International Journal of Architecture and Urban Development
Vol. 8, No.4 , Autumn 2018

Providing Design Strategies for Ventilation System in Treatment Environments (Proposed Sample: Hybrid Ventilation System in Hospitals)

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Recieved 30.01.2018 ; Accepted 05.02.2018

ABStRACT: One of basic principles in designing treatment environments is to design air conditioning/ ventilation system proportionate to environment. Essentially, appropriate air conditioner in treatment spaces must bear the following capabilities: providing healthy and clean air, reducing the concentration of pollutants produced in the atmosphere, emission of pollutants and impeding their spread in exterior space. Due to significance of the foregoing items in designing treatment spaces, in this research which has been conducted by descriptive-analytic method and using library studies, examination of hybrid ventilation system in treatment environments have been dealt with. Designing air conditioners in hospitals include ventilation design methods in form of natural/passive, mechanical, and hybrid ventilation systems. In this research, innovative design approach of hybrid ventilation system of hospitals have been introduced; having studied architecture of Iranian windtowers and greenhouse behavior of building façade and advantages and disadvantages of this system and superiority of the proposed system have been addressed. The system will be designed by using triple-walled shell (for the purpose of heating in winter season and airflow circulation in summer season) and cooling tower (plan design by viewing a vertical space in overall volume of the project and having direct access to AHU Rooms) A considerable advantage of this method is to reduce amount of energy consumption and subsequently decreased suction fan rotation period in cooling tower system as well as energy consumption reduction for heating air via fancoil.

Keywords: *Treatment Environments, Hybrid Ventilation, Triple-Walled Shell, Cooling Tower.*

INTRODUCTION

Due to the usage of hospitals and presence of patients in such spaces, it is essential that they have an optimal indoor air quality and an appropriate volume of contamination-free air be supplied into the building through air conditioning systems to replace the existing air. This requires the continuous performance of ventilation systems and their maximum functional power. Hence, air conditioners need to be designed in such a way that the best air quality is yielded inside the building through minimum energy consumption. There are different methods for designing air conditioning systems. In this article, we dealt with the examination of hybrid ventilation system in hospitals. Initially, the significance of design of air conditioning systems in hospitals was addressed. Then, the principles of designing such systems were examined, and finally, a new hybrid ventilation system for hospitals was introduced and the advantages and disadvantages of this system over the existing systems were analyzed.

Significance of Quality of Ventilation Systems in Designing Hospitals

Hospitals are the most important units of the state treatment networks that render health care services each comprising at least 32 beds for patients (Resources Development and Management Department of Ministry of Health and Medical Education,Vol.10, 2013). Due to the complex and various functions of their spaces, planning and designing hospital structures require special knowledge)Strategic planning and supervising of the presidential office, 2009).

The significance of indoor environmental quality index (IEQ)

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in designing hospitals is an important point in the design of green hospitals. The Reduction of treatment period is one of the golden aims of green hospitals. Indoor air quality and the function of cooling and heating systems and ventilation systems are considered as the quantitative dimensions of interior features which are effective in obtaining scores in this section because thermal comfort has positive impact on patients' statuses and their improvement (Mofidi et al., 2011). The impact of the ideal environment of a hospital over interactive mental system, decline of environmental stresses and consequently, the brain's order to focus on cure will lead to the reduction of treatment duration. Distractibility is another factor that lessens the concentration of patients on pain in hospital (Shakouri, 2011).

MATERIALS AND METHODS

In this research which has been conducted by descriptive-analytic method and using library studies, we initially dealt with the importance of ventilation system quality in designing treatment environments by studying the existing library resources and then the procedure of designing ventilation and temperature control systems in hospitals was examined and the key points in design methods were drawn. Next, advantages and disadvantages of ventilation systems were analyzed in form of inductive and deductive reasoning. Ultimately, an innovative plan for the purpose of designing hybrid ventilation system has been presented to be used in hospital spaces by studying and investigating the foregoing items.

Design of Ventilation and Temperature Control Systems In Hospitals

Ventilation is a typical method to dilute and eliminate the pollutants from contaminated environments by means of exterior clean air or returning the air that has been purified properly (Behrouzi, 2002). The design of thermal installations, air replacement, and ventilation for the environments of hospital wards must be carried out in compliance with the factors affecting the provision of comfort to patients and personnel as well as with the environmental health, and the people's social and economic status in the location where the hospital is established (Resources Development and Management Department of Ministry of Health and Medical Education,Vol.10, 2013). In designing air conditioning systems and calculating the capacity and type of materials, the conditions of the intended climate need to be considered (Resources Development and Management Department of Ministry of Health and Medical Education n, Vol.10, 2013). This system results in the decrease of the required energy for heating and cooling. In the air conditioning method, the electric power which is needed for handling ambient air, rate of outdoor air exchange, settings and usage of ventilation system, size and length of duct system (the higher the speed of air, the less the pressure), and the outdoor climate conditions depend on the type of the used ventilation system (central, semi-central, or non-central ventilation system) (Bauer et al., 2015).

