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OPERATIONAL ENERGY SAVING IN BUILDINGS: A COMPARISON OF GREEN VS CONVENTIONAL WALL

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ABSTRACT

The green wall concept has been introduced as one of the solutions to reduce energy demand for ventilation requirements while improving the natural vegetation in dense urban areas. Past studies revealed that the energy-saving of green walls can vary substantially, from 35% to 90% across countries such as United Kingdom (UK), Canada, Russia, Greece, China, Saudi Arabia, India, and Brazil. Given these differences in energy saving of green walls due to climatic conditions and other reasons, direct application of such findings to the Sri Lankan context is questionable. Therefore, this study aimed to assess the thermal performance of green wall applications in Sri Lanka through a case study analysis of an indirect green façade with a comparative conventional wall. The required data were extracted through on-site temperature measurements from different points of both the exterior and interior wall surfaces of each building in different time intervals per day for a period of fourteen days spanning from October to November. The analysis shows that the green walls contribute to 21% - 36% of temperature difference compared to the conventional wall. Eventually, this results in 0.06 kWh of energy-saving per m^2 of wall area, and thereby green walls contribute to the 80% energy saving for ventilation requirements. Hence, the study recommends that the use of green walls can be considered as one of the energy efficiency solutions while improving natural vegetation in tropical climatic cities and absorbing other benefits of green walls.

Keywords: *Energy cost saving; Green wall; Indirect green façade; Thermal performance.*

1. INTRODUCTION

In recent years, building designers have been searching for an effective way to enhance building energy efficiency in a sustainable manner (Pérez *et al*., 2014). Ottelé *et al*. (2011) identified that the integration of vegetation into the building is one of the retrofit technologies for energy efficiency in buildings relative to sustainable aspects. There are two main ways of integrating vegetation into the buildings: green roofs and green walls (Sheweka and Magdy, 2011). However, Dunnet and Kingsbury (2008) stated that most of the time, the green wall area could be twenty times bigger than the roof area of multi-storey buildings. Hence, it is evident that having green walls can have a more sustainable impact than the green roof in multi-storey buildings. Most of the researchers illustrated that the ability to reduce heat gain and to cool the atmosphere through evapotranspiration of green walls could reduce the energy consumption for ventilation and heating meanwhile, they reduce the operational cost of building (Wong *et al*., 2010; Ottele *et al.,* 2011; Pérez *et al*., 2011; Susorova *et al.,* 2013; Susorova, 2015).

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Sri Lanka is gradually adapting to urban development by converting the natural vegetation into concrete buildings (Herath *et al*., 2018). The consequent natural vegetation depletion increases global warming (Pan and Chu, 2016). As a result of global warming, energy consumption increases to fulfil the requirement of human comfort (Sun *et al*., 2019). In the Sri Lankan context, more than 75% of electricity is used for ventilation and air conditioning purposes from the total energy consumption in a typical building (Geekiyanage and Ramachandra, 2018). In this context, the use of green walls can be considered as a solution to optimise the energy consumption in buildings in Sri Lanka. However, the application seems minimal, could be due to the reasons of lack of public awareness of the concept and its potential benefits, particularly about its contribution to energy saving, perception of higher initial and maintenance costs, possible aesthetic effects to the wall surface, and more time-consuming for the absorption of benefits (Jefas *et al*., 2012; Peiris, 2017; Rupasinghe and Halwatura, 2018).

Despite some of the global researchers such as Wong *et al*. (2010), Ottele *et al*. (2011), Pérez *et al*. (2011), Susorova *et al*. (2013), and Susorova (2015) have focused on potential energy cost-saving of green walls, the application of such research findings to the Sri Lankan context is questionable due to the geographical differences. Hence, this research aimed to assess the thermal performance of green walls through a comparison of a green wall with a comparative conventional wall of a residential facility and thereby establish the potential contribution made to savings in energy in the Sri Lankan context.

