PASSIVE CLIMATE MODIFICATIONS IN DUTCH BUILDINGS: A STUDY ON PUBLIC BUILDINGS BY CHURCH STREET, GALLE FORT

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Abstract

Galle Fort is considered to be the largest preserved historical living settlement in Southeast Asia. The city has been influenced by multiple colonial powers, of whom the Dutch; masters of colonies were the longest rulers. Dutch architects created building designs adaptive to the coastal tropical climate in planning towards a sustainable city. The long enduringness with user fittingness to date witnesses it. This has attempted energy-efficient, cost-effective, and conveniently maintainable buildings while fulfilling the social needs of the time. Therefore, it is important to focus on sustainable design strategies which the Dutch have used in the absence of electrical energy for light and ventilation. These strategies can be effectively applied in building design to maintain and improve the quality of urban life and mitigate the effects of the energy crisis.

The current guidelines for sustainable residences in Sri Lanka have introduced four key passive strategies, building orientation, building materials, light, and ventilation. This study aims to investigate the strategies used by the Dutch and their compatibility with these guidelines. Numerous significant buildings were established by the Dutch along church street. Therefore, this street which comprises a wide variety of Dutch public buildings is selected for the study. Physical and non–physical elements are studied and compared with the four key passive strategies. According to the findings, building orientation was not specifically considered by the Dutch. However, lighting strategies, heat-controlling strategies, and ventilation systems were at a moderate level. Materials are compatible with the guidelines. In conclusion, the passive climate modifications used by the Dutch with some improvements are valuable in developing energy-efficient and effortlessly maintainable buildings to create sustainable cities.

Keywords: Sustainable guidelines, Positive climatic responses, passive strategies, energy efficiency, passive climate modifications

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Introduction

Buildings are the most pronounced elements of urban design. They are part of the urban realm that creates walls to the street (Hu & Chen, 2018). However, Petrichenko et al., (2015) point out that they are one of the largest energy consumers which will create a negative impact on the environment. Passive design modifications are the design strategies that can lower indoor air temperature. Dayaratne (2018) confesses that though the attention to sustainability is concerned with managing economic growth, the 'quality of life' of future generations is ensured; the focus is on energy production and use. Therefore, it is important to have passive climatic modifications in buildings for energy conservation and sustainable city planning.

Sustainable developments are evidenced as healthy, safe, convenient, well-planned, and built to last long. Concurrently, they are visually pleasing, aesthetically appealing, conveniently functioning, and overall user-friendly (Wijesundara et al., 2021). According to Soysa (2007) the sustainable ancestral settlements of Sri Lanka had been severely affected by several colonial powers. These colonies were mainly spread in the southern coastal belt of the island. The Portuguese were the first colonial nation who ruled Sri Lanka in 1505. (Roberts, 1993). They first arrived in Galle thenceforth Dutch (1640- 1796) and British (1796- 1948) took over the city for more than four centuries. This subjected them to spread their religion, law, education, and economy which was reflected in their architectural designs.

Dutch who ruled the country for more than 150 years has applied local construction technologies and traditional values in their designs (Roberts, 1993). These buildings are adapted for coastal tropical climatic conditions which sustained for centuries. Soysa (2007) points out that, according to the hierarchical order of the secondary streets in the Dutch era Church Street is the second most important street. He also stated that Dutch used the land preliminary for mercantile purposes and that created a diverse community of aristocrats, merchants, and militants. This has eventually developed different types of buildings like warehouses, schools, churches, hospitals, and residences. They have established most of the diverse Dutch buildings placed along this street Soysa (2007). Out of these different types of buildings, four building types with different passive climate modifications were studied accordingly. This paper illustrates how the Dutch have incorporated passive design strategies in Galle fort, especially in buildings on Church Street that will contribute to sustainable building design.

1.1 Research background

Portuguese and Dutch were ruling the Galle fort respectively since 1505 and 1658. (Roberts, 1993). Even though Dutch ruled the country for 150 years, Sansoni et al., (1998) point out that buildings in the first fifty years had the predominant Portuguese characteristics. However, during the 18th century Dutch characteristics were prominent in almost every detail of the building.

