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Abstract

The purpose of this study is to analyse the integration of the design of vernacular architecture and contemporary architecture in terms of design features to achieve thermal comfort in tropical climate [objective]. The design of the Malay vernacular house has been made to cool down the building through site responses and environmental context of the hot and humid climate. With modernization taking over in our fast developing age, the Malay vernacular architecture is often replaced by modern architecture due to substantial materialistic experiences and social housing in order to meet the economical demands. In cases where the relationship between buildings and sites has been overlooked, occupants often do not feel comfortable at all times [issue]. This paper is focusing on the study of the effectiveness of the featured green design strategies in PJ Trade Centre building through analysis of the design forms, spatial arrangements, openings, materials and vegetation. The research has been done on contemporary architecture to evaluate how PJ Trade Centre building makes use of elements from vernacular Malay architecture. In fact, PJ Trade Centre building employs passive design strategies to maintain thermal comfort indoors. In assisting the validation of research, literature reviews from various referenced sources indicate that the idea of integration of traditional designs with modern features used in contemporary housing can achieve a good outcome without eliminating the traditional design element [methodology]. Such design element can be seen in the form of a façade made up of concrete vent blocks, largely promoting energy saving in modern architecture [result]. While acknowledging the significance of cultural features and natural environment, PJ Trade Centre building was designed with a new construction and building technology. This demonstrates a new emergence in Malaysia's contemporary architecture with appreciation of Malay vernacular architecture. The integration of vernacular values promotes occupants and designers to conserve the local identity as they adapt to the user needs, environment and culture. [conclusion]

1.0 Introduction

The trend of contemporary architecture often neglects the vernacular design approach in this fast growing industrialized era. Today, society attaches a lot of importance to the looks of magnificent forms of contemporary designs instead of appreciating a building's design functionality. Such buildings may lack environmental and contextual considerations implemented in vernacular designs, and therefore rely on machines and technology to achieve proper characteristics of a built living environment. This results in high energy consumption used to achieve proper living condition inside a building. Instead, a building that responds to its specific site and that makes proper use of contextual characteristics is bound to use less energy. Hence it is important to understand the role of vernacular design and how to use them as a model in designing contemporary architecture.

To further analyse this research, PJ Trade Centre building was chosen to conduct as a case study for the integration of vernacular architecture into contemporary design. PJ Trade Centre is a green building design developed by Tujuan Gemilang Sdn Bhd. It is located in a hot and humid climate on a hillside in the vicinity of Damansara Perdana. The building occupies 5.4 acre of land and its four towers comprises 20 to 21 storeys each, offering a magnificent view of the locality. The construction was completed in December 2009 and the building is now fully occupied, mostly by office spaces.

In contrast to any conventional building design, Architect Kevin Mark Low intentionally designed PJ Trade Centre to make use of natural resources in order to reduce energy consumption within the building. PJ Trade Centre is featured as an excellent example of sustainable architecture where its vernacular design takes environmental needs and site responses into account by responding to the surrounding contexts. Features of vernacular design integrated in PJ Trade Centre have been highlighted to show on how they function to achieve thermal comfort inside the building. Detailed studies and analysis were conducted for the various vernacular features utilized. This case study paper will focus on the efficiency of the green design strategies used in PJ Trade centre to achieve thermal comfort indoors through application of vernacular design feature into contemporary design.

1.1 Research Questions

Main Question:

How effective are the green design strategies used at PJ Trade Centre to achieve proper indoor environmental quality?

Sub Questions:

- What are the design considerations for tropical climate?
- What are the design intentions of PJ Trade Centre?
- What are the types of green design strategies in PJ Trade Centre?
- How are the passive design strategies applied to achieve thermal comfort?

2.0 Design Consideration for Tropical Climate in Malaysia

The weather is undeniably hot and humid throughout the year in Malaysia. This weather condition requires buildings to have proper ventilation and shading devices in buildings' design to provide thermal comfort to its occupants. In tropical climates, houses are typically designed with naturally cross ventilated spaces with the use of openings, windows, louvered doors, elevated structure that helps to capture higher wind flow and steep roofs to protect from direct sunlight and shed away heavy rainfall. In order to build sustainable structures while also protecting the natural environment, the built structure should take into consideration climatic conditions in its design to promote natural cooling and shading. The principal design consideration of any tropical architectural design is very important as they are the key factors to design a building while having the aim to achieve thermal comfort for its occupants.

Five major design considerations of a tropical architecture are: orientation of the building, natural ventilation, building materials, envelope of the building and site context. In order to respond effectively to climatic conditions, these considerations should be taken into account by promoting the usage of shading devices, minimizing heat absorption and maximizing heat loss. This is due to the high relative air humidity and registered temperatures which are usually constant throughout the day.

In hot tropical climates, the natural air circulation does not reduce the temperature by itself but instead gives the user a feeling of freshness. This sensation is due to the convection heat loss as air flows and also because of ongoing increases in water evaporation within the human body. Hence, openings to the exterior through windows and open plan systems which allow maximum possible air movement should be favoured.

2.1 Design Intentions

The design intentions of a structure play a crucial part to produce an outstanding functional building. They lead the architect to design in a proper and sustainable way while also having a pleasant aesthetic value. PJ Trade Centre had clear green design intentions and the developer stated on its website that: ‘’*With PJ Trade Centre, the idea was to offer a new paradigm for office development. It is based on the use of simple local materials and local construction methods to create an office development that is suited to the local culture, climate and context*.’’

The gigantesque Forest Plaza of 2.5 acres designed in front of the main entrance of PJ Trade Centre is one of the strategies used to integrate the building using the concept of contextual architecture. This feature gives the impression that the design is a continuity of the forest from the hills. The area around PJ Trade Centre is not yet fully developed, hence the presence of greenery plays a substantial role when it comes to the building design. The idea of merging the building with the surrounding green context not only works on the exterior of the building but also inside the structure.

