Topic 3
Building Ventilation Systems

Introduction

- Air change and air movement or ventilation is a vital aspect of building design. It is necessary that ventilation does not fall below certain minimum levels. But at the same time excessive ventilation must be avoided as this will affect indoor temperatures and impact on heating or cooling requirements and energy use.
- In the case of hot or tropical climates, adequate ventilation may reduce the need for air-conditioning, or where air-conditioning is applied, it would increase energy loss when the coolth of a space is affected by unnecessary openings of doors or windows.

- Ventilation can sometimes be excessive due to the construction of the building.
- In houses in colder climates , for example, it is quite common for ventilation levels to account for 30%-50% of the heat losses that require spaces to be heated.

The level of ventilation will depend on the type of building and its use.

- Housing, for example needs ventilation rates of 0.5 to about 1.5 ach (air changes per hour)
- offices may need 4-6 ach (depending on several factors such as the numbers of occupants),
- cinemas and theatres 6-10 ach.

- Buildings in which contaminants are being generated will require even higher ventilation rates to ensure removal or adequate dilution of the contaminant.
- Laundries, for example, generate water vapour and need ventilation rates of 10-15 ach

Definitions

- Ventilation is the process of retaining the comfort of a space through appropriate temperature, humidity and oxygen levels by replacing stale air with fresh air.
- Ventilation is measured in terms of air changes per hour (ach). An air change rate of 1 ach is equivalent to removing all the air in the building and replacing it with fresh air once every hour.

Importance of Ventilation

- It is essential to ensure that a suitable level of ventilation is achieved within the building. Adequate ventilation is essential in a building for the following reasons:
- To provide fresh air for the occupants to breath
- To provide thermal comfort by removing air heated due to solar heat gain, body heat, and heat generating electrical appliances.

Importance of Ventilation

- To provide air for combustion appliances such as boilers
- To remove stale air which may be contaminated with moisture or smoke particles etc
- To remove or dilute odours
- To remove the combustion products for combustion devices without flues e.g. gas cookers.
- To control smoke and/or poisonous gases that may be spread in a fire.

- This can be done with the correct use of appliances or in some cases with suitable building design that embodies 'natural ventilation'. In the case of large buildings some form of forced ventilation may be required, usually in the form of a mechanical ventilation system.

- If it is necessary to provide air at a lower temperature or humidity then an air conditioning plant will be necessary.
- However, for housing and smaller commercial buildings simple ventilation equipment is usually specified, such as extract fans in kitchens and bathrooms or slot ventilators on windows.
- Heating appliances must have an adequate supply of air and for these balanced flues or chimneys are common.

Types of ventilation

There are generally three types of ventilation:

- Natural Ventilation
- Mechanical Ventilation
- Mixed mode ventilation

Natural Ventilation/Passive and Low Energy

- Modern natural ventilation is not just a matter of having an openable window of given size.
- It involves
  - the provision of background ventilation for periods of low occupancy,
  - rapid ventilation to deal with temperature and air pollution during occupancy,
  - and the removal of local air pollution at source rather than allowing it to escape to the general atmosphere.
- These aims have to be achieved while maintaining the security and weather

Natural Ventilation/Passive and Low Energy

- There is no significant control systems where natural ventilation is concerned.
- This system is dependent on the level of air movement and the temperature difference between indoor and outdoor air temperature.
- The rate of ventilation depends on how many openings there are in a building.
- With natural ventilation, outside air quality, height of the building, and noise pollution need to be taken into account.

- There are three methods of natural ventilation:
  - Air Pressure
  - Stack Effect
  - Combination of Air Pressure and Stack Effect

Natural Ventilation due to Air Pressure

- Occurs when there is a difference of air pressure between the indoors and the outdoors.
- Air moves from a high pressure area to a low pressure area.
- The higher the wind speed the greater the difference.