> *"An obvious reason for the resilience of the old Dutch building tradition lay in its conformity to the environmental conditions – it was a climatically adaptable architecture achieved by the employment of relatively primitive building techniques and crude materials…..it was an architecture at once practical and cheerful in a land of extremes."*
>
> Sansoni et al., (1998)

Evidently, the adaptability to the climate and resilience to time of Dutch buildings is significant in terms of their long-lastingness and fittingness to generations (Uditha, J 2020).

2. Research questions

This paper will focus on four long-lasting sustained Dutch public buildings in Church Street, Galle fort. The following questions were made to study the passive climatic modifications in these buildings.

1. How have the passive climatic modifications been determined by Dutch public buildings?
2. What modifications and implications can be improved in modern building constructions?

3. Research objectives

- To investigate the passive climatic modifications of Dutch public buildings compared to the current sustainable guidelines in Sri Lanka.
- To examine how these make it useful to optimize energy-saving parameters of buildings.
- To understand these strategies necessary to implement regulations for sustainable heritage conservation and restoration.

4. Literature review

Dayaratne (2018) declares that researchers understand that vernacular settlements possess an enormous wealth of knowledge of sustainable living and building. Even though many researchers have studied the sustainable strategies used in the Dutch townhouses and vernacular settlements in Galle fort, (Rajapakse, 2013) they have yet to examine Dutch public buildings in detail. Galle fort has limited space because of the narrow plan form, creating a barrier to design improvement. Therefore, it is important to study building elements, i.e., building orientation, building materials, and light and ventilation strategies which the Dutch have used to create a comfortable thermal built environment.

4.1 Architectural character of Church Street – Galle fort.

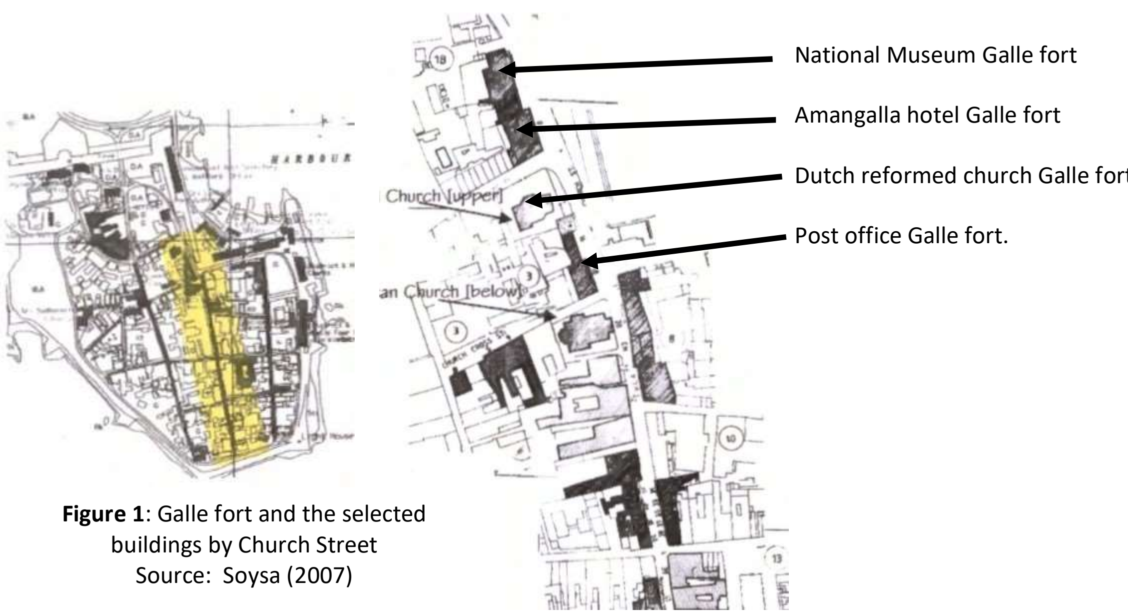

Figure 1: Galle fort and the selected buildings by Church Street
Source: Soysa (2007)

Church Street starts from the current National Museum in Galle fort. The street has created a building fabric with various buildings. The street is dominated by single-storied buildings with a front verandah. According to Soysa (2007) the function of the building determines the openness of the verandah. The territory was demarcated by using timber trellis, higher plinth beams, and gates. The verandah consists of a series of columns that supports the clay-tiled roof.