2. LITERATURE REVIEW

2.1 SIGNIFICANCE OF GREEN WALLS

Green walls refer to all types of vertical vegetation surfaces such as facades, walls, blind walls, and partition walls (Newton *et al*., 2007; Manso and Castro-Gomes, 2015). According to Dunnet and Kingsbury (2008), vertical vegetation can be climbing or hanging upward on the vertical surface or grow downward on the vertical surface. Green walls can be divided into two main categories as the green facade and living walls according to the method of construction (Köhler, 2008; Dunnet and Kingsbury, 2008). Green facades are further classified into direct and indirect green facades; based on a climbing plant directly attached to the wall and supported with structures such as steel cables or trellis respectively (Kohler, 2008). The living wall system is more complicated than the green façade system since it has prefabricated or pre-vegetated systems on a modular panel that contains growing media with balanced nutrients (Dunnet and Kingsbury, 2008).

When considering the construction cost of these green wall types, direct green facades are more cost-effective than indirect green façade and living walls due to the absence of support structure (Manso and Castro-Gomes, 2015). However, direct green facades comprise contribute to certain disadvantages, mainly, affecting the aesthetic appearance of the wall surface with the plant roots and collapsing of plant when further grows (Dunnet and Kingsbury, 2008). Manso and Castro-Gomes (2015) stated that indirect green facades and living walls are a solution to overcome those disadvantages of direct green facades. However, the construction cost of living walls is comparatively higher than indirect green facades.

The green wall concept has spread over the residential, office, commercial, and government buildings around the world with its numerous benefits (McCullough *et al*., 2018). In addition to the energy cost saving in green walls, it enhances the biodiversity in high-density urban areas with supporting foods and habitats for the animals (Lundholm, 2006), mitigates the urban heat island effect (Busato *et al*., 2014), and improve the air quality (Ottelé *et al*., 2010). Furthermore, Vox *et al*. (2018) stated that the green wall concept is mainly related to improving real estate value or rental value. Moreover, Ottele *et al*. (2011) identified that the green wall concept contributes to less external wall surface maintenance by absorbing the Ultra-Violet (UV) rays fallen onto the wall. However, the amount of benefits gained through the green walls depends on the green wall type, application, and the foliage thickness of the plant (Perez *et al*., 2011; Perini and Rosasco, 2013; Huang *et al*., 2019). Therefore, the study gives due consideration to those parameters in selecting the building for its energy assessment due to green walls.

2.2 ENERGY COST SAVING IN GREEN WALLS

The importance of green wall applications has become the forefront with the ability to reduce heat transfer between internal and external environments through plants (Susorova, 2015; Libessart and Kenai, 2018). Figure 1 shows the physical thermal process of the energy balance of the vegetated surface.

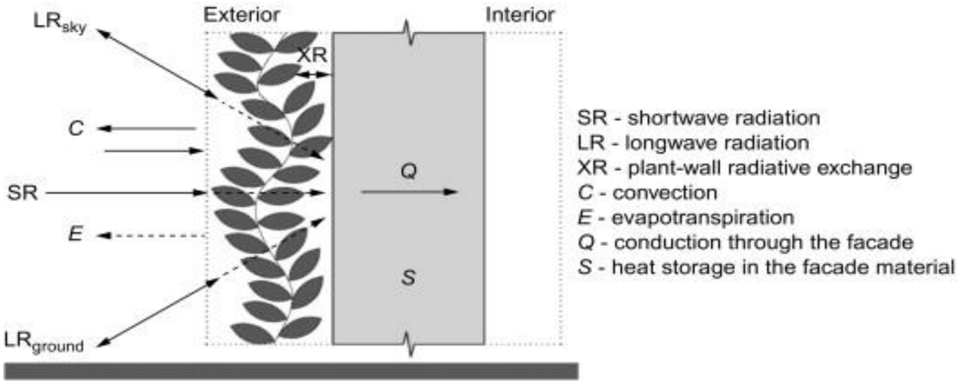

Figure 1: Energy balance of a vegetated façade (Source: Gates, 2003)

