + Green Roof	27.38	44.51
North Living Wall + Green Roof	26.77	44.32
South Living Wall + Green Roof	26.73	44.36
West Living Wall + Green Roof	26.92	44.89

Table 7. The most efficient air gap in north living wall.

Air Gap, cm	Air Temp., C	Total Cooling Loads, kW
5	26.87	44.77
15	26.77	44.32
25	26.88	43.86

Table 8. The most efficient air gap in south living wall.

Air Gap, cm	Air Temp., C	Total Cooling Loads, kW
5	26.72	44.82
15	26.73	44.36
25	26.73	43.91

10. RESULTS

1. The simulation that is carried out in both climatic zones has concluded that applying living walls in addition to green roof for a kindergarten class have an impact on decreasing both indoor air temperature and consumed energy in cooling loads.
2. The most effective facades in decreasing indoor air temperature and cooling loads are the north and south facades in Alexandria and Aswan.
3. The most efficient air gap between living wall and kindergarten façade is (25cm) that makes a difference in cooling loads but has no impact on indoor air temperature.

11. DISCUSSION OF RESULTS

As mentioned in the literature review of this study, the kindergarten is a place that should provide children with the appropriate atmosphere they need.

The paper’s objective is to find an integrated passive solution that may have an impact on decreasing indoor air temperature and the consumed energy in cooling loads. A simulation is carried out by Design Builder Software for a kindergarten class of area 100 m^2 in Alexandria and Aswan through two stages: <u>First Stage:</u> a- Analyzing the building normal case, b- Applying environmental code requirements, c- Applying green roof to the normal case, d- Applying green roof and living wall on each façade orientation to the normal case to identify the most efficient option in regulating both indoor air temperature and cooling loads consumed inside the kindergarten class. Second Stage: Observe the impact of changing the air gap between living wall and class façade to identify the most efficient one that can positively affect decreasing cooling loads. From the research findings, after the first stage of simulation it is concluded that in both climatic case studies, the application of north and south living walls in addition to the green roof, show better results in decreasing cooling loads, for the second stage of simulation, the most effective air gap between living wall and kindergarten class façade is the 25 cm.

12. CONCLUSIONS AND FUTURE STUDIES

The living skin application can be a key design to be considered in building developments, not as an aesthetic goal but also as a service to implement energy efficiency in newly constructed kindergarten buildings. It can reduce urban heat island phenomena in dense areas and reduce solar gain of the building. Through the study, it is concluded that by applying both green roof and living walls on certain facades with specific air gap, gives a positive impact on decreasing cooling loads inside the building. This study can make, the policy makers and designers have the awareness of factors that promote a better environment for children in kindergarten classes. Also, it is useful for the close co-operation with authority representatives involved in energy conservation and efficient use sector. For future studies, the simulation can be done by applying the living walls on more than one facade, which can give better results in decreasing the cooling loads, also the building orientation can be tested if it is changed and results can be investigated. In addition, a tool can be applied to facilitate the calculation of both, indoor air temperature and cooling loads inside kindergarten classes for any climatic zone in Egypt.

DECLARATION OF CONFLICT OF INTERESTS

The authors have declared no conflict of interests.