The roof is sloped towards the street to create a shady avenue for people. The entrance door is mostly placed in the middle of the building to maintain symmetry. The main entrance is usually leading towards the courtyard. The courtyard will make the narrow building plan, less compact, and spread out. In addition, the high internal volume and the use of high thermal mass materials are also common features in these designs.

According to Sansoni et. al., (1998) solid void ratio, material usage, and the proportions of the column will determine the character of the streetscape. The dwelling units were separated from each other by their side wall. This creates a continuous building fabric for the street (Rajapakse, 2013).

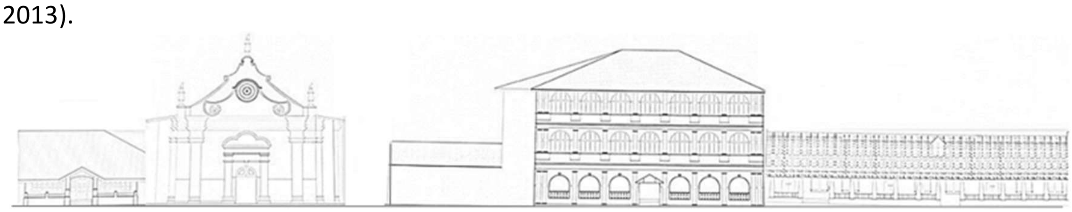

Figure 2: Church Street elevation
Source: Archeological Department, Galle

Karunaratne (2017) identified that when designing buildings in the coastal tropical climate, strategies should be made in terms of reducing the Solar gain. Using proper strategies, the high indoor air temperature in the daytime can be reduced. The guideline for sustainable energy residences in Sri Lanka (2019) has introduced four key passive design strategies, building orientation, building materials, and light and ventilation strategies to design thermal comfort buildings.

4.2 Building orientation

According to the guideline for sustainable energy residences in Sri Lanka (2019), the sun's location is critical to mitigating the solar impact. It also mentioned that in Sri Lanka, the sun affects the building surface mainly in the East-West direction. This surface is also known as the solar surface. Smaller elements should be placed on this surface to exclude direct heat.

4.3 Lighting Strategies

The guideline for sustainable energy residences in Sri Lanka (2019) shows that neighbouring buildings will also act as an external shading device and protect the building from direct sunlight. According to the guidelines, exterior shading fenestration and internal shading devices will also exclude solar heat from reaching the interior. According to the guideline for sustainable energy residences in Sri Lanka (2019), the roof is the building element exposed more often to the sun than the walls. This happens due to the high-altitude solar angle. Therefore, necessary steps should be made to reduce the heat reaching the building by convection. Light wells can be placed in a way that will not provide glare. This could be placed in either the North or South direction.

4.4 Ventilation Strategies

Guidelines for sustainable energy residences in Sri Lanka (2019) point out that, proper openings will spread fresh air equally inside the building while allowing natural light and blocking heat. According to these guidelines, there are two types of ventilation which can be lowering the internal air temperature, i.e., cross ventilation and stack ventilation. The shape, size, and placement of the window will also determine the air velocity of a building. Smaller windows should be placed in the windward direction on the bottom or the middle of the wall. Larger windows should be placed on a little high level. This will circulate the cold air in the building.
Guidelines for sustainable energy residences in Sri Lanka, (2019) also found that open-plan forms with open interior spaces will promote airflow. Neighbouring structures, landforms, elements, and vegetation can also allow air into the building. Pergolas, water features, and courtyards are some elements which can reduce heat gain. Tharanga (2017) has identified that increasing the height of the ceiling can also reduce heat gain.