The factors affecting thermal comfort inside a building are usually; air flow rate, radiant heat, temperature, humidity level and users themselves. PJ Trade Centre responds to these potential source of heat gain by featuring other methods to support its green design intentions such as the roof garden, interior vegetation, open plan layout and high ceiling level. Since PJ Trade Centre is situated in a tropical climate, the main goal behind its design intention is to promote natural air cooling in order to achieve thermal comfort. This simultaneously reduces the dependency and usage of air-conditioning systems.

3.0 Building Materials

3.1 Thermal mass

The thermal mass property of a material is defined as its ability to absorb and store heat energy. Materials having high density typically have high thermal mass property. Therefore these materials can absorb and store heat energy, and release it later.

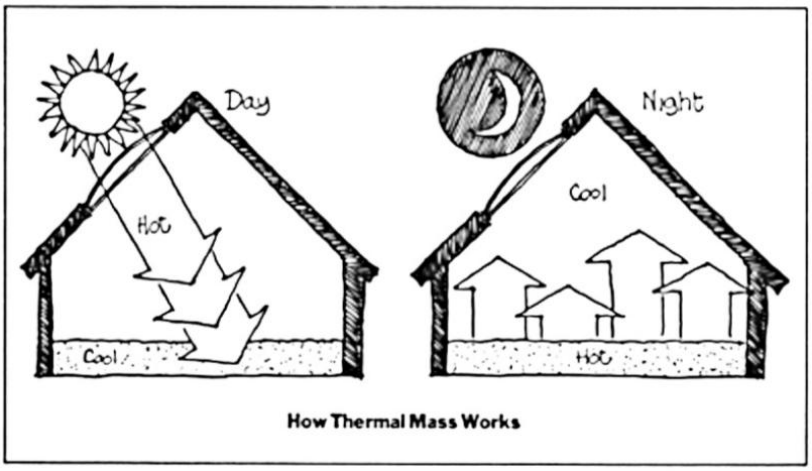

Figure 3.1: Thermal mass and heat transfer during day and night

Source: Passive solar housing system, East St. Louis Research Project Paper, http://www.eslarp.uiuc.edu/arch/ARCH371F99/groups/k/solar.html

Heavy weight materials used at PJ Trade Centre such as brick, concrete and tiles have higher thermal mass because it requires a lot of heat energy to change it temperature. During daytime when the bricks, concrete and tiles are exposed to direct sunlight, there is less rise in temperature when compared to a wooden building. However, materials with good thermal mass property do not only absorb and store heat energy but they also release it during night time.

3.2 Types of Building Materials Used

3.2.1 Red Mud Over-Burnt Bricks

A brick is a single unit of a kneaded clay used in masonry construction. Its constituents are a mixture of soil, water, sand and lime, or concrete material to create the correct clay constituency. The clay is then moulded to required dimensions and left to dry or burnt in a kiln. The characteristics of the bricks depend on the type of clay used. When dried and ready to use, the bricks are laid by layers and held together by cement. Usually such buildings apply a layer of plaster to the brick facades in order to obtain a smoother and plain finish. However PJ Trade Centre makes use of the brick material as it is naturally, and it has been aesthetically done.

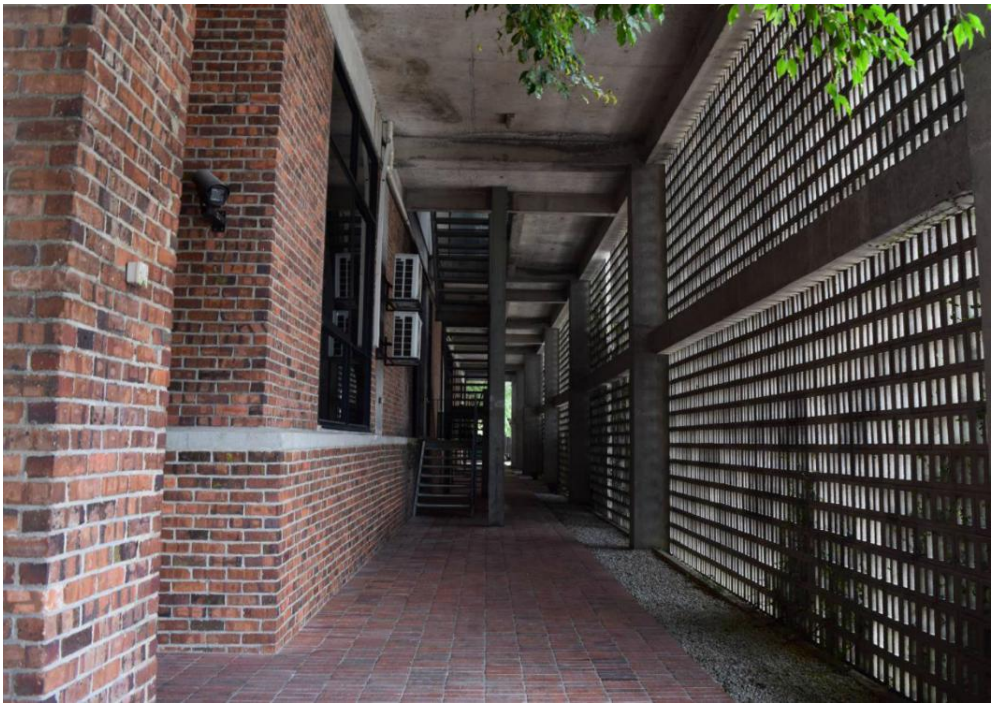

Figure 3.2.1.1: Wall and flooring made of red mud over-burnt bricks at PJ Trade Centre

PJ Trade Centre has mainly made use of red mud over-burnt bricks as building material. This can be seen throughout the building on the walls as well as the flooring. Two different grades of bricks have been used and the difference is shown in Figure 3.2 (Wall and flooring). The good bricks are used for walls and the lower grade bricks are used for flooring.

The most important property of red mud over-burnt bricks is that it has low thermal conductivity. Therefore a lot of heat energy is required to raise the temperature of the bricks. This characteristic of the bricks justifies its use in the construction of PJ Trade Centre. The layer of bricks act as a thermal insulator, and hence prevents heat from entering the building rapidly. Raw brick finish wall is common at PJ Trade Centre, even on façades exposed to all weather conditions. These bricks also absorb moisture or water, however the water absorption level should not exceed 20 percent by weight.

