SUSTAINABLE APPROACH FOR UNIVERSITY CLINIC; A CASE STUDY OF STACK EFFECT SYSTEM

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ABSTRACT

In order to keep the indoor climate comfortable without the need of mechanical ventilation, a well-designed building will stimulate air movement toward the interior sections. However, in cases where the air is not being circulated correctly or when the external wind speed is low, stack ventilation may be a reliable option. There is a lot of emphasis on the importance of good ventilation in hospitals and other medical centres. The air quality, the amount of air circulating around the clinic, and the effects on the patients are all factors in how efficient the ventilation mode is. Ventilation through openings such as windows and doors occur naturally when an interior pressure difference exists above the exterior pressure. Stack ventilation and wind driven ventilation are the most popular forms of natural ventilation. The fundamental objectives of this research are to (1) describe stack effects, and (2) determine a strategy in adopting stack effects system into clinic design.

Keywords: *Stack Effects, Clinic, Natural Ventilation.*

INTRODUCTION

Malaysia, like the rest of Southeast Asia, experiences hot, humid weather year-round but is not subject to the constant, yearly onslaught of typhoon-force winds typical of other tropical regions. Heat and dryness are the norm, with major downpours occurring toward the end of the year. Because of the country's tropical climate, passive cooling via cross ventilation is one of the most challenging environmental design objectives to meet in the country. In hospitals, mechanical ventilation is used most often on critically ill patients, especially those with respiratory failure, to facilitate better gas exchange and lessen the burden of breathing. The air supply and exhausts of a well-balanced mechanical ventilation system have been modified as needed to fulfil the requirements of the building's blueprints (Rudd, A., & Bergey, D., 2014). The most practical solution to the current predicament is the installation of mechanical HVAC systems. However, due to the installation and maintenance costs associated with an air conditioning system, its use will lead to low energy efficiency and a high cost of the building's life cycle. This indicates that passive cooling is preferable in Malaysia. Saving money and reducing energy consumption while building in a more environmentally friendly manner for future generations is the ultimate goal. The studies' goals are to identify the properties of stack effects and to recommend/suggest conceptual approaches for producing acceptable indoor air quality with stack effect ventilation systems.

LITERATURE REVIEW

According to (Ismail and Abdul Rahman (2018), in Stack Ventilation Strategies), man has used the stack ventilation method for ages to produce an appropriate indoor atmosphere in their constructions. This is based on the evolution of wind-induced ventilation over time. When natural cross ventilation serves only a limited purpose, stack ventilation has become increasingly important, according to Ismail and Hamdan. Stack ventilation is also known as the stack effect and the chimney effect. To generate airflow, the natural force that occurs from changes in air pressure, temperature, and density between equivalent within and outside environments is utilised. The upward movement of air through a building's entrance induced by thermal buoyancy or by negative pressure produced by the wind itself is referred to as "stack ventilation." Because it is less dependent on the outer wind condition or velocity, this ventilation is more vital to employ and improve air flow in the building (Wardah Fatimah and Nor Mariah, 2016).

