Original Research Paper Architecture

ARCHITECT'S ROLE IN DESIGNING OF SCHOOLS - VENTILATION STRATEGIES ADOPTED

Ar.Dr.N.L.Sireesha

Assistant Professor, Department of Architecture, School of planning and architecture, Jawaharlal Nehru Fine arts and Architecture University Hyderabad, Telangana, India

ABSTRACT

There are a variety of components that go into the creation and the execution of building an edifice. From the designs the architects and engineers can work together to create buildings that are suitable both for the purpose of its use, and the environment in which it is located. In today's world, with technological advancements, there are many more methods to increase ventilation in a building. In schools, the ventilation strategies can be limited to certain logistical details such as "classroom identification, location of the school building, mode of ventilation, classroom volume, type of windows, maximum openable areas [and] type of heating" (Mumovic et al., 1467). This article aims to discuss the types of ventilation methods, both natural and hybrid creations, in creating the appropriate amount of airflow in the designs of schools, and how the various factors affect adequate ventilation rates.

KEYWORDS Natural Ventilation, Mechanical ventilation, schools, airflow

INTRODUCTION

1.0 NATURAL VENTILATION

Natural ventilation has been the choice method for hundreds of years, since humans were able to develop housing structures, and it takes knowledge of the climate and direction to truly execute the proper natural ventilation in different types of lands. In air ventilation, air movement is extremely important in the process, so it is important to "integrate the building forms, openings and building orientation" into the entire development (Siew, Che-Ani, Tawil, Abdullah & Mohd-Tahir, 364). It has been found that when the direction of the openings are facing the entry, "designed as windward," there should be another opening in the direction of the air that is leaving and "discharging the used air" (Siew, Che-Ani, Tawil, Abdullah& Mohd-Tahir, 364).

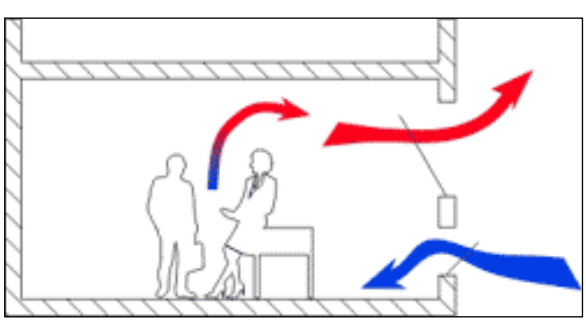

Figure 1 :Natural Ventilation

Natural ventilation in this way is more successful in this factor, and the number of openings in the building, including "windows, doors and other elements of the building façade" (Siew, Che-Ani, Tawil, Abdullah & Mohd-Tahir 364). In these designs, windows are one of the most important aspects of the ventilation process since they are components that can control the amount of ventilation according to preference (Siew, Che-Ani, Tawil, Abdullah & Mohd-Tahir). In this way, it is the responsibility of the architect to ensure that there are enough methods of natural ventilation, and to determine the direction of the aeration in the creation of the building.

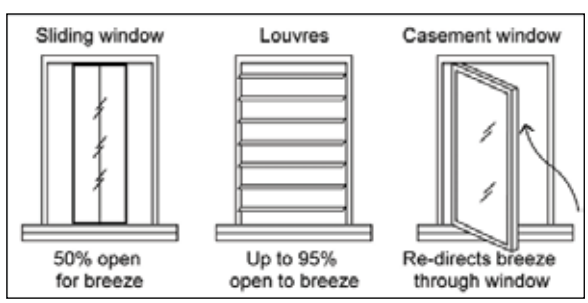

Figure 2 :Design of Windows
Source: Dept of Environment and Resource Management, Qld

Natural ventilation is generally more suitable in climates that are mild, and do not have extreme heat or extreme cold in order to reap the most cost effective designs (Santamouris & Allard). This type of ventilation is best suitable in these climates mostly because natural ventilation generally is more haphazard and cannot be