Compared to typical building materials such as timber or concrete, bricks have better thermal insulation property, hence they absorb and release heat energy slowly. This is how PJ Trade Centre makes use of bricks to keep the building cool during the day and warm at night.

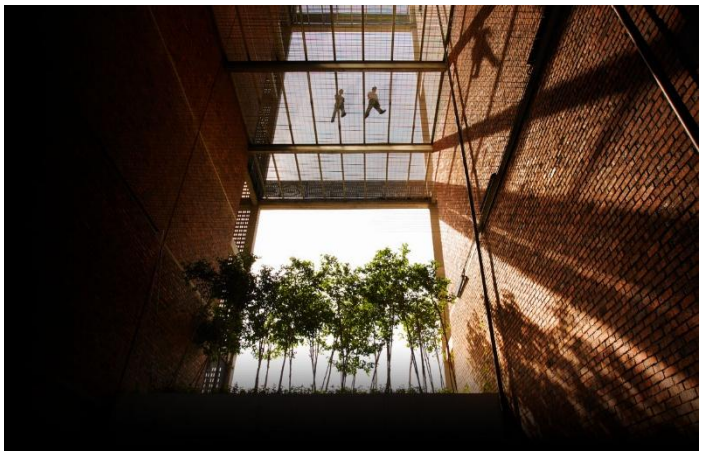

Figure 3.2.1.2: Entire façade made of red mud over-burnt bricks at PJ Trade Centre

Figure 3.2.1.3: Exposed area with brick walls made of red mud over-burnt bricks at PJ Trade Centre

3.2.2 Concrete Vent Block

Concrete vent blocks are integrated in modern designs to ameliorate air movement, hence improving indoor air quality. Concrete vent blocks are similar to typical concrete block except that they have perforated holes in them to allow natural ventilation. They are made up of concrete as base material which has high thermal mass property. In PJ Trade Centre, the application of concrete vent blocks on east and west wall has been well implemented since these façades receive the most sunlight during the day. Hence the usage of concrete vent blocks prevent direct sunlight from reaching the interior and it simultaneously allows air to penetrate the building through its air vent holes.

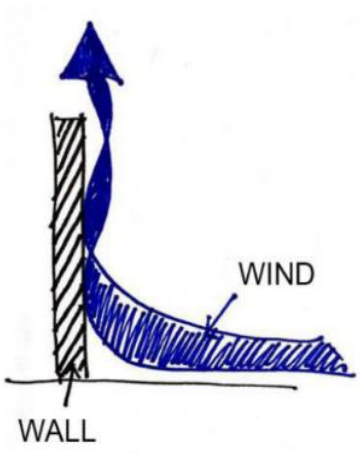

Figure 3.2.2.1: Wind action against solid wall

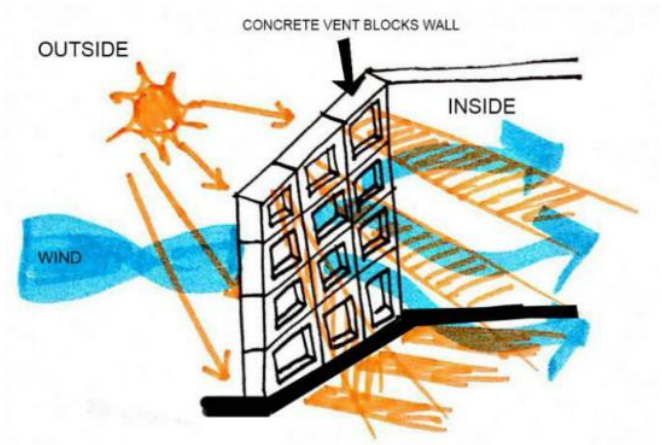

Figure 3.2.2.2: Wind action against concrete vent block wall

From the outcome of an experiment conducted on concrete vent blocks in Thailand, the results suggests that the average room temperature of a well-ventilated house is lower than the temperature of a non-ventilated house. Respective temperatures were recorded aster the house was left exposed full day under direct sunlight. The difference in temperature was about 2^{o}C, which is highly significant and clearly shows that the concrete blocks contributed greatly to cool the building.

Based on this experiment, it can be concluded that PJ Trade Centre makes use of this special property of its concrete vent block to improve the indoor air quality.

[Source: Khaderi J., Rungiyopas M., Sarachitti R. & Hirunlabh J. (2004). A new type of vented concrete blocks for zero cooling energy. *Building and environment,* 39(10), 1193-1197.]