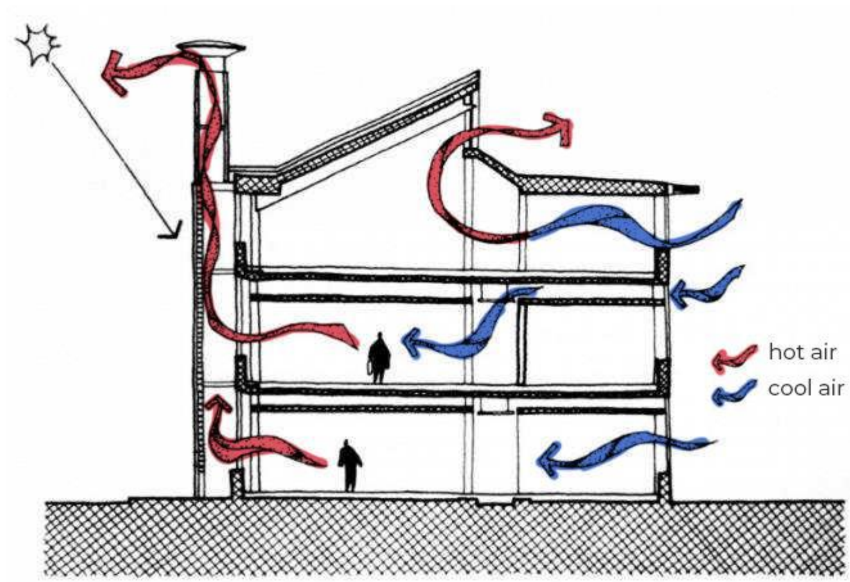

Figure 1: Air flow in Stack Effect System

Figure 1 depicts the air flow in the stack effects system. Passive cooling can be performed by using wind driving force that passes through the top of the roof and causes a reduction in pressure to the lowered level wind that pulls air into the structure and pushes it upward out of the duct. Because the stack effect is driven by temperature differences, stack ventilation requires that the outside air be cooler than the inner air. The greater the heat difference and buoyant force, the higher the structure is built. Thermal chimneys or wind turbine vents can be utilised to magnify the effect of hot air ascending.

It is the most energy-efficient ventilation system available and does not require power.

There are no mechanical equipment or heating recovery systems required, and installation costs are significantly lower than with other methods. Typically, the system incurs no operating or maintenance costs. It runs continually even when there is no electricity. The process is silent and makes no noise. However, there are several difficulties in adapting the stack effect system. Because stack ventilation alone is insufficient, the structure of medical facilities may occasionally require extra equipment and systems.

According to (Yasmine Mansouri', (2016) A Comprehensive Overview of The Principles and Applications), stack ventilation works on a few basic tenets that provide the foundation for the pressure difference and airflow across the entire system. Cross ventilation is one natural cooling method that employs the force of the wind on the exits and the effect of the wind on the inlets to remove warm, humid air from buildings. The goal of ventilation is to flow air around people and within buildings, and the position of inlets and exits has a big impact on air quality and demand optimization variables as shown in Figure 2. As a result of air circulation and movement toward certain routes, creating negative pressure, which draws warm, stale air out of the rooms, fresh air trickles or vents from the building's apertures, vents, and windows. Natural heat transmission is supported by the buoyancy and density of air at varying temperatures. To evacuate energy from a distance, the air becomes warmer and rises near the heat sources.

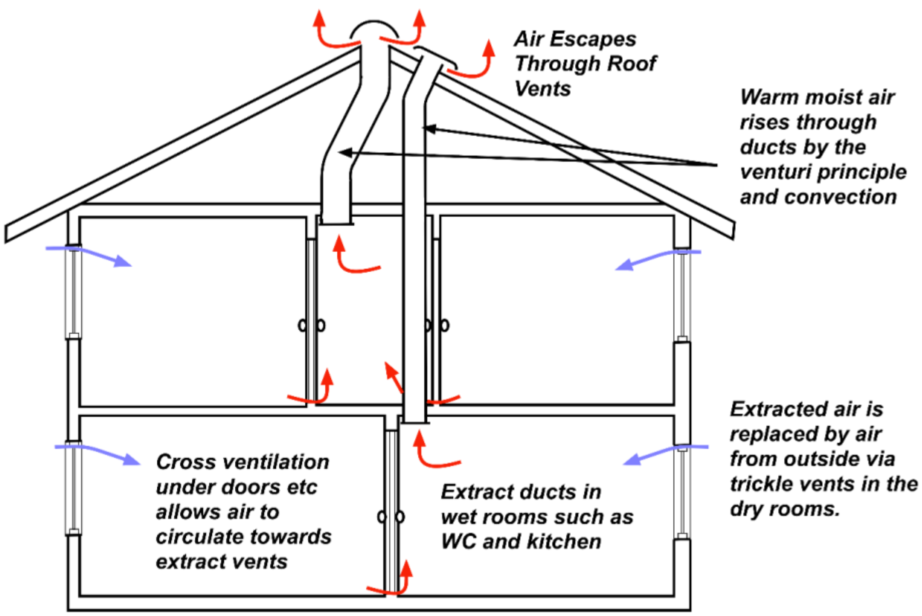

Figure 2: Passive stack ventilation and its guiding principles

One approach for increasing air flow and improving stack effect is to eliminate wind blockage and produce a high-pressure difference between the building surface and the outer wind. The building's aerodynamic or fluid shape is proposed to reduce wind blocking and because the aerodynamic design allows maximum air flow through the shape without steering it away. According to (Mazran Ismail and Abdul Malek Abdul Rahman (2015) Stack Ventilation Strategies in Architectural Context), the higher the stack height, the greater the effect of the buoyancy force to extract air from the inside.