According to Larcher (2003) and Straube (2005), the thermal process of the energy balance of the vegetated surface can be listed as follows. Shortwave solar radiation is received by the building wall through the sun. Longwave radiation also exchanges between ground, sky, and surrounding surfaces. Then those radiations are absorbed by the walls and transferred back into the environment by convection or transferred to the building interior by conduction. Some amount of energy is stored in the wall material. The authors further derived the following equations for energy balance:

The energy balance of a conventional/bare wall (bw) is;

$$SR_{bw} + LR_{bw} + C_{bw} = Q_{bw} + S_{bw} \tag{01}$$

The energy balance of a vegetated wall (vw) is;

$$SR_{vw} + LR_{vw} + XR + C_{vw} = Q_{vw} + S_{vw} \tag{02}$$

The foregoing review evidences that the plant layer acts as an additional thermal insulation layer.

Gates (2003) stated that the study of energy balance and heat flows through a vegetated wall surface of a building is important to evaluate the thermal performance and potential energy saving of green walls.

Table 1 illustrates the findings of some studies that depict the heat flows through green walls.

Table 1: Heat flows through green walls

Type of Green Wall	Plant Species	Foliage thickness (cm)	Climate (Koppen classification)	Temperature reduction (^{0}C)		Source
				External wall	Internal wall	
Direct	*Parthenocissus tricuspidata*	25	Cfb	5.7	0.9	(Eumorfopoulou and Kontoleon, 2009)
Indirect	Climber plants	-	Af	4.36	-	(Wong *et al*., 2010)
Direct	*Hereda helix*	20		1.2	-	
Indirect	*Hereda helix, Vitis, Clematis, Jasminum, Pyracantha*	10	Cfb	2.7	-	(Perini *et al*., 2011)
Living wall	Evergreen species	10		5	-	
Indirect	*Wisteria sinensis*	20	Csa	15.8	-	(Pérez *et al*., 2011)
Direct	*Hereda helix*	10-45	Cfb	1.7 - 9.5	-	(Sternberg *et al*., 2011)
Direct	*Parthenocissus tricuspidata*	-	Dfa	7.9	2	(Susorova *et al*., 2013)
Living wall	Climber plants	-	Cfb	20.8	-	(Chen *et al*., 2013)

From the review of Table 1, it is evident that the heat flow through the green walls depends on various factors such as climate, green wall type, and vegetation type.

Furthermore, most researchers identified that the green walls significantly contribute to the energy saving of buildings through their ability to less heat flow through a building's external and internal wall surfaces.

Bass and Baskaran (2001) found that the implementation of green walls helps to reduce energy cooling load by 23%, energy for fans by 20%, and as a result that, annual energy consumption by 8%. Furthermore, Alexandri and Jones (2008) concluded that, if all possible facades covered with vegetations, energy saving can vary from 90% to 35% by conducting computational fluids dynamics simulation to main cities in the United Kingdom (UK), Canada, Russia, Greece, China, Saudi Arabia, India, and Brazil. These countries have different climatic conditions. Hence, the potential energy saving of green walls also depends on the climate.

Additionally, Wong *et al*. (2009) researched the variation of cooling load based on the foliage thickness of the green wall and showed that the 74% cooling load reduction in a building with a fully covered wall with the vegetation, 10% cooling load reduction in a wall with 50% covered with vegetation and rest 50% glazing and 32% cooling load reduction in fully covered vegetation on the fully glazed wall. Price (2010) developed a mathematical model to evaluate energy efficiency in low-rise buildings with an indirect green façade and found that building cooling load reduced by 28% in a temperate climate. Pan and Chu (2016) researched the energy savings of green walls in Hong Kong and demonstrated that green walls contribute to 16%

saving of the energy consumed for air conditioning in the months of August and September which are typical summer months.