The table below illustrates the tips that need to be addressed in a ventilation system in order to maintain the quality of indoor environments. (Tabel 1)

Effective Factors In Designing Ventilation And Temperature Control Systems In Hospitals

Outdoor air conditions (hospital outdoor climate) and indoor air conditions:

Indoor and outdoor air conditions have been identified considering the reference book "Standard and General Requirements in Designing Safe Hospital" and also Issue 271 for Iranian cities. Designing conditions for air conditioning calculations depend on 1.dry temperature, 2. relative humidity,

Table 1:Top tips in designing ventilation systems (Bauer et al., 2015)

System Function or Performance	Fundamental Tips
Dilution by Using Outdoor Air	- Minimum air volume per hour must be supplied in terms of occupants. - The purpose should be refreshing the indoor air volume several times per hour. - The required air volume should be enhanced given the pollution resources increase. - In places where pollution-generating activities are performed, air exhaust must be done directly.
Air Intakes/Inlets	- Avoid from putting air intakes in proximity of contamination resources. - They should be kept away from places adjacent to stagnant water arising from cooling towers. - Prevent from entering animals and settling and nesting birds close to air intakes.
Air Exhaust/Vent Outlets	- Air exhaust outlets must be away from air intake inlets as much as possible and must have much more height. - Direction of these outlets must be against direction of air intake hoods. Air filtration and clearing.
Air Filtration and Clearing	- Mechanical and electrical filters should be used. - A system need to be installed for the purpose of omitting pollutants chemically. Microbiological control.
Microbiological Control	- Abstain from putting any kinds of porous material in direct contact with airflows. - If condensation occurs inside air conditioner, it should be prevented from gathering stagnant water.
Air Distribution	- Abstain from creation of idle space which does not bear ventilation. - It is better to mix indoor air with outdoor air in places where people reside. - Sufficient pressure in that place must be maintained according to the activity performed. - Air supply and exhaust systems must be controlled and balanced.

3.air replacement, 4. relative pressures, 5. air purification, 6. inappropriate noise level, and 7. lighting times respectively (Resources Development and Management Department of Ministry of Health and Medical Education,Vol.10, 2013).

Air temperature and moisture:

Air control is essential for protecting the tranquility and comfort of patients and staff against cold and hot weathers and it is necessary to control humidity for providing comfort and precluding much dryness or moisture which enhances the possibility of spreading infection (Resources Development and Management Department of Ministry of Health and Medical Education, Vol.10, 2013).

Air replacement: hospital spaces that need permanent air exhaust include:

1(Bathrooms and toilets within wards, 2(Isolation room pre-entrances, 3(Unclean workplaces, 4(Garbage collection rooms and laundry rooms, 5(Cleaning rooms, 6(Unclean room pre-entrances (Resources Development and Management Department of Ministry of Health and Medical Education, Vol.1, 2013). Furthermore, the ventilation of isolation rooms of wards must be carried out independently and separately and the exhaust outlets in unclean areas must be must be placed in the most contaminated part of the rooms and the most distant location from air inlet (Resources Development and Management Department of Ministry of Health and Medical Education, Vol.1, 2013).

Relative Pressures

Controlling relative pressures means that air pressure in rooms and stairways should be adjusted proportionately so that the indoor airflow is directed from clean sections to unclean sections. The minimum pressure difference should be 2.5 Pascal. Plus, it is required that the air pressure in internal surgery hospitalization ward be positive in proportion to the pressure in the adjacent spaces. The air pressure of cleaning and hygienic environments (bathrooms, cleaning rooms, etc.) in internal hospitalization wards/general surgery units should be negative towards the pressure in the adjacent areas (Resources Development and Management Department of Ministry of Health and Medical Education, Vol.10, 2013). It is necessary to create a pre-entrance between stairways and isolation hospitalization rooms in internal wards/general surgery wards to control the spread of pollution from isolation rooms to the ward's stairways and also from stairways to the rooms, and the pre-entrance environmental air pressure should be kept negative towards the rooms (Resources Development and Management Department of Ministry of Health and Medical Education,Vol.1, 2013).

Air Purification:

Spaces of examination and treatment rooms, medication and cleaning rooms, isolation rooms, clean bedsheets and laundries storage rooms need to be controlled against pollution and infection by means of installing anti-bacterial filters for air purification (Resources Development and Management Department of Ministry of Health and Medical Education,Vol.1, 2013).

Types of Ventilation Systems

Three basic modes used for hospital ventilation are as follows: natural ventilation, mechanical ventilation, and hybrid (mixed-mode) ventilation. Hybrid ventilation method is a combination of natural and mechanical ventilation methods. The following parts deal with the introduction of hybrid ventilation system.