4.5 Building materials

Thermal comfort is one of the main considerations in building design. No doubt using proper building materials can reduce the internal heat gain of the building. According to Tharanga (2017) climatic responsive buildings can also flatten the daily temperature fluctuations. He further elaborated that using high thermal mass materials for the interior can absorb the surrounding higher thermal energy and provide this thermal energy back to the building when the indoor temperature is less. Tharanga (2017) substantiated that light-colored paint applied on the exterior wall can reduce heat transmission more than bright colours.

5. Scope and limitations

Church Street in Galle Fort is rich with several Dutch buildings. This study is limited to four Dutch public buildings on upper Church Street. This study examines two building units of the post office even though it was amalgamated during the British period.

6. Research method

Many studies have been implemented on climatic responsive strategies used in private buildings in Galle fort, they have yet to consider the strategies used in Dutch public buildings. Thus, this study was conducted on church street, where the most diverse public buildings were located.
Following Mills (2010) the study adopts the fact that appropriate sampling best portrays the research problem. Accordingly, the research was based on four selected case studies to deeply explore the real aspects of Dutch public buildings by the upper Church Street in Galle fort. A religious building (Dutch reformed church), a civic building (national museum), an institutional building (post office), and a commercial building (Amangalla hotel) in this street were the selected cases.

According to Soysa (2007) the relationship between a space and a character will be determined on two factors. i.e., physical properties and activities. Following these two factors, the detailed case study was conducted by studying the building’s physical and nonphysical elements.

(1) Analyzed the documented evidence (measured drawings and other structural details) from three government offices, i.e., the archaeological department of Galle fort, Galle

heritage foundation, and Galle Heritage Centre. Then secondary data was collected from historical maps, books, journals and articles on the selected area.

(2) The documented thermal compatibility evidence was verified by further studying the building elements through on-site observation.

A qualitative analysis was conducted to study the architectural characteristics and the unique building elements for thermal comfort. Aksoy & Sagiroglu (2022) stated that qualitative comparative analysis is usually used to analyze qualities if research has a minimum and complexed data collection with changing factors due to different time series. The selected buildings have several functions and design in different stages in Dutch period, was based to use this method**. Accumulated data** were analyzed on the validity and appropriateness of the climatic conditions within Dutch planning. They were evaluated against the four key passive design strategies introduced by the current guidelines for sustainable residences in Sri Lanka.
Finally, the thermal comfort of those buildings was analyzed, and recommendations for improvements were suggested. The discussion was further extended pointing directions for further studies.

7. Findings and analysis

Passive climatic modification of Dutch public buildings with high public attraction was studied, referring to four selected cases. The analytical structure in terms of elements is based on the literature.

7.1. Case studies

7.1.1. Case Study-1: Commercial building: Amangalla Hotel

The selected hotel is a five-star five-storied hotel located on Church Street which was used as the headquarters for the Dutch commanders. (Roberts, 1993). During the British era, this was used as a hotel building named “New oriental hotel” for more than 140 years and before that, as the quarters for British soldiers for a shorter period Soysa, 2007).

7.1.2. Case Study-2: Civic building: National Museum

Roberts (1993) examine and identified that the existing national museum built was originally established as a military warehouse by 1656. He stated that this building has been latterly used as a billiard room as a part of the Amangalla hotel without doing any significant changes to the physical appearance of the building.

7.1.3. Case Study-3: Religious building: Dutch reformed church

The Dutch reformed church was placed at the pinnacle of the Galle fort. This site was previously used by the Portuguese as a capuchin convent (Soysa, 2007). The building is surrounded by a large graveyard. There is an earth cave near the side gate which is believed to be a burial chamber. Some burials were laid even on the floor of the church where the written plaques are still conserved. This building has followed the cruciform plan form with a shorter transept. Since the church has no central tower, two Dutch cables in the North-South direction are bearing the roof load. Doorways have a crowded classical classicist with circular pediments with a high masonry Dutch gable in the front facade. This is an authentic Dutch architectural feature (Soysa, 2007).