3. RESEARCH METHODOLOGY

The study primarily used a quantitative approach where the required data were collected from preliminary survey and a comparative analysis. Initially, a preliminary survey was carried out into various sources such as site visits, internet, green wall suppliers, and green rating systems (GREEN^{SL} Rating System and LEED Certification) to identify green wall applications in Sri Lanka. Accordingly, forty-three (43) applications were identified through green wall suppliers (18), green rating systems (12), site visits (11), and internet surveys (6). The summary of identified cases is illustrated in Table 2 and further discussed in the following sections.

Table 2: Green wall application

Building	No	Green Wall Type			Application		
		Direct	Indirect	Living wall	External wall	Internal wall	Boundary wall
Hotel	15	8	5	2	4	1	10
Residential	10	2	6	2	6	2	2
Industrial	8	-	6	2	6	1	1
Office	7	-	7	-	6	-	1
Educational	2	1	1	-	2	-	-
Religious	1	-	1	-	1	-	-
Total	43	11	26	6	25	4	14

Among the 43 green wall cases, indirect green façade is the most used in Sri Lanka, compared to direct green facades and living walls. According to Perini and Rosasco (2013) and Huang *et al*. (2019), the application of green walls to the exterior walls of a building greatly contributes to the energy-saving of a building. Accordingly, it is evidenced that applications to external walls are significant in the Sri Lankan context. Furthermore, the amounts of energy savings gained from the green walls depend on the amount of the foliage thickness (Pérez *et al*., 2011). Hence, it was decided to select a building profile that contains an indirect green wall on the exterior wall surface of the building with significant foliage thickness to evaluate the thermal performance of the green wall effectively. From the 43 cases, only nine (9) cases were comprised of the green walls covering the entire building envelope. The remaining cases were limited to the boundary walls and internal walls (partition walls) of the buildings with less green wall coverage. Of the nine (09) buildings, due to the COVID 19 pandemic situation and related data accessibility and time constraints, it was possible to choose one case study of green walls. Furthermore, for this comparative study, there needs to be two buildings: with green walls and without green walls with similar physical properties which would influence the thermal performance and energy. Hence, when selecting the cases, due consideration was given to location, purpose, building shape, and size and thereby to ensure the reliability and accuracy of the research findings.

Based on aforementioned factors, a temple building (Religious) in Matara (5.95° N, 80.54° E, classified as tropical rainforest climate [Af], according to the Koppen climate classification), was selected as it contained buildings with both green walls and conventional walls in the same location.

Heat transfer through the conventional wall and green wall was calculated to evaluate the thermal performance of the indirect green façade. The ground floor walls of the green wall building were not covered with the climbing plant. Hence, the first and second floors of each building were selected to obtain the field measurements. An infrared thermometer and relative humidity meter were used to obtain the on-site temperature and relative humidity measurements. Measurements were taken for fourteen days scattered over the period from 21st October to 14th November in each building due to the time restrictions. The rays of the sun that fall on the external wall surface are not constant at every point. It changes due to the orientation of the building (North, South, West, East), the composition of the external wall, and surrounding buildings. Hence, to increase the accuracy of this study, temperature measurements were taken from different points on the first and second floors of each building. All measurements were taken from both the outer surface and inner surface of the walls. The intensity of solar radiation is not constant throughout the day. Therefore, to increase the reliability of the study, measurements were taken at five-time intervals per day (8.30a.m., 10.30a.m., 12.30p.m., 3.00p.m. and 5.00p.m.). Ultimately, the mean values of obtained measurements were considered to calculate the energy saving cost.

3.1 PROFILE OF THE SELECTED BUILDINGS

Both buildings selected for the study are rectangular in shape. Even though these buildings belong to the temple, they are used for residential purposes. The longitudinal sides of both buildings are oriented to the North and South directions. All sides of the building are fully exposed to the sunlight without obstructing from surrounding objects. An indirect green façade is present in one of these buildings. The plant is well grown around the wall surface of the building except for the south wall and the ground floor. *Thunbergia laurifolia* is the climbing plant used in this building. Average foliage thicknesses of north, east, and west wall surfaces are 45cm, 15cm, and 12cm, respectively. The support structure is made of one and a half-inch dia Galvanized Iron (GI) pipes and 3mm Polyethylene terephthalate (PET) wire. Table 3 illustrates the summary of both building profiles.