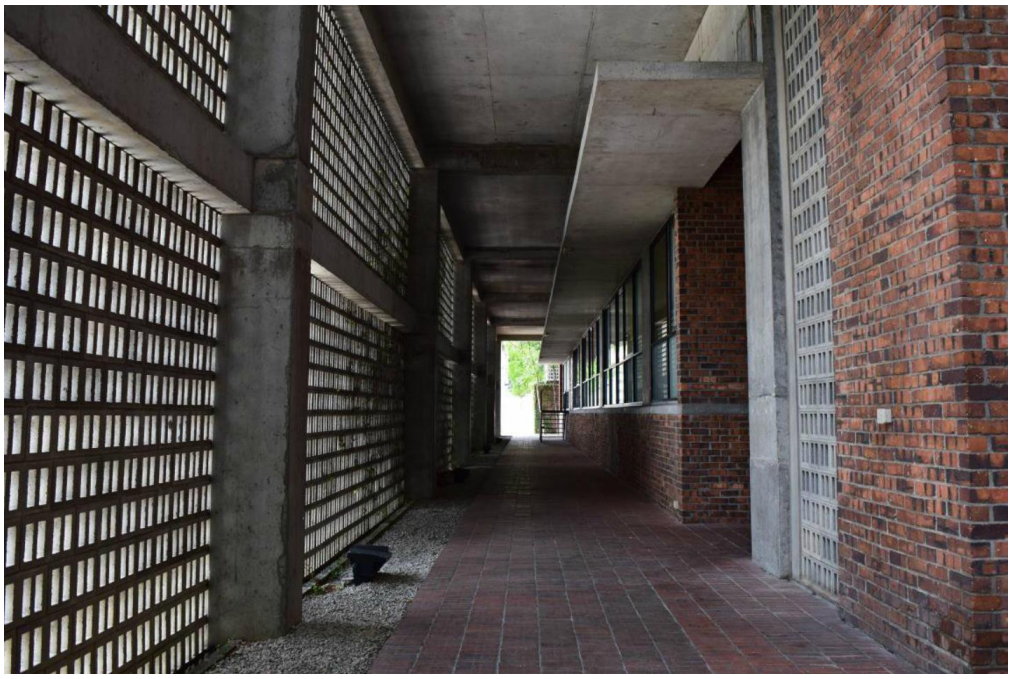

Figure 3.2.2.3: Concrete vent block façade acting as double skin and use of concrete vent block wall on the interior.

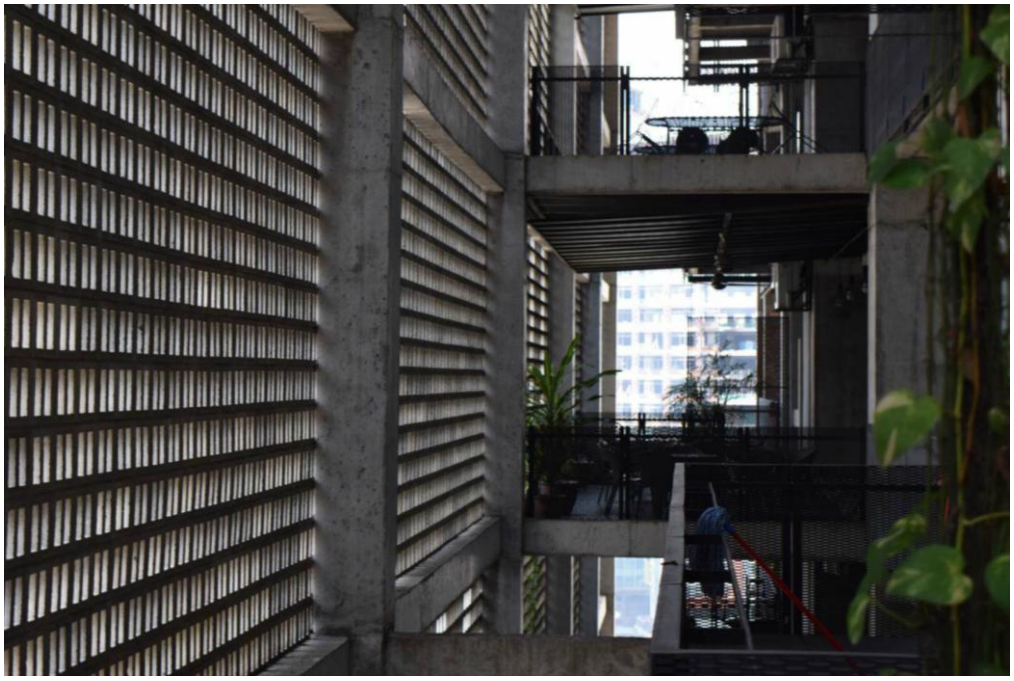

Figure 3.2.2.4: Concrete vent block wall façade interior

3.2.3 Concrete Finish

The walls at certain areas in PJ Trade Centre features a smooth concrete finish. This type of finish is called fair-faced concrete finish and it is considerably cheap compared to any other finishes since it is made from raw natural material such as cement, aggregate and sand. Fair faced concrete is identified as an ecological building material for PJ Trade Centre since its constituents can easily be obtained from the surrounding area.

Moreover, concrete features as excellent thermal insulation properties since it has a high thermal mass. Therefore it is able to reduce heat gain from direct sunlight by requiring more heat energy to raise its temperature. This type of wall finish is not only valuable for its function, but it also gives a pleasant aesthetic look to the building.

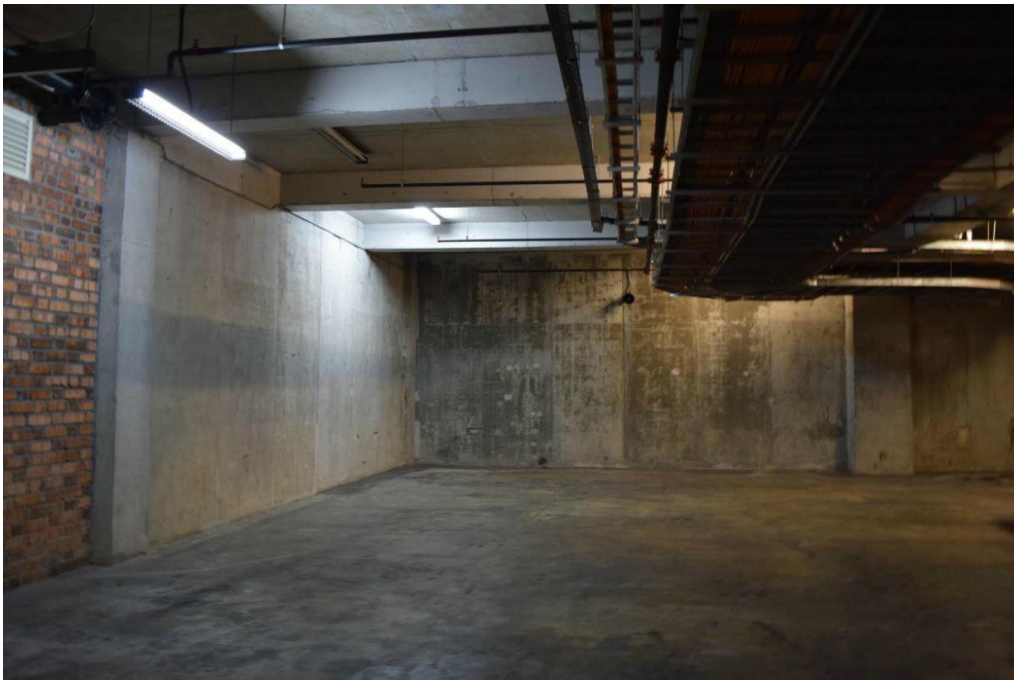

Figure 3.2.3: Fair-faced concrete finish on some interior walls at PJ Trade Centre