This type of ventilation can occur through:

- Windows
  - The design of the window i.e. its shape, position, size and numbers will determine the effectiveness of the ventilation.
  - As wind direction frequently changes, windows should be placed on all walls.
  - Generally wind direction can be determined by conducting tests on site
  - the effectiveness of the building design can be tested by the use of wind-tunnel tests.

Stack Effect

- Another method for the natural ventilation of buildings utilises the driving force of the 'stack effect' in order to promote ventilation.
- The stack effect results from the tendency of warm air to rise in a building and this is displaced by colder external air
- In high buildings, above 10 storeys, the stack effect becomes very marked. In winter the difference between the outside cold air and the inside warm air can be as high as 20 ^{0}C.
- Under these conditions the warm air inside the building tends to rise within the stair wells, service ducts and lift shafts, the top of the building can become excessively hot and the bottom very cold.
- Individual levels (floors) will not be affected by the stack effect, because of the subdivision into individual dwellings (flats) or other partitioning (offices).

- The natural stack effect and the pressure variation due to the prevailing wind on one façade of the building can be used to good effect to ventilate commercial buildings of a certain size and shape.
- There are many such examples of buildings that are ventilated in this way. Some use solar chimneys or atria to encourage the stack effect.
- Stack ventilation can be controlled by vents at the top of the stack that are automatically operated by temperature sensor controls.

- The rate of air movement is dependent on:
  - Temperature difference
  - Height of the building or space
  - Size and location of the air inlet openings.

Combination of Air Pressure and Stack Effect

- This occurs when wind blows at a considerable rate towards the stack opening.
- This causes the internal air to be drawn out through suction via the stack.
- Air will be quickly replaced by cleaner outside air at the lower levels.

Mechanical ventilation

Reasons for mechanical ventilation

- The ventilation flow rates that can be achieved by natural ventilation are limited.
- For high flow rates mechanical ventilation will be necessary.
- Natural ventilation provides little or no opportunity to treat the incoming air supply.
- If the air has to be cooled, heated or filtered mechanical ventilation will be necessary. Consistency and full control of ventilation is not possible with natural ventilation systems.
- If a building is located in a noisy town centre it may not be possible to provide adequate natural ventilation without excessive sound transmission. In such cases mechanical ventilation will be the only option.

Mechanical ventilation

Reasons for mechanical ventilation

- But if cost is the criteria natural ventilation systems should be cheaper to install and operate than mechanical systems.
- Natural ventilation systems in their simplest form have no maintenance requirements as there are no mechanical parts and no associated energy costs. This makes it an attractive option if the end use

- Mechanical ventilation is usually accepted as being the use of ducted air distributed to and from centrally located fans with the addition of air filtration, heating, cooling, humidification or heat recovery.
- Such systems are usually only installed in commercial buildings but are sometimes essential for the operation of the building.
- Hospitals, for example, require areas to be sterile and this usually implies that there are no windows in these areas. The only recourse to achieve a suitable indoor air quality is for some form of mechanical ventilation system.

- Windows in large offices located in the centres of cities cannot be opened for reasons of security, noise or the ingress of dust and dirt.
- In such cases mechanical ventilation will be necessary.
- In summer these buildings may be subject to overheating, especially if a large area of the façade is glazed.

- To maintain suitable indoor air temperatures the warm, stale air is extracted and replaced by external air that is cooled before being ducted to the offices.
- It is likely that this type of system will also include filters to extract incoming air pollutants.
- In this way not only is ventilation provided but the air is conditioned either by filtering unwanted pollutants or by cooling or in some cases by heating.
- These systems are known generically as Air Conditioning systems because they modify the incoming air supply.

- The use of mechanical ventilation and air conditioning systems does have an associated energy cost.
- Energy is required to operate fans and the more filters used the higher the fan power necessary to move air around the building.
- If some form of heat recovery is used savings can be made.
- But in general mechanical ventilation and air conditioning systems have a high initial capital cost, a running cost and a maintenance cost which should be considered.
- Air conditioning plant requires regular maintenance to ensure that there is no bacteriological build up that will cause legionella, for example, in the cooling water.