METHODOLOGY

This paper employs a case study as the primary method for studying stack effects ventilation system for university health centre building. The hot and humid temperature was one of the aspects that had to be considered when studying the stack effects. Aside from that, the building typology might be from a public building with a stack effect ventilation system.

The case study that is selected must originate from the healthcare typology of building or any other public building that contributes to the enhancement of the general welfare of the community. It is of the utmost importance to have the same building typology in order for the application to be integrated in the design in a direct and efficient manner. It is also recommended that the size of the building referenced should be on the moderate end of the spectrum, with roughly 4,500 square metres of buildable surface and the ability to service approximately 12,000 patients.

CASE STUDY 1: HEALTH CENTER OF EASTERN MEDITERRANEAN UNIVERSITY, TURKEY.

Figure 3: Health Center of Eastern Mediterranean University, Turkey.

On the campus of Eastern Mediterranean University (EMU), there is a health facility building that is available for use by students, faculty, and employees. The building is comprised of two floors, with the first floor being where the doctor's offices are located and the ground floor being where official business is conducted. It has a rectangular form that is 1370.97 m2 and contains a total of 42 zones. There are no other buildings in the immediate vicinity of it. This particular structure was selected as a case study because it has the same typology as the plan under consideration. This structure employs a ventilation method called cross ventilation in order to solve the problem of inadequate ventilation.

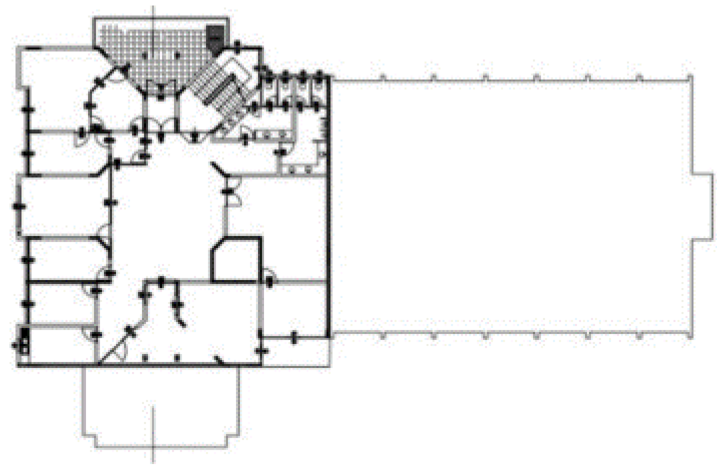

Figure 4: Ground Floor Plan of the Health Center.

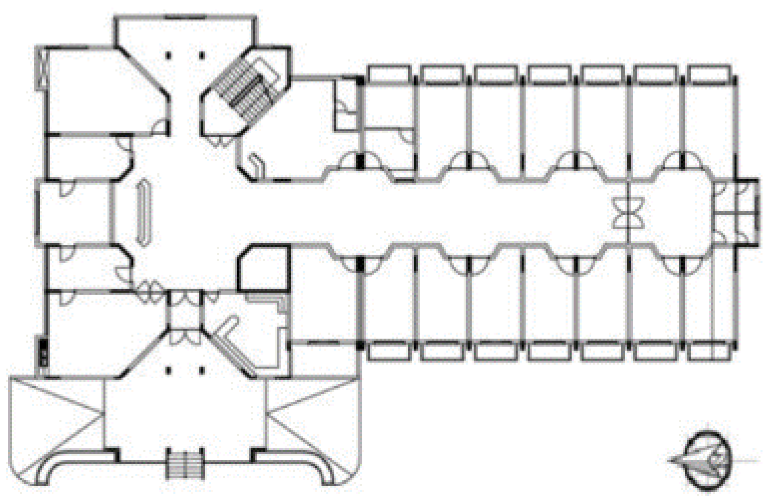

Figure 5: First Floor Plan of Health Center.

Cyprus experiences a hot, humid atmosphere. Summers are very hot, winters are not very cold, and the summers are exceedingly dry with very little yearly precipitation. Cyprus, the third-largest island in the Mediterranean Sea, is located on the northwestern side of the water. The city of Gazimagusa can be found on the eastern shore of the island, which is where the coast meets the water. The average daily temperature in the winter is between 9 and 12 degrees Celsius, and the average daily temperature in the summer is between 37 and 40 degrees Celsius.