4.0 Open Plan System

An open plan system is one in which open spaces are favoured to create opportunities where the building makes use of natural air flow instead of using mechanical ventilation or air conditioning. Such system is applied at PJ Trade Centre throughout the building in terms of open spaces, large openings, corridors and the high ceiling levels. These features help to promote natural air circulation. This system is categorized under passive design strategies since it does not depend on mechanical ventilation and air conditioning, which reduces the cost of maintaining the building temperature to optimal thermal comfort. The diagram below shows the open plan layout at PJ Trade Centre.

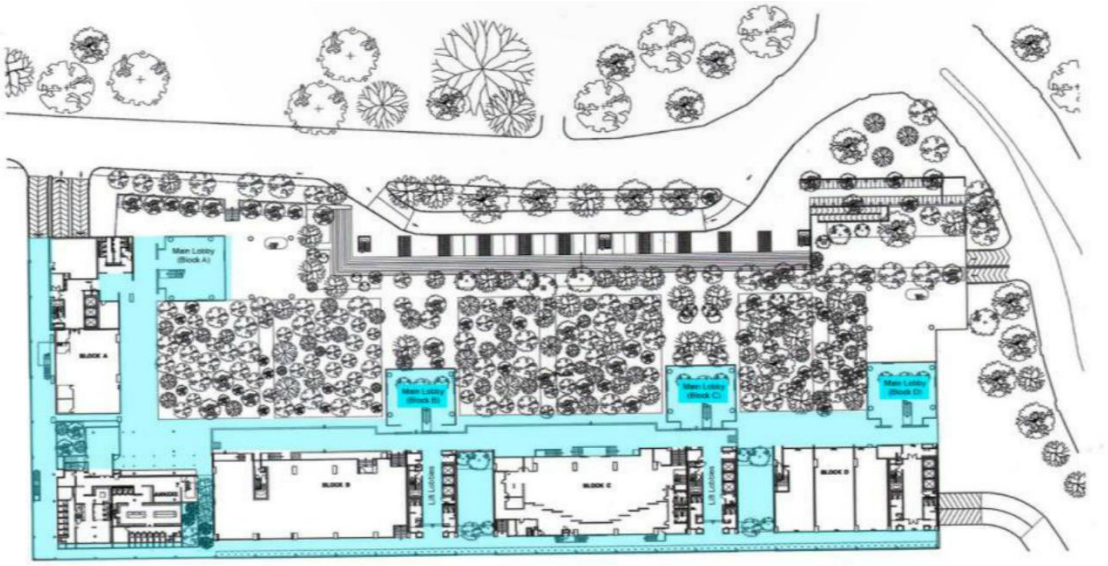

Figure 4.1: Shaded blue area shows the location of the open plan layout at PJ Trade Centre

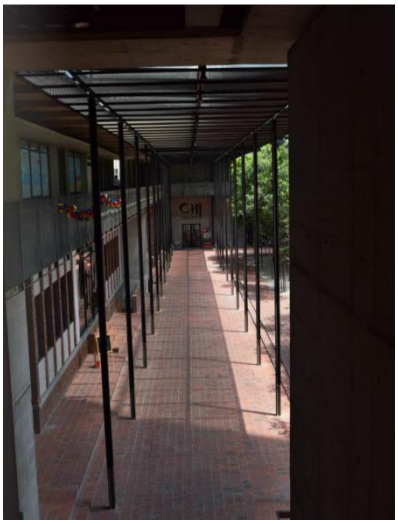

Figure 4.2: Open plan system at PJ Trade Centre

Figure 4.3: Open plan system at entrance of PJ Trade Centre

PJ Trade Centre comprises of only 1 to 4 units per floor and its ceiling measures 3.7m high. Since the ventilation rate depends largely on occupancy rate, in this case, the ventilation rate is very high compared to typical buildings of same size. Thus, having a non-compact layout and high ceilings helps to evacuate heat as it makes way for natural air to flow. This type of feature also forms part of the passive solutions applied to building to reduce their indoor temperature and hence achieve thermal comfort.