Hybrid (Mixed-Mode) Ventilation

Hybrid ventilation system uses mechanical and natural ventilation systems and provides an opportunity for the selection of the best ventilation method based on the conditions. In hybrid (mixed-mode) ventilation system, natural and mechanical ventilations (fan) are used for the purpose of supplying the required airflow. You can see the schematic diagram of all kinds of hybrid ventilation methods used in hospitals below. On occasions that natural ventilation is not solely appropriate, fans with proper power can be utilized to increase ventilation rate in rooms. These fans should be mounted in such a manner that room air is directly let out through walls or ceiling. Number and size of these fans depend on the intended ventilation and their powers should be checked prior to usage (Work And Environment Health Center, Institute of the Environment, 2014).

RESULTS AND DISCUSSION

Given the conducted researches and examination of the existing ventilation systems in treatment environments, we present hybrid ventilation system as a system which bears more advantages as analogous to other systems. Actually, the two following innovative methods may be introduced for the improvement of ventilation in hospital and the reduction of energy consumption.

Using triple-walled shells: Using triple-walled shells is effective for heating in wintertime and hence causing airflow recirculation in summertime. In winter, it functions via greenhouse process so that sun rays pass through the first façade wall (glass) with a specific wave length and then its wave length changes and is stuck in the middle space. Then, at night and when air temperature declines, the stuck heat enters the room by opening air vents mounted in interior shell. Furthermore, in spaces that ventilation should not be performed naturally for preventing the penetration of microbes and bacteria, an outlet for the suction of hot air is made to enter it into the air handling unit (AHU) which is suctioned because the weather is hot and in the stage of passing through warm coil for providing suitable heat to the environment, the warm coil needs less energy. The above-mentioned outlet should be installed on the second shell between structural ceiling and dropped ceiling through which facility systems are passed.

Using cooling tower: In this method, we start to draw up the plan of floors by viewing a vertical space in the overall volume of the project, with perpendicular floors that all have direct access to the air handling unit (AHU). The air existing in the higher part that has proper speed and low temperature enters through cooling tower and moves the mounted energy-saving wind turbine and saves kinetic energy in form of electrical energy (For supplying the electricity required for movement of fan in air handling units (AHUs)). The temperature of the entered airflow reduces after coming into contact with water surface and enters air handling unit via installed vents, and

Table 2 : Advantages and disadvantages of ventilation systems

	Mechanical ventilation	Natural ventilation	Hybrid ventilation
Advantages	Suitable for any types of weather and seasonal change	Suitable for hot and moderate weather	Suitable for most of weather conditions and seasonal change
	Creation of pleasant environment (more comfortable) and more controlled	Lower costs of investment, operation and maintenance	Energy saving
	A limited area of environmental elements is controlled by occupants.	Capability of supplying great deal of ventilation	High flexibility
		A great deal of environmental factors can be controlled by occupants.	
Disadvantages	High costs of installation and maintenance	Highly influenced by outdoor weather as well as performance of occupants.	Probably expensive
	Incapable of distributing the required air from exterior to interior wards of hospital on some occasions	Difficult to predict, analyze, and design	Probably more difficult to be designed
	Potential factor of noise making	Reduces comfort in hot, humid or cold climates	
		Incapability of creating negative pressure in isolation rooms which may be possible by correct design.	
		Noise may be entered from exterior building given the hospital's situation.	
		Using high-tech natural ventilation has some limitations and disadvantages of mechanical ventilation.	

passes through the filters and gets the cooled or heated phases and in case of contact with water surface in coils stage, it needs less coldness in summer and as a result, less energy consumption by cold coil. On the other hand, the AHU function is to absorb air from outside of building via suction fan and push it into the interior canal after passing through different stages, and there is need for fan rotation with a specific period, and we reduced the first fan rotation (suction fan) by raising airflow and air recirculation and consequently we decreased energy consumption.

The Advantages And Disadvantages Of Hybrid Ventilation System Over Other Ventilation Systems

After ventilation systems were studied, the advantages and disadvantages of hybrid ventilation system over other ventilation systems were addressed.(Tabel 2)

CONCLUSION

Designing air conditioning systems for hospital usage must be carried out by observing the effective factors in providing comfort to the patients and personnel as well as environmental health, climate of building area, technical facilities, technology level, flexibility, etc.

Three principal methods of designing ventilation include natural, mechanical and hybrid ventilation systems. In this study, two methods have been proposed for hybrid ventilation. 1. Triple-walled shell: it is useful for heating in wintertime and thus leading to recirculation in summertime. 2. Using cooling tower: in this method, building plan is drawn up by considering a vertical space in the overall volume of the project in which all floors are in the same vertical line and have direct access to AHUs and we declined suction fan rotation period by using fan and raising airflow and recirculation and as a result, we reduced energy consumption. The proposed methods enjoy capabilities such as applicability to most climate conditions, high flexibility, and energy saving.

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