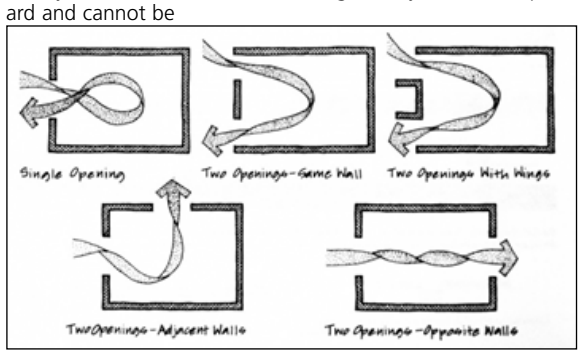

Figure 3 : Cross Ventilation,
Source : Sun, Wind, and Light, by G.Z. Brown and Mark DeKay,

precisely controlled (Santamouris & Allard). Another aspect to consider is the environment of the building setting (Santamouris & Allard). If the building in which the natural ventilation that is to be implemented is in an urban setting, the architect will need to determine how the outdoor conditions such as "air pollution and noise" will effect the ventilation status (Santamouris & Allard, 7).

1.1 NATURAL VENTILATION METHODS

In the school setting, there are methods of creating natural ventilation using windows, and using windows can be extremely important because of the control for this airspace (Epstein). Using windows allows them to be closed most of the winter period, and to be open when warm weather permits (Epstein). When placing these windows in an architectural design, the purpose is to create more airflow with the least amount of air pollutants (Epstein). In this way, the architect's role in this creation would to be to ensure that the windows in the school are placed in areas that are as distant as possible from any possible air pollutants (Epstein). Pollutants would be trapped into the ventilation, and would negate any positive airflow that does come into the school (Epstein). It is part of the architect's role in designing this building that the ventilation sources are away from areas that could cause pollutants such as dumpster or bus drop off areas (Epstein).

Figure 5 : The Chinese University of Hong Kong, The design maximises daylight and natural ventilation.

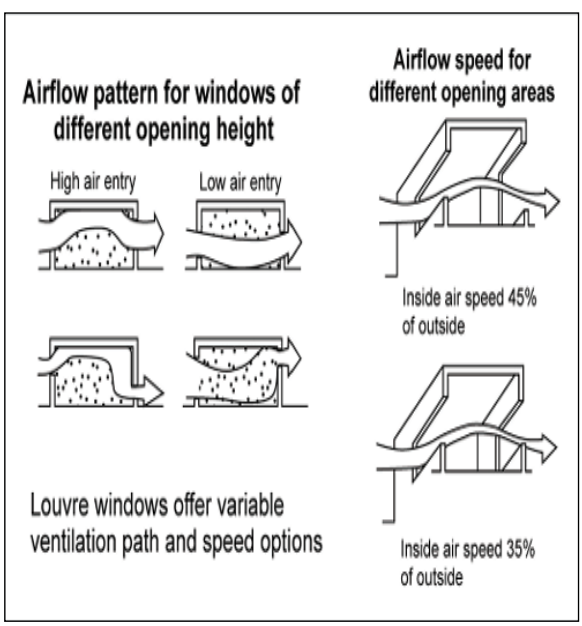

Figure 4 : Airflow pattern and speed for different opening areas.
Source : Passive Cooling by Chris Reardon

Another important aspect that the architect needs to consider is the rate of the airflow in addition to the source and direction. The rate of airflow that can possible pass through the window is important to predict in order to be able to "control and supply the right amount of fresh air in the building" (Larsen & Heiselberg, para. 4). This balance needs to be maintained between low and high airflow, where high airflow could cause a "high-energy consumption for heating" (Larsen & Heiselberg, para. 4). Cross ventilation has also been used in natural ventilation for buildings, such as schools which come with stipulations for building height, room depth and room height (Larsen & Heiselberg). This cross ventilation solution, however, works only for situations where there are ventilation sources on multiple sides of the building, and not for buildings which only allow ventilation sources on only one side the building (Larsen & Heiselberg). These are requirements are important for the architect, who is creating the building according the needs of the school district, and according to these, the architect can use the rate of airflow from different areas of the building, as well as cross ventilation if possible, to create adequate ventilation for the school building. In terms of airflow rates, other components to consider are "wind speed, wind direction and temperature differences between inside and outside the building" (Larsen & Heiselberg, para. 4). These differences become important because in order to maintain ventilation, the architect must be aware of the wind direction and speed as well as what types of temperatures are likely to come these winds in order to determine the best placement for the windows (Larsen & Heiselberg).

