An Environmental Quality Assessment: Study on Natural Ventilation in Buildings

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Abstract - *Natural ventilation is outlined as victimization passive ways to provide outside air to a building's interior for ventilation and cooling. Conventional commercial buildings with airtight envelopes are typically conditioned with mechanical HVAC systems. Although airtight envelopes contribute to energy efficiency, introducing fresh air through natural ventilation strategies can both save energy and improve indoor air quality. With correct style, appropriate to the building location and use, natural ventilation can replace all or part of a mechanical system, thereby reducing construction, energy and operating costs. Natural ventilation systems believe natural driving forces, like wind and temperature variations between a building and its surroundings, to drive the flow of recent air through a building. Both work on the principle of air moving from a air mass to a unaggressive zone.*

Key Words: **Ventilation, Air Ventilation, Indoor Air Quality, Natural Ventilation, Analysis, Energy Efficiency, Modelling**

1. INTRODUCTION

Indoor environment in a room has to meet level suitable for people and theirs activity. Ventilation is one of systems keeping habitable environment. It requires air flowing between interior and exterior and it provides exchange of polluted air for fresh outside air or clean air from neighboring rooms. Thus it is necessary to start and maintain air flow according to requirements in a ventilated space. Ventilation promotes and directs air movement in the space, removing excessive heat and/or moisture essential for comfort and well-being. In industrial building ventilation requirements may relate also to industrial processes. In an agricultural building all focus aims to animals.

Natural ventilation could also be outlined as ventilation provided by thermal, wind or diffusion effects through doors, windows, or different intentional openings within the building as against mechanical ventilation that is ventilation provided by automatically powered instrumentation like motor-driven fans and blowers. Although some in the India may think of natural ventilation as merely which means operable windows, natural ventilation technology has been advanced in recent years in Europe.

2. Categorization of Ventilation

Generally categorization of ventilation is done on the basis of:

- Wind induced
- Driving forces

2.1 Single-Sided Ventilation

Single-sided ventilation generally serves single rooms and so provides a neighborhood ventilation resolution. Ventilation airflow in this case is driven by room-scale buoyancy effects, small differences in envelope wind pressures, and/or turbulence. Consequently, driving forces for single-sided ventilation tend to be relatively small and highly variable. Compared to the opposite alternatives, single-sided ventilation offers the smallest amount engaging natural ventilation resolution however, however, an answer that may serve individual offices. Single-sided ventilation can be useful for single rooms as it provides a local ventilation solution.

2.2 Wind-Driven Cross Ventilation

Wind-driven cross ventilation occurs via ventilation openings on opposite sides of an enclosed space. The building floor plan depth in the direction of the ventilation flow must be limited to effectively remove heat and pollutants from the space by typical driving forces. A significant difference in wind pressure between the inlet and outlet openings and a minimal internal resistance to flow are needed to ensure sufficient ventilation flow. The ventilation openings are typically windows.

2.3 Stack Ventilation

Buoyancy-driven stack ventilation depends on density variations to draw cool, outside air in at low ventilation openings and exhaust heat, indoor air at higher ventilation openings. A chimney or atrium is frequently used to generate sufficient buoyancy forces to achieve the needed flow. However, even the smallest wind will induce pressure distributions on the building envelope that will also act to drive airflow. Indeed, wind effects may well be more important than buoyancy effects in stack ventilation schemes, thus the successful design will seek ways to make full advantage of both.

2.4 Hybrid Ventilation

In Hybrid (Mixed Mode) Ventilation the airflow is due to wind and buoyancy through purposely installed openings in the building envelope supplemented, when necessary, by mechanical systems. The mechanical component of the hybrid system can be a fan for increasing the ventilation rate, and/or a heat exchanger for heating or cooling the outdoor supply air.

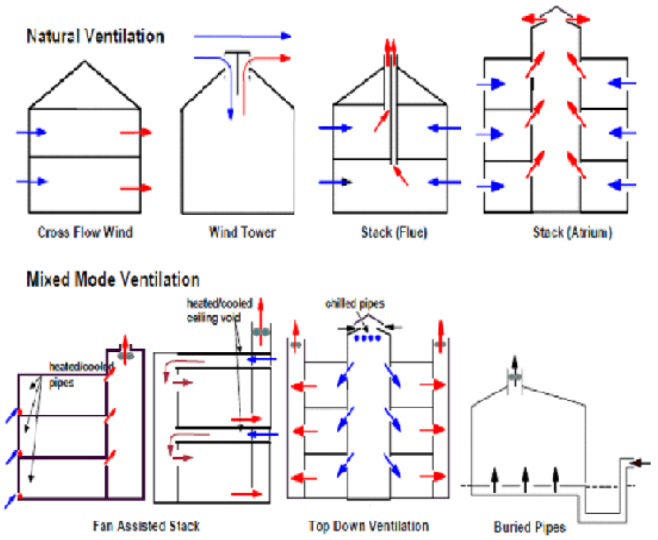

Fig - 1: Natural and Mixed Mode Ventilation Mechanisms

3. Design and Analysis of Natural Ventilation Systems

3.1 Develop design requirements

This step consists of establishing design requirements against which the success of a building design can be measured. This step should also establish, early on, whether or not the option of implementing natural ventilation is viable from both a practical and economic perspective. Consideration should be given to the indoor environmental requirements with respect to internal heat gains, air quality and humidity; space requirements; prevailing and extreme weather conditions; ambient pollutant levels; and construction and operating costs.