According to Pourazis (2008), double skin facades greatly reduce the amount of heat loss that occurs within the cavity. On the other side, overheating problems will occur during the summer months if the facade does not have adequate ventilation. Because of the stack effect, roughly 25% of the heat may be removed by natural airflow, while the remaining 70% of the heat can be removed via the exterior skin by mechanical or natural ventilation systems.

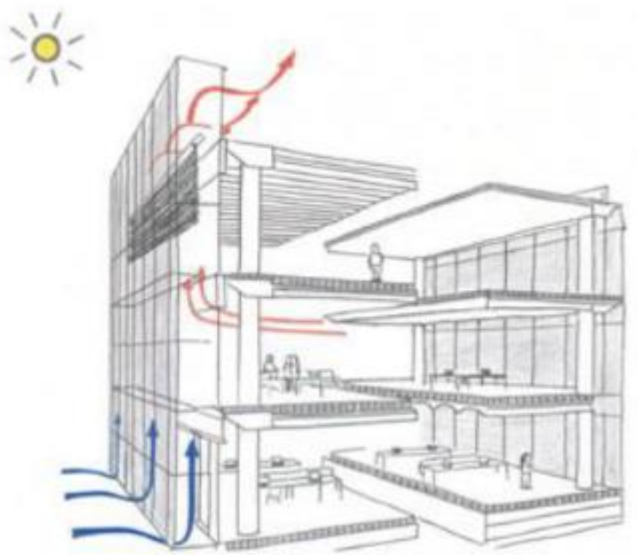

Figure 6: Double Skin Façade and Chimney.

CASE STUDY 2: BUILDING RESEARCH ESTABLISHMENT, UNITED KINGDOM.

Figure 7: Front View of Building Research Establishment, United Kingdom.

The Building Research Establishment is a research institution located in the United Kingdom that is owned and operated by a charitable organisation known as the BRE Trust. Up until 1997, the government of the United Kingdom operated it as a national laboratory. This distinctive structure in the middle of the BRE campus combines high architectural standards with cutting-edge environmental design technologies. It has office space that is 1,350 square metres and seminar facilities.

The chimney formal appearance, which differs from structure to structure and building to building, is the most common method. The stack natural ventilation devices are not included in the construction framework at this time. As a consequence of this, they do not have any influence on the spatial organisation of the building. As a consequence of this, the positioning-related constraints imposed by this technology are not considerable. The "BRE Structure" seen in figure 7 features overlaid regions that make it possible to obtain ventilation through a unique stack chimney located at the front of the building.

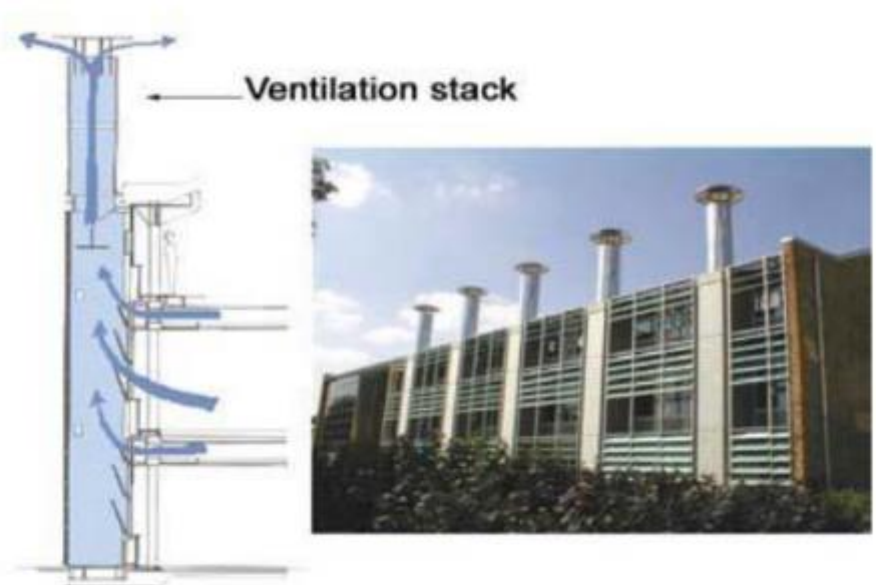

Figure 8: The façade system and the structure features ventilation stacks.