Table 3: Summary of building profiles

Description	Indirect Green Façade Building	Conventional Wall Building
Number of floors	3 floors with a rooftop	3 floors with a rooftop
Floor height	3.3m	3.3m
Exterior dimensions	Length - 22.6m Width - 9.75m	Length - 14.7m Width - 8.10m
GIFA per floor	210.74m^2	125.28m^2
Service life	3 years	4 years
A/C	-	-
Wall type	Block Wall	Block Wall
Wall thickness	150mm	150mm
Wall Finishing (Internal and External)	Plastering + Painting	Plastering + Painting
Window type	Louver Aluminum framed glazed windows	Louver Aluminum framed glazed windows
Door type	Louver Aluminum Door	Louver Aluminum Door

4. DATA COLLECTION AND ANALYSIS

4.1 THERMAL PERFORMANCE OF GREEN WALL

Based on the geometric mean temperature of each day, the average temperature difference between the external and internal surfaces of both conventional wall and green wall was calculated separately and the summary is presented in Table 4. The outer surface and inner surface are represented as O and I respectively.

Table 4: Summary of average temperature

Indirect Green Façade Building – Average Surface Temperature (^{0}C)												
Location	**North Wall**			**East Wall**			**West Wall**			**South Wall**		
	O	**I**	**O- I**	**O**	**I**	**O- I**	**O**	**I**	**O- I**	**O**	**I**	**O- I**
1st Floor	28.9	28.7	0.18	29.1	28.9	0.21	30.0	29.6	0.42	30.6	30.0	0.65
2nd Floor	28.9	28.8	0.16	29.1	28.9	0.22	29.7	29.4	0.28	30.6	29.9	0.70
Conventional Wall Building – Average Surface Temperature (^{0}C)												
1st Floor	30.1	29.3	0.77	30.6	29.4	1.18	30.8	29.8	0.98	30.5	29.6	0.87
2nd Floor	30.2	29.2	0.91	30.7	29.4	1.30	30.8	29.9	0.93	30.5	29.7	0.82

According to Table 4, in all points of location, a significantly higher temperature difference increment is observed in the conventional wall compared to the green wall. This temperature difference indicates the heat loss through the wall surface. Furthermore, the temperature behaviour of north, east, and west walls are approximately equal in indirect green façade buildings. However, temperature measurements of the south wall, which are not covered with the indirect green façade are considerably high and similar to the conventional wall building.

The following formula was used to calculate the heat transfer through the external wall surface of both building profiles.

$$\boldsymbol{Q} = \frac{\boldsymbol{K.A.\Delta\theta}}{\boldsymbol{L}} \tag{01}$$

Where, Q = Heat Transfer (W), $\boldsymbol{\Delta}\theta$ = Temperature Difference (^{0}C), L = Thickness of Surface (m), K = Thermal Conductivity (W/m^{0}C), A = Heat Transfer Area (m^2)

According to The Engineering Toolbox (2020), the thermal conductivity of the blocks was considered as 1.7 W/m^{0}C. Furthermore, 1m^2 of wall surface was considered in heat calculation.

Heat transfer calculations for wall surfaces of both buildings are shown in Table 5.