3.2 Plan airflow paths

This step consists of selecting the overall type of natural ventilation strategy to use. It requires the establishment of airflow paths of the outdoor air into the occupied spaces of the building and then out through planned exhaust locations. Consideration must be given to the orientation of the building to prevailing winds, surrounding terrain and obstructions; external pollutant sources; and potential stack flows. Consideration should also be given to implementing mechanically assisted and mixed-mode ventilation strategies as well as the use of night cooling of the building thermal mass.

3.3 Identify building uses and features that might require special attention

This step requires the designer to consider issues that might affect the behavior or effectiveness of a natural ventilation system. Issues include the presence of relatively large heat gains, internal obstructions to airflow, indoor and outdoor pollutant sources, envelope leakage characteristics, and acoustic isolation.

3.4 Determine ventilation requirements

This step requires the designer to determine the airflow rates required to satisfy the previously determined design requirements. As previously described, ventilation is provided for four basic purposes including air quality control, direct cooling (advective and personal) and indirect night cooling. Ventilation for air quality control typically establishes minimum ventilation rates based on existing ventilation standards and building codes. Weather data and internal loads are used to determine required flow rates during the different seasons of the year for both direct and indirect cooling purposes. This step should highlight circumstances that may lead to excessive heat gain that could reduce the likelihood of cooling by natural means. These circumstances will either require modifications to design building configuration (e.g. shading to reduce solar gain) or indicate when and how much mechanical ventilation and conditioning might be required (e.g., to overcome insufficient driving forces or extreme climatic conditions).

3.5 Estimate external driving pressures

This step requires the designer to select or determine the driving forces to which the building is likely to be subjected including wind and stack-induced and to determine the design conditions to be used in selecting and sizing the ventilation devices. If detailed analysis is to be performed, then detailed weather data will be needed. This could be in the form of measured data or other available design weather data (e.g. WYEC2, TMY2, etc.).

3.6 Select types of ventilation devices

This step requires the designer to identify the locations in the previously planned airflow paths at which ventilation devices will be required and the types of devices that will be used in those locations. The locations are typically inlets and outlets through the building envelope and openings within the space through which ventilation air is intended to flow. Ventilation devices include windows, trickle vents, exhaust stacks, louvers and doorways, and mechanical assist fans. The flow characteristics of these devices must also be identified. These characteristics typically consist of relationships between the airflow rate through the device and the pressure difference across it.

3.7 Size ventilation devices

This step requires the designer to determine the size of the ventilation devices that were selected in the previous step. Sizing can be performed using either explicit or implicit methods. Explicit methods are based on equations relating driving forces (e.g., wind and stack-driven flows) to airflow characteristics and sizes of the ventilation devices. Implicit methods require sizes of the ventilation devices to be used to determine airflow through them, so this process is often an iterative one in which the designer selects from available devices, analyzes their effectiveness in meeting design ventilation requirements, and iteratively selects devices until a viable solution is obtained. The use of sizing methods and tools can be very helpful in minimizing or even eliminating the iterations depending on the complexity of the design. The sizing of ventilation devices can be complicated by a potentially large number of unknown design parameters. Therefore, this process requires sound engineering judgment in providing additional design constraints to see the sizing process to fruition.

3.8 Analyze the design

This step requires the designer to thoroughly evaluate the design for its effectiveness in providing ventilation rates to meet the design requirements. This includes evaluating the design under various weather conditions and heat loads, determining potential situations where design goals might not be met, evaluating the effects of "unintentional" envelope leakage, and evaluating the potential "misuse" of occupant-controlled ventilation devices. The use of analysis tools can be very beneficial here to provide detailed simulations of the behavior of the building design including airflow rates, pressure relationships between zones, contaminant/exposure information, temperatures, and energy use.

4. CFD Modelling of Natural Ventilation

There are few reasons to use CFD for natural ventilation, such as:

I. Lack of knowledge of effective opening area (i.e. *Cd*).
II. The interaction between mechanical and natural systems is difficult to predict by standard calculation methods.
III. Lack of confidence in pressure coefficient data for wind-driven flow calculations
IV. Difficulty in differentiating between air supply and extract openings (dependent on wind direction, turbulence, temperature difference, etc.). Calculations are needed for different wind directions but classical methods cannot accurately predict the effect of wind direction.
V. Usually room air movement predictions are needed in addition to air flow calculation.

CFD modelling of natural ventilation is done as :

4.1 Building model

The translation of a true building into Associate in Nursing "electronic model". Most CFD codes can import CAD files but this still requires some engineering and modelling skills.

4.2 Air inlets and outlets

Air supply devices (grilles, louvers, etc.) can be complex and some simplification is needed. Understanding of device airflow characteristics will provide more accurate modelling.