The chimney is brought back into use in a variety of forms over the majority of Europe. On the other hand, given the nature of his design, one could argue that this device functions as a wind catcher. From a topological point of view, there is no connection between the architecture of the building and the natural ventilation scheme. A stack device is responsible for providing ventilation to each individual compartment.

ANALYSIS AND RECCOMMENDATION

The use of the least amount of energy possible while providing the greatest degree of comfort indoors is the goal of climatic design. The direction of a building, its location, the type of building envelope it has, and the materials it is made of are all key factors that influence the thermal performance of a building. It has been established that passive building design results in a reduction in the amount of energy that a structure consumes. Depending on the ventilation parameter, the most effective ways to incorporate ventilation into diverse designs are those that involve sophisticated ventilation systems. When making plans, a number of different tools should be taken into consideration because natural convection may on occasion require aid in order to be efficient.

The stack effect ventilation system strategy that can be adopted into healthcare clinic are;

- **Solar Induced Ventilation**
  This strategy takes into account the interplay that occurs between sun radiation, temperature variations, and stack ventilation. These systems' "double-faced," "solar chimney," and "roof" components are essential to their operation. This strategy was founded on the concept of ventilation from multiple directions.

- **Double Faced**
  Buildings that have two layers of glazing are able to collect more of the daylight energy that is available to them and also have a greater pressure difference between the lower inlet and higher exits of their respective systems. The venture impacts served as the organising concept for the method.

- **Solar Chimney**
  This technique is dependent on the amount of solar radiation and absorption that occurs at the very top of the structure. As the amount of solar radiation grows, the temperature in the upper areas also increases, which in turn causes an increase in the rate of ventilation.

- **Solar Roof**
  A solar roof, often referred to as a double roof, is a small room that is constructed on the main floors of a building. This area is designed to absorb solar energy and is believed to be connected to air buoyancy. The substantial gap between the outer and the inner roofs serves to improve the ventilation and the overall efficiency of the structure.

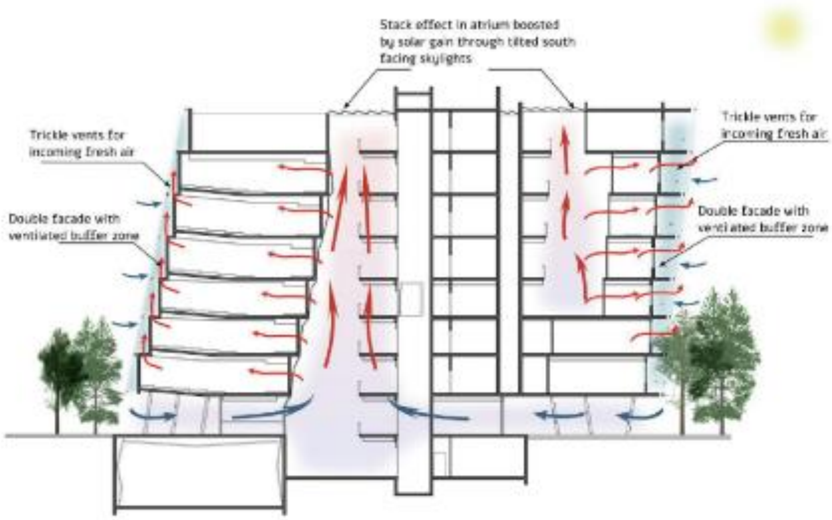

Figure 9: Ventilation caused by the sun in a building.

CONCLUSION

Consumption of energy in buildings is a fairly complicated topic that may be handled from a number of different directions. This study aimed to investigate the characteristics of stack impacts in healthcare facilities so that they might be incorporated into the design stage. This was done with the goal of achieving a high level of indoor air quality. The structure that was selected for the case study is an excellent illustration of the application of stack effects. As a consequence of this, there may be considerable reductions in energy consumption. According to the findings of the study, the most effective strategy for enhancing the quality of the air within healthcare facilities is to combine stack ventilation with other ventilation methods. Some of the more effective methods for stack ventilation include making use of the building's design, its systems, its orientation, and a great number of other elements.

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