REFERENCES

1. Stankovic, D., “Improvement of Energy Efficiency of Schools and Kindergartens”, MATEC Web of Conferences, Vol. 53, pp. 1–6, 2016.
2. Haddad, S., King, S., and Osmond, P., “Enhancing Thermal Comfort in School Buildings”, 10th International Healthy Buildings Conference 2012, Vol. 2, No. 1995, pp. 1745–1750, 2012.
3. Stankovic, D., Tanic, M., Kostic, A., Vrecic S., Kekovic, A., Cekic, N., and Nikolic, V., “Resurgence of Indoor Environment of Preschool Building”, Procedia Engineering, Vol. 117, No. 1, pp. 742–755, 2015.
4. Mohidin, H. H. B., Ismail, A. S., and Ramli, H. B., “Effectiveness of Kindergarten Design in Malaysia”, Procedia - Social and Behavioral Sciences, Vol. 202, No. December 2014, pp. 47–57, 2015.
5. Ismail, Z. S., Darus, F. M., and Salleh, N. M., “Thermal Environment of Natural Ventilated Preschool Buildings in Warm-Humid Climates”, ISBEIA 2012 - IEEE Symposium on Business, Engineering and Industrial Applications, pp. 664–667, 2012.
6. Senitkova, I. J., “Indoor Air Quality and Thermal Comfort in School Buildings”, IOP Conference Series: Earth and Environmental Science, Vol. 95, No. 4, 2017.
7. Hammad, M., Ebaid, M. S. Y., and Al-Hyari, L., “Green Building Design Solution for a Kindergarten in Amman”, Energy and Buildings, Vol. 76, pp. 524–537, 2014.
8. Ramli, N. H., Masri, M. H., Taib, M. Z. H. M., and Hamid, N. A., “A Comparative Study of Green School Guidelines”, Procedia - Social and Behavioral Sciences, Vol. 50, No. July, pp. 462–471, 2012.
9. Suman, N., Zigart, M., Premrov, M., and Leskovar, V. Z., “Approach to Refurbishment of Timber Preschool Buildings with a View on Energy and Economic Efficiency”, Journal of Civil Engineering and Management, Vol. 25, No. 1, pp. 27–40, 2019.
10. Gajic, D., Stupar, D., Antunovic, B., and Jankovic A., “Determination of The Energy Performance Indicator of Kindergartens Through Design, Measured and Recommended Parameters”, Energy and Buildings, Vol. 204, 2019.
11. Faggal, A. A., “Investigating the Thermal Comfort Conditions in an Existing School Building in Egypt”, Ain Shams University, Vol. 45, No. 3, pp. 344–359, 2017.
12. Mainka, A., Bragoszewska, E., Kozielska, B., Pastuszka, J. S., and Zajusz-Zubek, E., “Indoor Air Quality in Urban Nursery Schools in Gliwice, Poland: Analysis of the case study”, Atmospheric Pollution Research, Vol. 6, No. 6, pp. 1098–1104, 2015.
13. Tucker, R., and Izadpanahi, P., “Live green, Think green: Sustainable School Architecture and Children’s Environmental Attitudes and Behaviors”, Journal of Environmental Psychology, Vol. 51, pp. 209–216, 2017.

14. Stankovic, D., Tanic, M., Kostic, A., Timotijevic, M., Jevremovic, L., Jovanovic, G., Vasov, M., and Sokolovskii, N., “Revitalization of Preschool Buildings: A Methodological Approach”, Procedia Engineering, Vol. 117, No. 1, pp. 723–736, 2015.
15. Besir, A. B., and Cuce, E., “Green Roofs and Facades: A Comprehensive Review”, Renewable and Sustainable Energy Reviews, Vol. 82, No. September 2017.
16. Ahmed, R., M., and Alibaba, H., Z., “An Evaluation of Green Roofing in Buildings”, International Journal of Scientific and Research Publications, Vol. 6, No. 1, pp. 366–2250, 2016.
17. Arefi, I., and Keivanizadeh, E. “Reviewing The Green Walls and Their Effects on The Formation of Sustainable Architecture”, Science Journal”, Vol. 36, 2015.
18. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.830.1281&rep=rep1&type=pdf (Accessed 05/06/2020)
19. Sameh, H., El Zafrany, A., and Attiya, D. N., “Analysis of Thermal Comfort Enhancement Using Vernacular Architecture in Siwa Oasis, Egypt”, Journal of Engineering and Applied Science, Vol. 66, No. 6, pp. 679–701, 2019.
20. http: //www.designbuilder.co.uk, (Accessed on 18/7/2020).
21. https://downloads.hindawi.com/journals/ace/2019/6326138.pdf (Accessed 01/08/2020)
22. https://www.mdpi.com/1996-1073/13/3/587 (Accessed 15/08/2020).

استخدام الغلاف الأخضر كأداة لتقليل درجة حرارة الهواء وأحمال التبريد داخل فصول حضانات الأطفال

يهدف البحث إلى تقييم كلاً من درجات الحرارة الداخلية والأحمال المستخدمة فى عمليات التبريد لفراغ فصل حضانة أطفال فى كل من محافظتى الإسكندرية وأسوان، وذلك من خلال عمل محاكاة رقمية باستخدام برنامج Design Builder ورصد نتائج وضع green roof ووضع living wall على الواجهات الأربعة للفصل ومن ثم الوصول إلى الواجهات الأفضل لوضع الliving walls، ثم معرفة المسافة المثلى بين ال living wall وواجهة الفصل.