7.1.4. Case Study-4: Institutional building: Post office

Soysa (2007) mentioned that this building was used as a residence of Dutch officers at different times. The adjoint Dutch building in the church cross street was amalgamated during the British period (Soysa, 2007). Currently, this building is under renovation according to the conservation guidelines.

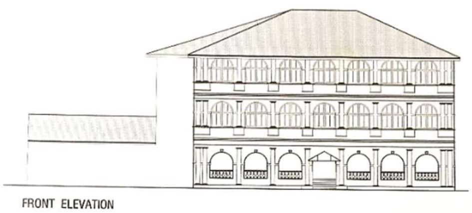

Figure 3: Amangalla hotel – Galle fort
Source: Department of Archeology

Figure 4: National Museum – Galle fort
Source: Department of Archeology

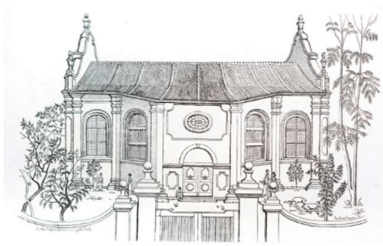

Figure 5: Dutch reformed church– Galle fort
Source: Sansoni et. al., (1998)

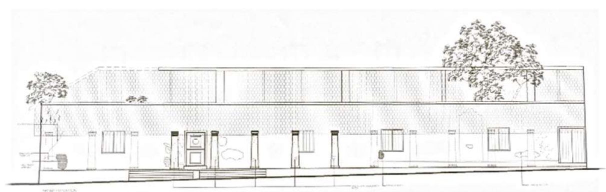

Figure 6: Post office – Galle fort
Source: Department of Archeology

Building orientation

None of the selected buildings is orientated towards the East-West direction that will not respond to the climatic condition in Galle fort. It can be concluded that the Dutch were not specifically concerned with building orientation when designing buildings. Limited area and narrow street pattern may be a reason for this.

7.2. Lighting Strategies

Dutch have used a lot of strategies in terms of allowing lighting while mitigating the heat. Some of them are a long shady corridor, large front verandah, sloped roof and fanlights with diagonal lattice grills.

In the Amangalla hotel, there is a series of arches leading from the main living space that creates a walkway for users without exposure to the direct sun. High shutters used in the walkways allow more natural light and fresh air.

A lot of glass windows have been used in the front façade. This maximized natural daylight but has glare. However, this was reduced with the roller blinds. These can be drawn like curtains when the glare is unbearable. Finally, it manifests that the lighting strategies used in this building are compatible with the guidelines.

The national museum is darker than the rest of the buildings in Galle fort and hence used a lot of artificial lighting at present. A hole is created at the top of the roof as a separate structure to get light. However, discomfort glare is caused during the daytime. Therefore, this is controlled with a curtain. A large colonnade reduces solar exposure to visitors. Finally, this shows that the lighting strategies used in this building are contrary to the confirmed guidelines.

In the Dutch reformed church, the smaller façade of the building is exposed to the sun which is similar to the guidelines. More wall areas and fewer windows have been incorporated in this direction as a heat-controlling strategy. External shades are placed on top of each window to further protect the building from glare. Finally, it manifests that the lighting strategies are in a good condition. However, excessive glare and heat can be observed during the daytime.

In the post office building, large series of columns in the front verandah has been created as a shady walkway for visitors. This large verandah has a 36-degree sloped roof which can reduce direct and defuse solar radiation. It can conclude that the post office building has used positive climatic responses regarding lighting.

7.3. Ventilation strategies

In Church Street, the wind direction is observed in the East-West direction. Therefore, it is necessary to concern to mitigate the glare and heat while allowing natural ventilation.

> *"Very large windows and doors open alternately into the wide shaded verandah which fronts the rear courtyard. …the arrangement of the plan allows cross ventilation through center of the house from the front to the back"*
>
> Sansoni et al., (1998)

Sansoni et al., (1998) also stated that the tiles of the roof are loosely joined to remove hot air from the building while creating a thermal comfortable space in most of the buildings in Galle. This statement manifests how the use of Dutch elements was adapted to the climate in Galle. Courtyards have been used in many buildings that ensure cross-ventilation by placing windows towards the courtyard.