Another factor that becomes important for natural ventilation purposes are characteristics of the airflow, which include the turbulence and pressure differences between the wind gusts (Larsen & Heiselberg). Generally, airflow and wind speed would not be a high consideration, and would be an addition to the other aspects of ventilation, however, in areas which receive a high intensity of wind gusts, turbulence becomes an important issue, as it can become quite a disturbance and not the proper ventilation.

The types and the amounts of natural ventilation design should depend on the overall location of the school. For example, in school designs in the United Kingdom, it is more common to reduce natural methods of ventilation according to the noise and air pollution balance by the benefits of fresh air that natural ventilation can supply (Mumovic et al. 1467). Specifically, the architect should be able to determine a design which uses "a minimum fresh air supply that is equal or greater than 3 l/s per person" where the noise level inside the classroom should not exceed "the upper limit for the indoor ambient noise of 35 dB" (Mumovic et al. 1467). This means, that in the overall design, there is a limitation to the potential negative qualities that would be coming in through the ventilation source that affect how much natural ventilation can be used, where the role of the architect is to determine design which take account for both aspects.

2.0 HYBRID AND MECHANICAL VENTILATION

2.1 METHODS OF MECHANICAL VENTILATION SYSTEMS

Although natural methods of ventilation provide a cost efficient solution, they can prove to be rather difficult to accurately predict. Other methods that have proven to be more reliable are hybrid methods of ventilation as well as mechanical methods of ventilation. Hybrid methods of ventilation are ones in which the nature of the ventilation system is natural, however the method of achieving the ventilation is mechanical, and an example of this, is the use of automatic windows (Mumovic et al., 1467). Here, the window is the natural method of ventilation, however it is using the mechanics to do so. Mechanical ventilation use systems to "circulate fresh air using ducts and fans, rather than relying on airflow through… walls, roofs or windows" ("Energy Star,"1). There are many benefits of using these mechanical versions of ventilation, which include better air quality than natural ventilation methods ("Energy Star," 1). It has been found that the air indoors can be much more polluted than even outdoor air, because of the lack of circulation within the building ("Energy Star"). To prevent these pollutants, or at the very least limit them, me-

chanical ventilation systems can improve the air quality by limiting "allergens, pollutants and moisture that can cause problems" ("Energy Star," 1). Additionally, mechanical ventilation can give the users more control over the ventilation quality when compared to natural ventilation methods because mechanical ventilation methods provide fresh air with separate locations for air intake and air exhaust ("Energy Star"). Furthermore, these types of ventilation systems oftentimes are able to change multiple aspects regarding air quality ("Energy Star"). This means that the mechanical ventilation unit could also provide other benefits in addition to air filtration, such as "dehumidification, and conditioning of the incoming outside air" ("Energy Star," 1).

A type of mechanical, or forced, ventilation system is a powered fan or an air blower ("Mechanical/ Forced Ventilation"). These types of fans are able to circulate air through a room by being able to reduce "the perceived temperature by method of evaporation of perspiration on the skin of the occupants" ("Mechanical/ Forced Ventilation," para. 2). It is known, that hot air rises, and so the placement of the fan on the ceiling provides the opportunity of the fan being able to circulating the warm air near the ceiling to the floor when the climate cools down, and the warm air needs to be dispersed throughout the room ("Mechanical/ Forced Ventilation"). In this way, using a ceiling fan for air circulation is beneficial in that it can be used in cool and warm seasons to achieve the desired temperature. Although air circulation in this manner can help with ventilation, it is not considered to be a true type of an air ventilation design ("Mechanical/ Forced Ventilation"). This is because in this system, "there is no introduction of fresh air" whereas natural and mechanical systems do move fresh air into the rooms ("Mechanical/ Forced Ventilation," para. 2).