4.3 Obstructions

Both internal and external flows are greatly influenced by the size and location of obstructions. Can be passive or emit heat and pollution.

4.4 Heat and pollution sources

Internal or external heat and pollution sources should be accurately positioned and emission of heat and/or pollution from them should be specified.

4.5 Computational grid

External flows sometimes need an oversized range of machine cells for correct results. Therefore, convergence can sometimes be difficult. Turbulence modelling will be difficult specially wherever giant areas of flow separation occur.

4.6 Simulation

Sometimes a dynamic simulation is critical which might be terribly exacting.

5. Natural Ventilation: Issues, Advantages, Disadvantages & Balance

5.1 Natural Ventilation Issues

I. Weather-dependence: wind, temperature, humidity Outdoor air quality
II. Immune compromised patients
III. Building configuration (plan, section)

IV. Management of openings
V. Measurement of ventilation rate(s)

5.2 Advantages of Natural Ventilation

Natural ventilation exercise in buildings, compared to the mechanical ventilation, has several blessings. This includes (Energy efficiency Best Practice Programme, 1998):

I. It requires less construction and operation cost, and minimum maintenance.

II. It is fossil fuel free. This has no direct negative environmental impact like air pollution, global warming, etc.

III. It is reliable and easy-to-use in many varieties of buildings like residential and workplace buildings. The potential for private management of the atmosphere will increase users satisfaction and productivity.

5.3 Disadvantages of Natural Ventilation

Despite of the preceding blessings of natural ventilation, it still has some disadvantages including:

I. Natural ventilation exercise has several resultant problems like building security, safety, including the event of fire, and reliable control.

II. Wind has a random nature in both direction and magnitude. This means that securing stable indoor atmosphere relying altogether on natural ventilation can't be warranted, compared to the steady conditions of mechanical ventilation.

III. Utilizing natural ventilation in some building sorts appears to be impractical, especially those of deep plans, or those requiring high control level of indoor environment such as hospital buildings.

5.4 Balance between advantages & disadvantages of Natural Ventilation

It is crucial in the early stage of the design process to balance between advantages and disadvantages of natural ventilation utilization considering the conditions of each individual project. Thus, it's tough to state associate degree absolute rule here. However, associate degree from an environmental purpose of read, the utilization of natural ventilation ought to be promoted where attainable and possible. As indicated in the introduction, mechanical ventilation has been heavily used in buildings in the last few decades.

This has caused a rapid increase in energy consumption in these buildings, which has to be rationalized and reduced. As a general rule of thumb, naturally airy buildings ar four-hundredth less operating energy value compared to automatically airy buildings (CIBSE, 1997). As a result, the concept of „energy-efficient design‟ has developed the architectural design priorities. This style strategy aims to "provide thermal comfort and acceptable indoor air quality with the minimum use of energy" (CIBSE, 1998, p.6-1). Several studies are allotted to create the utilization of natural ventilation in buildings additional economical, and reduce the use of mechanical plants (Liddament, 1996). This includes the following aspects:

I. Producing natural ventilation style pointers for various varieties of buildings.

II. Exercise of hybrid ventilation systems, wherever the use of natural ventilation as a sole strategy is impractical. These systems integrate natural ventilation with mechanical energy-efficient plants

III. Up the elaborated style of branch of knowledge components that may be utilized for natural ventilation.

Table -1: Limits of some internal gaseous pollutants in buildings

Pollutants	Source	Levels (ppm)	Limits (ppm)
Carbon Dioxide	People, combustion	320 to 2500	5000 ppm
Oxides of Nitrogen	Combustion, cooking, smoking	0.5 to 0.3	---
Carbon Monoxide	Combustion, cooking.	3 to 17	35 ppm

6. CONCLUSIONS

Natural ventilation systems presently lack proven ventilation heat recovery and filtration capabilities, are generally difficult to control and are inherently unreliable when natural driving forces are small. The key to overcoming these shortcomings and realizing the potential advantages of natural ventilation is the emergence of hybrid natural and mechanical system strategies.

Three important considerations specific to the application of natural ventilation to commercial buildings in India are climate suitability, ambient air quality, and relevant codes and standards. A new ventilative cooling metric was described and used to demonstrate that the coastal climates of India are potentially very well-suited to natural ventilation. The hotter, inland locations are less suited to a simple natural ventilation strategy but may be able to benefit from night cooling or hybrid system strategies. A review of ambient air quality data indicates that much of India fails to meet the national standards for one or more contaminant. However, since ambient air quality problems may vary by season, time-of-day, and locality, natural ventilation strategies may still be considered acceptable at all times in some areas and part of the time in other areas through innovative hybrid systems. While relevant national, state, and local building codes and standards allow natural ventilation in commercial buildings, they provide minimal guidance on acceptable application. Again, hybrid systems may eventually be more acceptable due to greater assurance that sufficient ventilation rates can be maintained at all times.

Finally, there is a lack of proven, fundamental-based tools and processes for design and analysis of natural ventilation systems in commercial buildings.

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