There are two major units in the Amangalla hotel which are separated by an internal courtyard for unrestricted air movement. The entry point of the hotel has a high ceiling area which is about 6m in height. This can escape the heat during the daytime. The balcony of every room is facing towards the internal courtyard aids natural cooling. The pool in the garden can reduce heat through evaporation.

Louvered windows are placed opposite the seaside and the front verandah is a bit covered when compared to other Dutch buildings thus, straightly open to the street (Sansoni et al., 1998) identified that the introduction of louvered shutters and doors was a later addition by the British. However larger windows have been placed towards the windward direction and smaller windows placed towards the leeward direction. This is contrary to the sustainable guidelines. However, it can conclude that the overall building has used adequate ventilation corresponding with the accepted parameters.

The national museum in Galle fort has the least consideration for ventilation compared with other selected buildings. The previous usage of the military warehouse may be the reason for this. The large, sloped roof is used as a climatic responsive strategy. Even though the front verandah has used a lot of openings, none of them was placed on the rear side. This will not create a pressure difference for air circulation. Therefore, the warm air will be trapped trapping inside the building without flowing through. However high-volume ceilings can reduce the hot air. But currently, this was blocked by the new addition of the administration office. At present all the openings are closed therefore an artificial ventilation system has been used in this building. Finally, this building shows that the used ventilation strategies were not according to the sustainable guidelines.

In the Dutch reformed church, the passive climatic modifications were much different compared to the rest of the selected buildings. Restricting the cruciform plan form may be the reason for this. Even though Dutch have considered the natural light system, the building has not been encouraged for ventilation. No colonnade (front verandah) or courtyard has been used in this building like others. The roof is sloped to drain off rainwater, but the roof eave is a bit smaller. The high vaulted wooden ceiling used in this church can escape the hot air through openings. The same size doors were placed towards the windward and leeward direction without considering the pressure difference. This was contrary to the confirmed parameters. It manifests that the ventilation system used in the church is not specifically considered.

The post office has a ventilated high roof which facilitates cross-ventilation. In this building, a lot of wooden doors and windows were placed towards the windward direction. Windows facing the church street are smaller and placed in the bottom or middle of the wall to create a high-pressure zone in the windward direction. In the leeward direction, bigger windows were placed on the top of the wall to create a low-pressure zone. This creates a pressure difference for air to flow through the building. This is a positive climatic response when comparing the other selected buildings. There is an existing courtyard in the middle of the building which will disperse hot air via stack ventilation. This building has used a lot of ventilation strategies compared to other buildings.

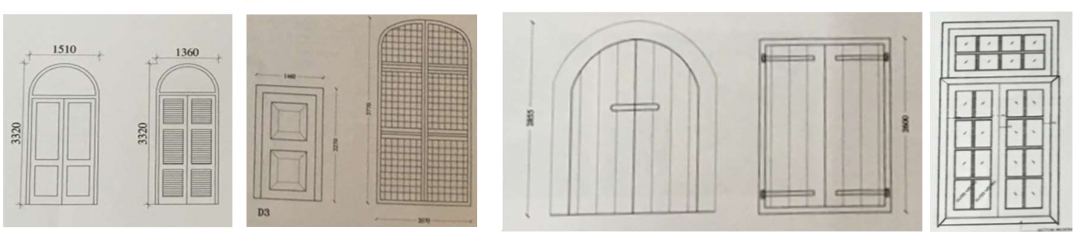

Figure 8: Types of openings used in four case studies respectively.
Source: Department of Archeology, Galle.

7.5. Building materials

Dutch have significantly considered the building materials. They have used a lot of thermal insulative materials like brick, water, terracotta, limestone, and sandstone.