Importance of Mechanical Ventilation

The following situations require mechanical ventilation or air conditioning:

- Internal rooms
- Large, closely populated rooms where the distribution of natural ventilation is inadequate (BS5925:1991)
- Rooms where the volume per occupant is too low for efficient ventilation

Importance of Mechanical Ventilation

- Rooms where close control of the environment is required: typical aspects are temperature and relative humidity
- Where natural ventilation cannot be provided because of external air pollution or noise
- In tall buildings where wind and stack effects render natural ventilation impractical
- Extract ventilation may be required to deal with fumes and smells from cooking or other special processes

Types of Mechanical Ventilation

- Supply System
- Extract System
- Combination System

Supply system

- This system makes use of a Mechanical air intake device and expelling by natural exhaust.
- The air volume in the space and the quantity of oxygen will increase rapidly.
- The oxygen from the outside needs to be cleaned by the use of a layer of filtering material before the air enters the space.
- The air is forced in thereby increasing the internal air pressure.
- This in turn expels the air already in the room through any existing openings. This system is mainly used in basements, boiler rooms and factories.

Extract system

- This system extracts the indoor air via mechanical means and intakes air naturally.
- It consists of at least one fan, usually a propellar, placed at a height 1.8m above the outside floor level.
- All openings need to have filtration layers to ensure the intake air is clean. This is a more popular system.
- This system is used to effectively extract “dirty” air from an internal space.
- This system may use ducting to extract air, odour and/or gases that are localized or generic.
- Its also used for extracting humid air from bathrooms, toilets, changing rooms

Combination System

- A system that uses mechanical means for controlling air supply and air extraction. Air intake and extraction can be varied according to the building's needs.
- Internal air pressure can also be varied, for example in smoke lobbies, positive air pressure can prevent smoke from entering the space (lift shaft).
- This system can effectively replace the air in the space, extract heat, odours, and internal air pollution.

- This system is used for spaces that have complex ventilation requirements where full control of the environment is required eg. Theatres, restaurants, ball rooms, kitchens, shopping complexes, offices etc.
- For spaces with a high number of smokers, the supply air should be more than the exhaust air so that cigarette smoke can be quickly removed. Exhaust air is 70% to 90% of supplied air.

- For spaces that produce uncomfortable odours or dirty air, negative pressure is desirable eg in hospital treatment rooms. The exhaust air should be 20%-30% higher than the supplied air.
- Unfortunately this will distribute the polluted air to adjacent buildings. The air pressure in the space should be higher than the outside to prevent the exhaust air from reentry.
- For spaces such as dining halls, the exhaust should be higher than the supply especially from kitchens, washrooms etc. This is to prevent unclean air from entering the dining area.
- Outside air can be supplied via ducting. Figure 3.10 . Figure 3.11 is an example of a fan room that is used for basements.

Choice of vents

The choice of vents to be used is based on the following criteria:

- Volume of air that needs to be handled
- The types of barriers facing the vents whilst in operation
- Allowable noise levels
- Comfort levels of the ventilated spaces
- Implications of the design of the ducting on the type of vent used.

Air pressure depends on the speed of the vents and care is needed on the choice of vent and the ducting design to avoid unwanted noise levels.

- Its advantage is the lower initial cost compared to other vent types.
- It is used where ducting is not required and is ineffective if there are barriers such as around corners. Usually placed on walls and quite noisy during operation.

- Its advantages is that it is relatively quiet in operation and is 90% effective.
- There are various types depending on the type of motor and the speed.
- Its disadvantage is that it tends to be bulky and requires a significant amount of floor space. It is also costlier than other types.

Choice between Mechanical ventilation and Natural ventilation

The choice between natural or mechanical ventilation will depend on several factors:

- Volume of air required
- Quality of air required
- Consistency of control required
- Separation from external or local environment
- Cost of system

- To be continued in air conditioning systems….