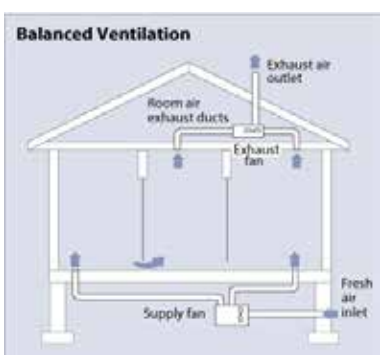

Figure 8 : A pressure balanced ventilation system includes specific controls for both air intake and air exhaust.
Source : Whole House Ventilation

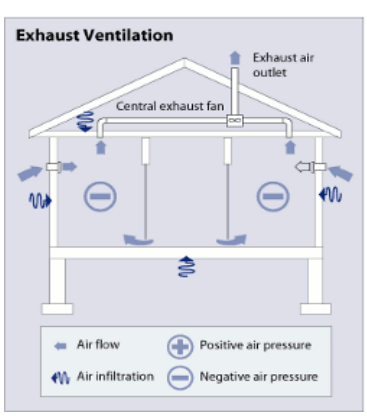

Figure 7 : Exhaust Ventilation
Source :Energy.Gov Moisture Control

In the manner in which they work, mechanical ventilation systems can be selected based on the climate of use. In hot or mixed climates, a supply ventilation system is used, where the "fresh air is drawn in through an air 'intake' vent and distributed to many rooms by a fan and duct system" ("Energy Star," 1). These ducts can be connected together as well to the main air duct of the building in order for the "heating or cooling system's fan and ducts to distribute fresh air" ("Energy Star," 1). An addition to having the air ventilated to multiple rooms is that the air can also be further "conditioned or dehumidified before it is introduced" into the building ("Energy Star," 1). From introducing new air from the outdoor space in a continuous manner, the building can also become somewhat pressurized ("Energy Star"). In this situation, the architect will be able to determine what type of climate the particular location belongs to, and in the situation of using this system in a classroom, which is a building with many rooms, this ventilation system may prove to be ideal.

Another type of ventilation system is one that is used for cold climates and is called exhaust ventilation systems ("Energy Star"). This system works by continuously drawing out the air from inside the building by using the one or more fans inside the building, which eventually depressurizes the building ("Energy Star"). Since the building will be depressurized, it is generally not suitable for hotter weathered climates because there other complications could arise from other cracks and holes from the construction, causing moisture issues within the building ("Energy Star"). Here, the architect will be able to determine the building's structure, and if there are significant cracks and or structural damages which would deter the use of this type of ventilation. Additionally, the architect's role in this type of evaluation is to determine if the climate is considered cold weathered, and if the building can benefit from the exhaust ventilation system.

Finally, a ventilation system, which can be used in all climates, is aptly called the balance ventilation system, where an equal amount of air is pumped in as it is pumped into the building ("Energy Star"). This works by using two fans in the ventilation system, where one fan will bring the air in, and the other fan will bring out the used air ("Energy Star"). These two fans keep a balance between the inside and outside climate, and both areas remain with the same pressure. As the architect's role, this type of ventilation should be used in areas where the climate is not either extremely cold or extremely hot.