In the Amangalla hotel, some of the walls are made of sandstone. The floor of this building is made with jackwood and teak which has a 300-year history (Anjalendran et al., 2016). These materials can absorb heat during the daytime and create a thermally comfortable space. A lot of glass windows have been incorporated towards the seaside to provide the best view to the visitors. (The heat and the glare are controlled by adjustable blinds) The asbestos roof sheet is covered with half-round clay tiles. Since asbestos and clay are thermally insulative materials they can absorb the heat outside. The wooden ceiling can lower the internal temperature.

Table 1: building materials used for different elements – Amangalla hotel.

Wall	Floor	Ceiling	Stairway and handrail	Doors and windows	Roof
Brick Corral (Cement walls were used for new buildings) 1m thickness walls	Yellow terracotta tiles Wood	Wooden ceiling Plastered concrete ceiling	Stairway – Timber and red cement Handrail- Timber	Door - Double planked wood with glass panels on top Windows – Arched shaped sashed windows with glass fanlight	Asbestos sheets covered with half round clay tiles.

In the national museum, wooden openings have been used towards the direction of the sun. This will not heat the building during the daytime. The overall material usage of this building is compatible with the accepted guidelines.

Table 2: building materials used for different elements – National Museum

Wall	Floor	Ceiling	Stairway and handrail	Doors and windows	Roof	Columns
Brick, Corral	Red cement Terracotta cement painted with red (Terracotta tiles)	Wooden ceiling connected with planks (Does not cover the entire area	Wooden stairway Wooden handrail	Arched shaped timber doors (Painted in black)	Half round clay tiles	Masonry columns

The church has used a lot of climatic-responsive materials. However, the selection of stained glass is heating the building during the daytime even though it is properly placed opposite the solar surface. To reduce the heat and gain further British placed a canopy over the stained-glass windows as a later addition (Soysa, 2007). Wooden doors, window frames and sashes have 1 ½ inches thickness and the wall thickness is also around 635 mm which will absorb heat without transferring the interior. Limestone and tombstone have especially been used as thermal insulative materials. Clay tile roofs and iron wooden ceilings are used as positive climatic responses.

Table 3: building materials used for different elements – Dutch reformed church

Wall	Floor	Ceiling	Stairway and handrail	Doors and windows	Roof	Columns and beams
Brick wall (635 mm thickness) Stained fixed decorative glasses (Red, yellow, blue and green)	Clay tile Red colour cement Tomb stone (where the dead bodies were buried) Red terracotta tile	Iron wood ceiling painted with white. Small area is painted in blue	Wooden stairway and handrail Polished wood finishes	Door: Black timber Window: Wooden frame with stainless glasses in different colours	Half round clay tile	Limestone columns Columns are not wide therefore does not support the roof Wrought steel tie beams

The overall materials selection of the post office was responding to the coastal tropical climatic condition.

Table 4: building materials used for different elements – Post office.

Wall	Floor	Ceiling	Doors and windows	Roof	Columns
Brick Corral stone, Lime and sand render	Yellow terracotta tiles	Wooden ceiling	Doors: Wooden doors with glass fanlight on the top Windows: Wooden framed windows including glass fanlight. Widows are covered with side protectors	Half round clay tiles	Masonry columns

7.6. Discussion

Dutch have used a variety of doors and windows which will block heat but allow ventilation and visual view. Sansoni et al., (1998) point out that during the early Dutch period (1640 – 1720) the windows and the doors were not very large and highly decorated. Doors have a long strap hinge. Most of the windows in this early period were square-shaped with two shutters and a central mullion. There is no fan light in this type of window, and some have a fixed sash over the casement on the upper level. Centre-pivoted upper sashes can be also found in Dutch buildings. However, glass was rarely used for windows in this period.

According to Sansoni et al., (1998) during the second Dutch period (1720 – 1770) Dutch used one-panel windows. Some upper sashes in this period have a central mullion with two shutters. In 1740 the upper fanlight in both doors and windows was made with a diagonal lattice grill. This provides natural light and ventilation the entire day while maintaining security. Some fanlights were radiating concentric circles like a shape of a fan. However, during the latter part of the Dutch period (1770 – 1796) doors and windows became more decorative.