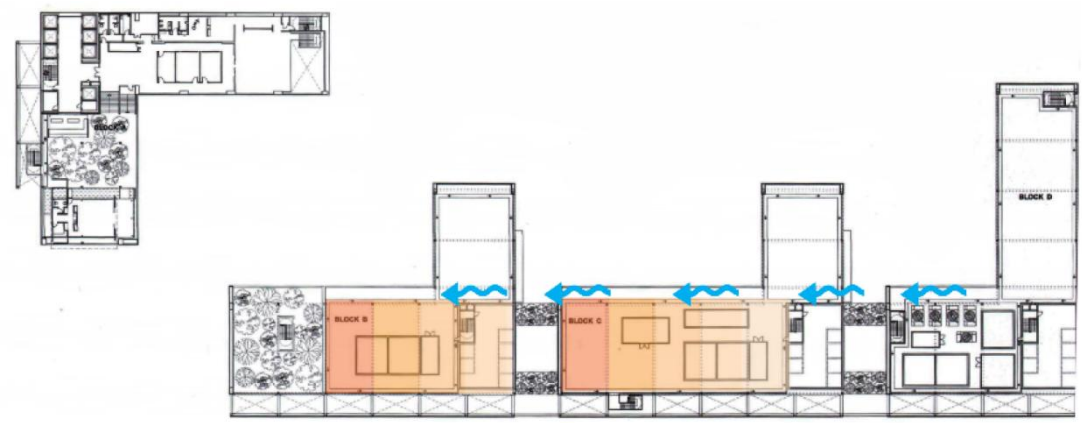

Figure 4.4: Open plan system for offices at PJ Trade Centre

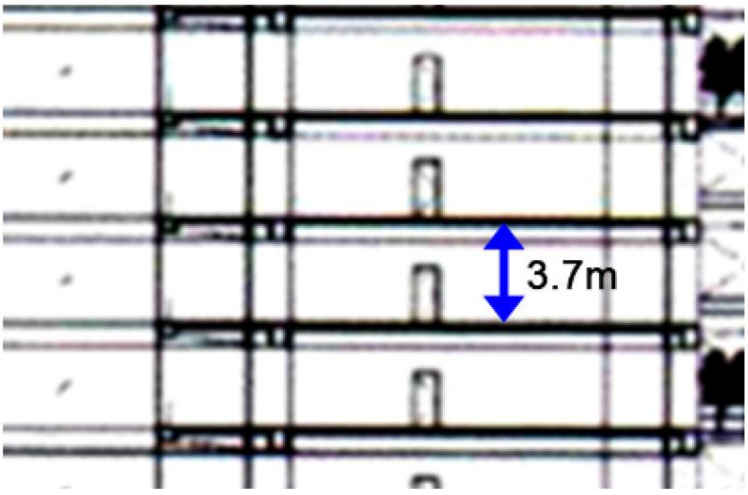

Figure 4.5: Ceiling height of 3.7m for office areas throughout PJ Trade Centre

5.0 Ventilation

The introduction of air from outdoors into a space is known as the process of ventilation. It is used principally to control indoor air quality inside a building by displacing and diluting air pollutants. Ventilation systems can be used to help achieve thermal comfort or to dehumidify space when properly designed. Ventilation consists of convection currents which blow away hot air and bring in cool outdoor air inside a space. At PJ Trade Centre, there are mainly two types of passive ventilation incorporated in the design namely: stack ventilation and wind tunnel effect.

5.1 Stack Ventilation

Figure 5.1: Stack ventilation effect at PJ Trade Centre

Stack ventilation is an example of passive ventilation that makes use of air pressure differences to circulate air through the building. Air at higher places in the building have low pressure and the air coming inside the building at lower levels usually have high pressures. The pressure difference draws the air from lower level to high up the building. Since the air coming inside the building is fresh and cool, it is mixed with the stale air inside the building and forms a fresher composition of air. This gives a feeling of freshness to the users since the temperature is lowered by this process.

5.2 Wind Tunnel

PJ Trade Centre mainly comprises of four tower office buildings. These four towers have a gap between them which provide opportunities for natural wind to flow. As the natural air flow hits against the façade, it is compressed into the tunnel's gap created between the buildings. During this process called wind tunnel effect, the wind speed is increased greatly and the drafts can now reach further inside the building. Hence it can be deduced that the higher the wind speed, the more fresh air it will bring indoors to achieve thermal comfort.

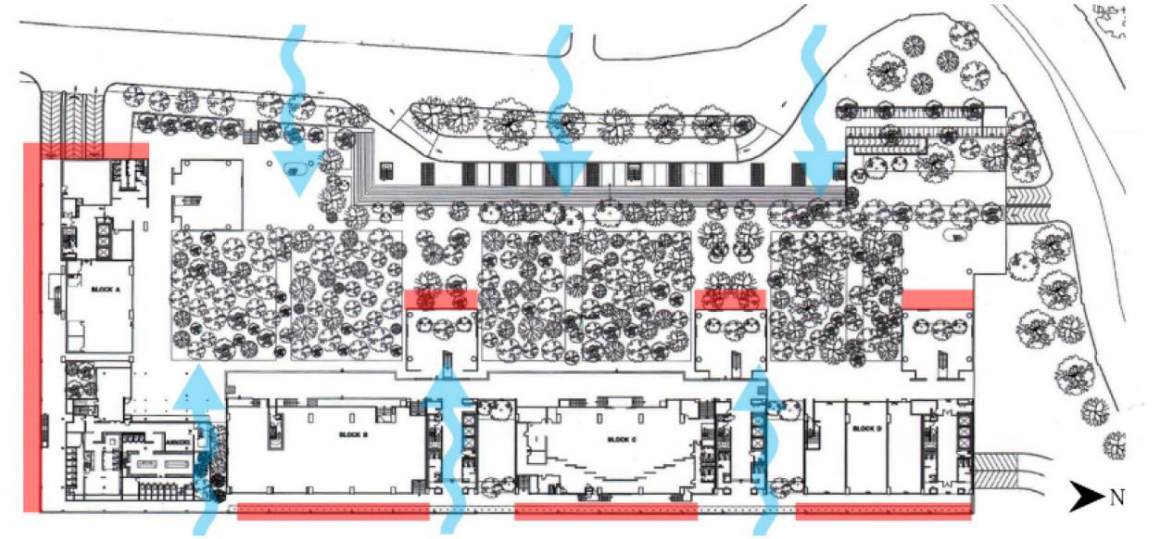

Figure 5.2.1: Wind tunnel effect at PJ Trade Centre

Figure 5.2.2: Building façade where wind tunnel effect occurs at PJ Trade Centre

5.3 Concrete Vent Blocks

The concrete vent blocks at PJ Trade Centre also act as ventilation blocks and help to reduce the temperature indoors, hence amelioration the indoor environmental quality. The indoor environmental quality depends on many factors such as the amount of sunlight coming inside a building, presence of natural air and air circulation. The concrete vent block wall not only act as a shading device but it also allows natural air to circulate through it to cool the interior. Moreover, at PJ Trade Centre concrete vent block are also used for building façade as a double skin. There is gap between the outer concrete block wall and the red mud over-burnt brick wall which allows stack effect to take place while shading from direct sunlight.

At PJ Trade Centre, there are mainly 3 types of concrete vent blocks of different sizes and designs. The standard dimensions of concrete vent blocks used at PJ Trade Centre are illustrated below.