Table 5: Heat transfer calculations for green wall and conventional wall

Indirect Green Façade per m^2		
	First Floor (W)	Second Floor (W)
North wall	$Q = \frac{1.7 \times 1 \times 0.18}{0.15}$ = 2.04	$Q = \frac{1.7 \times 1 \times 0.16}{0.15}$ = 1.79
East Wall	$Q = \frac{1.7 \times 1 \times 0.21}{0.15}$ = 2.41	$Q = \frac{1.7 \times 1 \times 0.22}{0.15}$ = 2.50
West Wall	$Q = \frac{1.7 \times 1 \times 0.42}{0.15}$ = 4.76	$Q = \frac{1.7 \times 1 \times 0.28}{0.15}$ = 3.17
South Wall	$Q = \frac{1.7 \times 1 \times 0.65}{0.15}$ = 7.34	$Q = \frac{1.7 \times 1 \times 0.70}{0.15}$ = 7.92

Conventional Wall per m^2		
	First Floor (W)	Second Floor (W)
North wall	$Q = \frac{1.7 \times 1 \times 0.77}{0.15} = 8.68$	$Q = \frac{1.7 \times 1 \times 0.91}{0.15} = 10.35$
East Wall	$Q = \frac{1.7 \times 1 \times 1.18}{0.15} = 13.36$	$Q = \frac{1.7 \times 1 \times 1.30}{0.15} = 14.73$
West Wall	$Q = \frac{1.7 \times 1 \times 0.98}{0.15} = 11.16$	$Q = \frac{1.7 \times 1 \times 0.93}{0.15} = 10.57$
South Wall	$Q = \frac{1.7 \times 1 \times 0.87}{0.15} = 9.89$	$Q = \frac{1.7 \times 1 \times 0.82}{0.15} = 9.32$

According to the above calculations, conventional wall accounts for 88.06 W heat transfer per m^2 of wall area. However, the wall surfaces of the building which is having an indirect green façade account for 31.93 W per m^2. Generally, the building requires equivalent energy as the cooling energy for this transferred heat through the wall surface. As per Table 5, the conventional wall is responsible for an additional heat transfer of 56.13 W per m^2. Hence, the energy required for the cooling purposes of a building with an indirect green façade is relatively lower than the conventional wall building.

Table 6 presents the heat transfer and energy requirement through the selected conventional and green walls.

Table 6: Summary of heat transfer and energy requirement of conventional wall and green wall

	Green Façade Building	Conventional Wall Building
Heat transfer (W/m^2) per day	31.93	88.06
Energy requirement per month (kWh)	204.52	397.53

Green walls contribute to a reduction in heat transfer through the exterior and interior wall surfaces and the energy requirement of a building compared to the building with the conventional wall as evidenced in Table 6.

Using current unit rates published by the Ceylon Electricity Board (CEB) of Sri Lanka - 2020 for domestic buildings, monthly and annual energy costs for both buildings were calculated and presented in Table 7.

Table 7: Annual energy consumption of both buildings

Description	Unit rate (LKR/kWh)	Amount (LKR)	
		Indirect Green Façade Building (Energy consumption per month = 204.52 kWh)	Conventional Wall Building (Energy consumption per month = 397.53 kWh)
For first 60kW	7.85	471.00	471.00
For Next 30kW	10.00	300.00	300.00
For Next 30kW	27.75	832.50	832.50
For Next 60kW	32.00	1,920.00	1,920.00
For rest	45.00	1,103.40	9,788.85
Fixed		540.00	540.00
Total (Per Month) - Building		5,166.90	13,852.25
Total (Per Month) - Per m^2		24.20	92.05

Description	Unit rate (LKR/kWh)	Amount (LKR)	
		Indirect Green Façade Building (Energy consumption per month = 204.52 kWh)	Conventional Wall Building (Energy consumption per month = 397.53 kWh)
Total (Per Annum) - Building		62,002.80	166,228.20
Total (Per Annum) - Per m^2		290.39	1140.65

According to Table 7, the energy cost per m^2 of a wall area in a green wall building is Rs. 290.39 per annum while the same for the conventional wall is Rs. 1140.65 per annum. Hence, the green wall building shows Rs. 850.26 cost-saving per m^2 than the conventional wall per annum. In other words, indirect green façade building shows 80% of energy cost-saving than the conventional wall building.