During this study, it has been substantiated that openable fanlight and upper sashes are special strategies that the Dutch have used to allow light while excluding heat. Lattice panelled windows are also incorporated as new addition by Dutch. This will create a screen for the street.

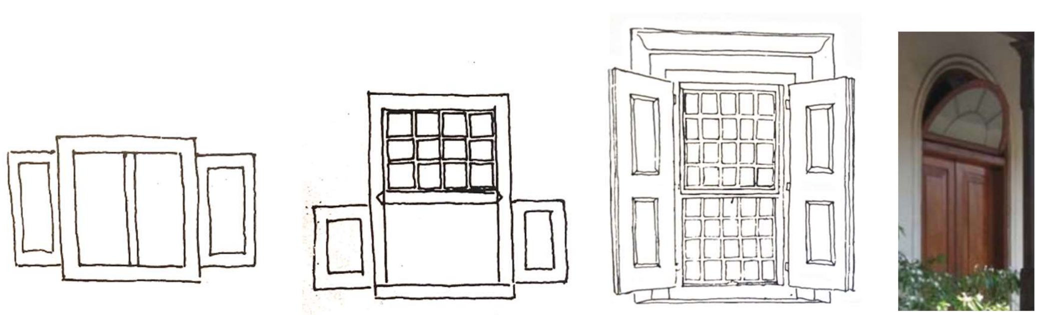

Figure 9: Different types of openings used in the early and late Dutch period.
Source: Sansoni et al., (1998)

Thick walls have been used in all these buildings. Pale/ faint colours have been used for the exterior walls that will reflect more heat than brighter colours. High thermal mass materials like brick, coral, clay, terracotta, limestone, and wood have been used in all buildings. Clay tile roof has been incorporated into all the buildings. The wooden ceiling is used to reduce heat transferring the building. The overall material selection of all the buildings is climatic responsive. However, during the British period, the architectural character of some buildings was changed. It has been clearly identified that in some Dutch buildings, the use of smaller eaves and closing the rainwater drainage system damaged the walls due to water leakage from the roof. In some buildings, the British have introduced reinforced concrete columns, but this affected corrosion through wall cracks due to sea breeze. Also, wood on the outer surface can get decay due to rain. This will ultimately affect the structural stability of the building. It can affect the aesthetical and historical value of the Galle fort while creating adverse impacts on environmental sustainability. Therefore, it is mandatory to be concerned about the above-mentioned issues when implementing coastal building regulations, structural conservation, and restoration guidelines to stop unauthorized refurbishments and construction. These propositions can be made to redirect the architectural planning and practices in the country.

Conclusion

Buildings which are the most noticeable elements of urban design define the streets of the city. However, they are responsible for the largest energy consumption. The long enduringness with user fittingness to date witnesses that the Dutch buildings are energy efficient.

The building characteristics of the Dutch show profound uniqueness, which can be noted through their constructions made over the span of 150 years of their rule. Most Dutch buildings are compacted and made with high thermal mass materials. The front verandah was the most prominent building element that was identified in this study. It is also identified that the Dutch have used a lot of innovative passive design modifications which is suitable for coastal tropical climatic condition. Adjustable glass fanlight angled louvered panelled openings and lattice panel openings are a few of them. However, few of the generally accepted sustainable guidelines in tropical climates were not considered by the Dutch. Those are proper building orientation and internal space arrangement.

This study manifests that the Dutch have significantly considered building materials more than building orientation light and ventilation strategies. However, the heat-controlling strategies, light, and ventilation strategies are at a moderate level.

The climatic responsive strategies which the Dutch have used can be useful for the current energy crisis, urban climate change, and sustainable city planning. This will optimize the site potential, improving indoor air quality and reducing nonrenewable energy consumption. The sustainable design strategies will also be useful in implementing necessary building regulations for building conservation and restoration.

Passive climate modifications used by the Dutch with some alternations are important in developing energy-efficient buildings, which is the initial step to creating environmentally feasible, socially responsive, and economically viable cities.

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