2.2 DESIGNING SCHOOLS WITH MECHANICAL / NATURAL VENTILATION SYSTEMS

When it comes to the design of schools, these structures generally are built with the mechanical ventilation systems (Epstein). In this case, the system will remove air from the classrooms, "mix it with fresh-air, filter the air and return it back to the space" (Epstein, para. 3). Since schools can vary in sizes, mechanical ventilation systems can also be programmed or created to handle different capacity sizes as well (Epstein). It was also studied that mechanically ventilated classrooms have less of a fluctuation between pollutants such as carbon dioxide, when compared to natural systems of ventilation (Mumovic et al.). It is assumed that since the mechanical systems are able to control the airflow and quality more easily, that there is more control over the use. While this is true, the mechanical ventilation systems also do pose the problem of not being able to be flexible for the occupants or users (Mumovic et al.). This means that the mechanical ventilation unit cannot be changed to the preference of more than one user, and the entire school must receive one setting placed on the system (Mumovic et al.).

Figure 9 : TU's Indoor Air Program shows maintaining adequate ventilation and thermal comfort in classrooms could have direct impacts on student learning and performance

Although the mechanical system still provides a more reliable manner of providing ventilation when compared to natural methods of ventilation, the natural ventilation method provides the option for each classroom to be able to adjust the airflow according to preference. In this manner, the role of the architect would be to design a school ventilation system, which can be used easily for all parties involved in the classrooms, and appease the wishes of the client, who wants the school designed.

Additionally, it was determined that even though mechanical ventilation systems are inside the building, they would not let in outside noise, it seems that they do however create noise themselves which are above ambient level noise detection (Mumovic et al.). It has been found that fans in the mechanical ventilation are the components that seem to be causing the noise pollution (Mumovic et al.). So, although the mechanical ventilation systems would be able to prevent noise pollution from the outside environment, they do also create noise themselves.

3.0 CONCLUDING REMARKS

Overall, the architect should be able to determine the type of ventilation system which the school requires, according to the climate, airflow and desires in terms of noise levels. Natural methods of ventilation provide a more cost effective method of airflow and the user of the classroom is able to adjust the airflow according to the window opening. However, using the natural methods means that airflow ventilation can be unpredictable, and there could be noise and air pollutants that would enter the school building, since the fresh air entering from windows is generally unfiltered. On the other hand, using mechanical ventilations would also add some type of noise level to the school and classroom, but the airflow in which this type of ventilation provides would be filtered from air pollutants, and would remain constant throughout. Ultimately, the architect's role would be to thoroughly calculate the noise and air pollutants for each option, as well as determine the school's need for flexibility for ventilation in order to create the final designs.

References

1. "Energy Star." *U.S. Environmental Protection Agency,* 2016, https://www.energystar.gov/ia/new_homes/features/MechVent_062906.pdf. Accessed 15 ,October 2016.
2. Epstien, David. "Improving Your School- Part II: Maximizing Ventilation." *TruexCullins.com,* 2015,http://truexcullins.com/improving-your-school-part-ii-maximizing-ventilation/. Accessed 12 October 2016.
3. Larsen, T. & Heiselberg, P. (2008). "Single-sided natural ventilation driven by wind pressure and temperature difference." *Energy and Building,* 2008,http://www.sciencedirect.com/science/article/pii/S0378778807002137. Accessed 13 October 2016.
4. "Mechanical/Forced Ventilation."*Ventilation, http://uol ventilation.weebly.com/mechanical.html.* Accessed 13 October 2016.
5. Mumovic, D., Davies, M., Orme, M., Ridley, I., Oreszczyn, T., Judd, C… Way, P. "Winterindoor air quality, thermal comfort and acoustic performance of newly built secondary schools in England." *Building and Environment,* 29 January 2008, . Accessed 12 October 2016.
6. Santamouris, Matheos & Allard, Francis. *Natural Ventilation in Buildings: A Design Handbook,* 1998,Accessed 14 October 2016.
7. Siew, C., Che-Ani, A., Tawil, N., Abdullah, N. & Mohd-Tahir, M. "Classification of Natural Ventilation Strategies in Optimizing Energy Consumption in Malaysian Office Buildings." *Procedia Engineering,* 2011,http://www.sciencedirect.com/science/article/pii/S1877705811029870. Accessed 13 ,October 2016.