5. DISCUSSIONS

Green walls contribute to saving the energy requirement for cooling and ventilation purposes of buildings via maintaining the building's internal temperature (Susorova, 2015; Libessart and Kenai, 2018). It is due to the less heat transfer through the external wall surface with the presence of green walls. The data retrieved through the case study analysis of the current study also supports the above statement.

Moreover, Sternberg *et al*. (2011) stated that, during the daytime, the exterior façade surface temperature is reduced by a 1-9^{0}C due to vegetation on the wall surface than the wall without vegetation layer. Similarly, as per Table 5, the exterior surface temperature of the green wall is always lesser than the conventional wall's external surface temperature. However, there was no such high difference in temperature reduction between the green wall and conventional wall observed in this study. The difference was limited to 0.8^{0}C - 1.5^{0}C. The reason for this dissimilarity could be due to the use of green wall type and the climate difference between the two studies. Sternberg *et al*. (2011) conducted a study regarding the direct green façade on Cfb climate (Reference to Koppen Climate Classification) and this study focused on indirect green façade on Af climate. However, Wong *et al*. (2010) conducted a study on indirect green façade on Af climatic condition and showed that the temperature reduction of 4.36^{0}C of external wall surface, which is having a vegetation layer. Hence, it is evidenced that the thermal performance of green walls not only depends on the green wall type and the climate. There seem other reasons such as façade orientation, foliage thickness, and vegetation type which could contribute to the different degrees of temperature difference.

In agreement with that, Pérez *et al*. (2011) depicted that the thermal performance of green walls varies with the foliage thickness and the orientation of the façade. As per Table 4, a lower average surface temperature difference of 0.16^{0}C is shown by the north wall with 45cm of average foliage thickness. West wall has a less average foliage thickness compared to other sides and shows a high surface temperature difference of 0.42^{0}C. This proved that the plant layer in the exterior wall surface of green walls provides an additional insulation layer and helps to reduce heat conduction through the exterior façade. Therefore, the literature findings were proved further by the case study analysis.

Furthermore, the analysis results indicate that the indirect green façade building accounts for 80% of energy cost-saving than the conventional wall building. This supports the finding in previous studies Alexandri and Jones (2008). Alexandri and Jones (2008) concluded that, if all possible facades are covered with vegetation, energy saving can vary from 90% to 35%. Moreover, Pan and Chu (2016) stated that green walls contribute to saving 16% of the energy consumed for air conditioning in hot and wet summer seasons in Hong Kong. However, this figure has been derived by considering the seasonal changes are in Hong Kong while no such seasonal changes are visible in Sri Lanka. Hence, the energy-saving percentage is considerably less than the findings of the current study. This further shows that the potential energy saving of green walls depends on the climatic conditions.

6. CONCLUSIONS

In this study, a comparative analysis of the thermal performance of green walls and conventional walls was performed to determine the energy-saving contribution of green walls. From the study findings, it was apparent that all common building types: commercial, residential, and office have incorporated with the most popular indirect green façade type in Sri Lanka. Direct green facades are mostly applied to the boundary walls in the hotel buildings with the intention of aesthetic appearance. Energy cost saving for cooling and ventilation purposes of buildings via maintaining the building's internal temperature is a significant benefit of green walls. The current study found that the significant temperature difference increment in the conventional wall compared to the indirect green façade and thereby indirect green façade building accounts for 80% of energy cost-saving than the conventional wall building. Hence, it is expected that the findings of the study would convince the public of the awareness and perceptions about the energy-saving cost benefits of green walls and thereby enhance its application in the Sri Lankan context.

This study has limited its focus only to energy aspect of the most used type of green wall, indirect green façade type in Sri Lanka. However, there are other types of less commonly used green walls and green walls offer benefits beyond energy saving. Therefore, it is recommended that these aspects need to be evaluated comprehensively for effective implementation of green walls and to absorb its optimum potential.

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