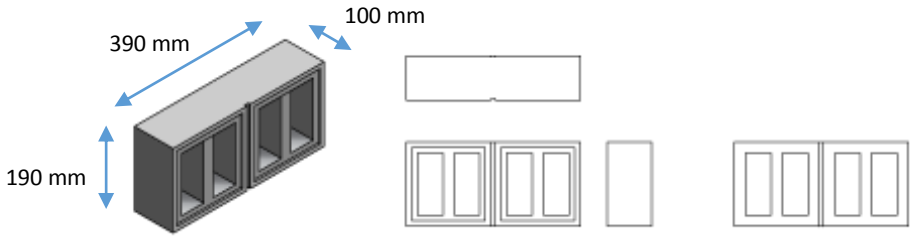

Figure 5.3.1: Type A concrete vent blocks at PJ Trace Centre

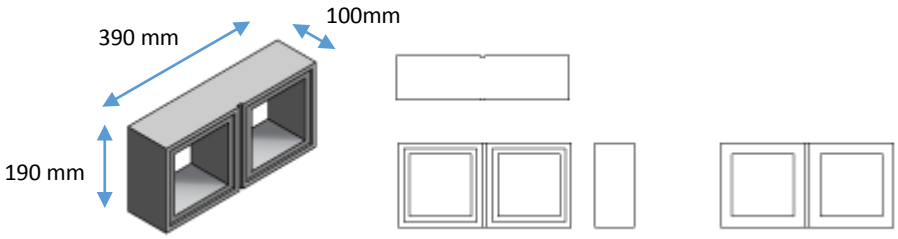

Figure 5.3.2: Type B concrete vent blocks at PJ Trace Centre

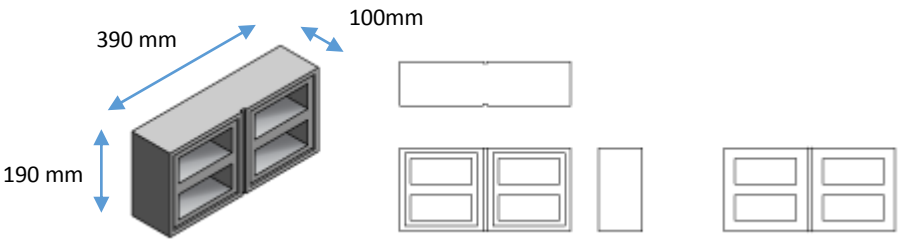

Figure 5.3.3: Type C concrete vent blocks at PJ Trace Centre

Source: Ventilation Block, PBM, http://www.premierbm.com/products/ventblock

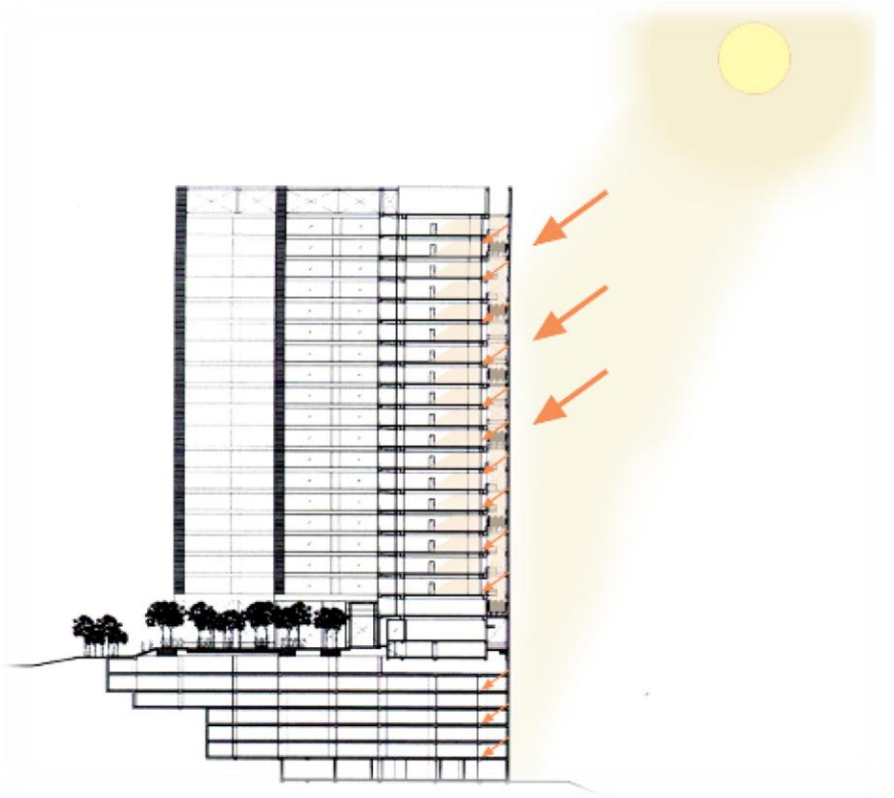

Figure 5.3.4: Diagram showing sunlight acting on west façade of PJ Trade Centre

Figure 5.3.5: Gap between double skin of concrete vent wall and red mud brick wall

6.0 Orientation

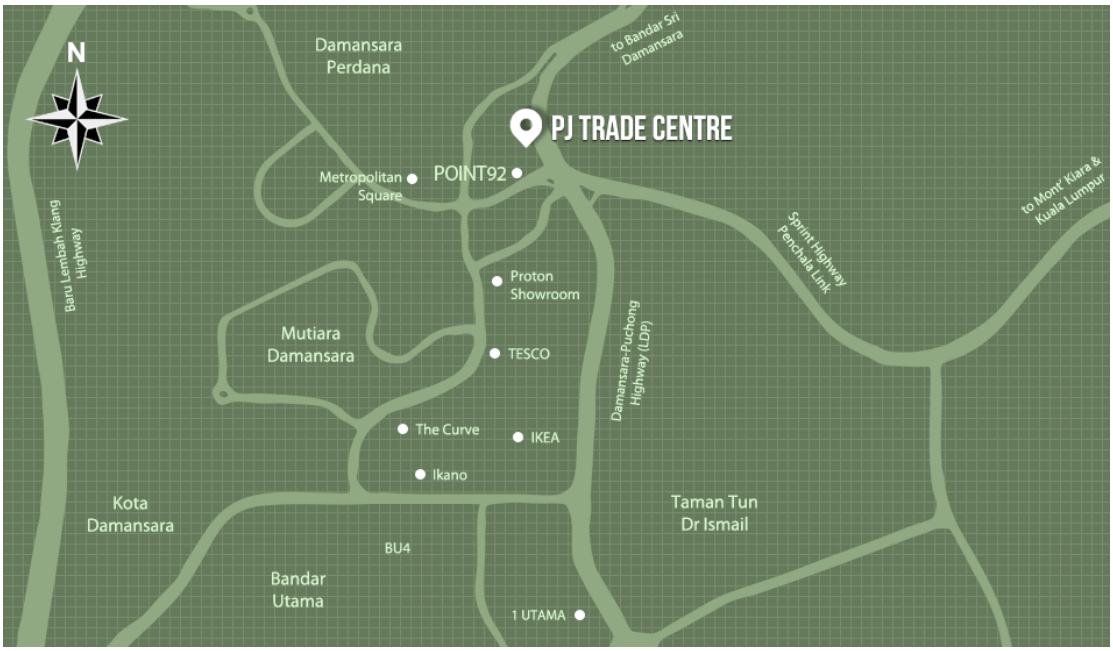

Figure 6.0: Location and orientation of PJ Trade Centre

Source: http://www.pjtradecentre.com/location.html

In order to take full advantage of the sun path in terms of indoor lighting, PJ Trade Centre is well orientated, having its longer façade along the North-South axis. PJ trade Centre made use of concrete vent block wall as design façade which not only allows sufficient light to penetrate the building but they also allow air to circulate through them. The sun path and direction of the wind has been well thought of before designing PJ Trade Centre in order to achieve thermal comfort inside the building. Moreover, this reduces the cost of cooling down the building by the use of mechanical ventilation and air conditioning.

7.0 Vegetation and Landscape

The vegetation and landscape at PJ Trade Centre offers additional means to cool down the building naturally. Given that the building is surrounded by green areas, the use of vegetation brings the idea of contextual architecture where these vegetation are planted throughout the building. This feature helps in bringing cool air in to the offices and hence less energy is required to achieve thermal comfort.

The plaza area at PJ Trace Centre offers many opportunities for the users to enjoy cool and fresh air as it is immediately located outside the four office towers. It acts as a social gathering area where users can relax and enjoy nature's benefits. The thousands of trees at the plaza acts as heat buffers.

The reason why the concrete vent block walls are left unfinished is that, when the developer designed the building, they made provision for crawlers and moss to grow on the blocks itself. This feature not only will have good aesthetic values, but it will also act as heat buffer to direct sunlight.

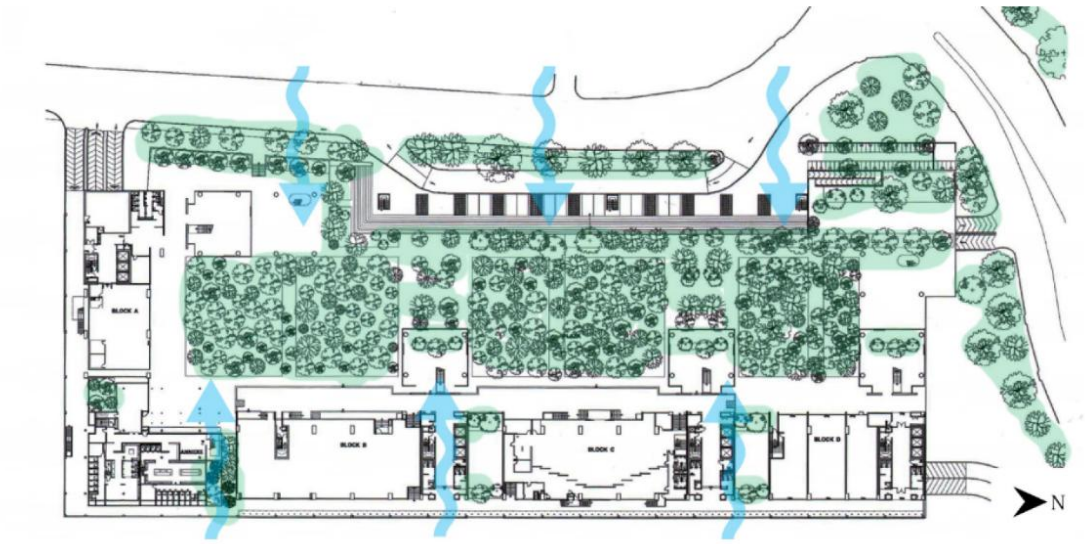

Figure 7.0.1: Plaza garden at PJ Trade Centre

Sky terraces are commonly found at PJ Trade Centre. This is a form of open plan system which allows air to circulate without any obstacles. Vegetation is included in the design of these terraces and when air passes through, it is filtered naturally and becomes cooler.

Figure 7.0.2: Vegetation on sky terraces and ventilation

Figure 7.0.3: Plaza garden at PJ Trade Centre

Figure 7.0.4: Sky terraces at PJ Trade Centre

8.0 Conclusion

From the study conducted on PJ Trade Centre, it is reasonable to conclude that PJ Trade Centre effectively makes use of green design strategies in order to achieve thermal comfort inside the building. This is proved by the various strategies incorporated in the building to perform better. The idea behind this study is to identify which factors needs to be considered while designing a building so that the end result requires less energy to cool down the building. PJ Trade Centre took into account surrounding buildings, its orientation, ventilation and direct sunlight and responds to those opportunities in the best way possible. By making use of the surrounding environment, the cost of maintaining the building's temperature to thermal comfort is made easier and naturally. Hence the use of air conditioning systems and mechanical ventilation is lowered, which leads to lower energy consumption.

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