Javanese House’s Roof (Joglo) with the Opening as a Cooling Energy Provider

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Abstract. Natural ventilation and air movement could be considered under the heading structural controls as it does not rely on any form of energy supply or mechanical installation but due to its importance for human comfort, it deserves a separate section. Air infiltration can destroy the performance of ventilation systems. Good ventilation design combined with optimum air tightness is needed to ensure energy efficient ventilation. Ultimately, ventilation needs depend on occupancy pattern and building use. A full cost and energy analysis is therefore needed to select an optimum ventilation strategy. The contains of paper is about the element of Javanese house (the roof) as the element of natural ventilation and a cooling energy provider. In this research, the Computational Fluid Dynamics Program, is used to draw and analysis. That tool can be track the pattern and the direction of movement of air also the air velocity in the object of ventilation of the roof Javanese house based. Finally, the ventilation of the roof of this Javanese house can add the velocity of air at indoor, average 0.4 m/s and give the effect of cooling, average 0.7°C.

1. Introduction

Roof is an important component that determines whether the space within the building on the right floor under the roof will be hot or not. Heat derived from the first solar radiation fell on the roof. Heat radiation from the sun is reflected in part, partially absorbed by a roof covering layer like a tile that will then be irradiated back into the outside air and the other is passed downward into the building. Absorption of perspiration and cool the body directly by convection across the skin and body are result performance of natural ventilation in buildings. The air flow must be directed towards the “living” or occupied zones of a building. Air exchange may be done with some air velocity, but generally, low-velocity mechanical system designs have little direct effect on the human physiological cooling system to Transperspiration. Openings in a building can be manipulated to increase or decrease the speed of the air movement. Often considered part of “design of bioclimatic,” natural ventilation is effective for cooling buildings that are properly shaded and otherwise designed to suit local climatic conditions, such as air and earth temperatures, relative humidity, daily and seasonal wind and breeze direction. Building types and in many location, these climatic design elements can provide the principal source of cooling comfort in buildings. Javanese traditional house has specific characteristics as an identity. That image can be used as range of design simulation for obtaining ventilation and thermal performance optimization. It must be done on that range, so the simulation design cannot ignore traditional image. Base on the traditional
element study (Wonorahardjo, 2000), the element of the traditional house which potential for ventilating optimization is building roof. These 3 (three) elements affect the amount of global solar radiation/global irradiance (w/m²). In addition, there are 2 (two) elements that have an influence on the amount of heat resistance, the type of roof covering materials and design of the roof space, with and without the ventilation.

The description of the selection of objects and background underlying this research, supported by research conducted by Satwiko (2005) that reviews the basic theories used and the potential of the object you want selected and the presence of an opportunity that will be achieved, associated with wind movement patterns within and outside the building which has implications for thermal condition of the building.

2. Review of theories
Determine a configuration of the openings, variations in natural ventilation in general depend on use of driving force/driving force of the wind and temperature difference between the inside and the outside, although it is a variable, but will not produce the satisfactory design, it is without taking into consideration:

1. The dimensions of effective ventilation
2. Air temperature of indoor
3. The average air substitution in one hour (Liddament, 2007)

Regarding to the driving force of Straube (2007), also said the natural ventilation controlled by wind thermally, moving out pressure. The planning on natural ventilation strongly influenced by this force respect to size and position openings. According to him, driving force is influenced by several elements, namely:

1. Pressure of the wind: The wind entered the building and induces a positive pressure on windward face and negative pressure in the opposite direction in the area woke up on the sides of buildings.
2. Pressure Stack or Air Temperature: Stack effect is built as a result of difference between the temperatures, hence air and water density, between inside and outside of the building. It is produce an imbalance in the pressure gradient of inside and outside of air masses which is the result in an outside vertical pressure which is the result in a vertical pressure difference. When the indoor temperature is greater than the outdoors,

![Figure 1. Wind pressure effect on representatives building](source: Straube, 2007)

The air passes through the openings at the lowest level of building, when the indoor air temperature is greater than outdoor and throughout the openings at the highest level. Humid tropical climate conditions that have temperatures and high humidity cause be the specific problem. The specific problems are overheating, where the conditions of outside of the building above the comfort air temperature is in need of the human. Minimizing the heat entering the building can be an effort to create passive cooling and also minimizing the impact of climate conditions that are less conducive is to realize the condition,
so some things to note are:

1. Break into the heat rate in space and the other word is minimize the heat into the building’s room
2. The wind flow performance taking into the building to remove accumulation of heat occurs.
   According Szokolay (1980), this system is passive cooling design strategy, most optimal in humid tropical climates, where is the potential temperature and high humidity.

The velocity of air is very important in cooling the people. Our body will take the faster air to move moisture and more heat by evaporation. By having a small inlet and a large opposite outlet inside the inlet, we can get maximum airspeed. The common and intuitive idea of placing windows to face the breeze doesn’t work best. The ratio of the inlet to outlet determines the speed of the airflow. If we have a small opening of inlet area, 0.09 sq. m and larger outlet area, 1.1 sq. m. We can produce a breeze that is fast enough. And if we put our exposure effects next to smaller holes, we will get a good cooling wind.

The outlet should be 10 percent larger than the inlet. While air velocity is important, the quantity of air moving through the interior (air change) is the most important factor, and it is achieved by the same inlets and outlets.

3. Result and Discussion

The pressure differences on exterior fenestration cause “surface vectors,” or currents that move along the surface of the building, seeking a way around or through. Projections on the fenestration—overhangs, louvers, and columns—can alter these pressure differences further and change the way the breeze is forced into the inlet. As the breeze starts to flow into the inlet, the way the inlet is designed will also affect the pattern the air takes. In a rectangular building with the inlet in the center of the windward fenestration, the air will tend to move straight through the opening. If the inlet is off-center, the breeze will tend to enter the opening and move off to one side. This happens because the air pressure on the exterior fenestration will be greater over the larger wall surface and smaller over the smaller wall surface, relative to the location of the opening. In the architectural design in the humid tropical climate region, with relatively high outside air temperature, the role of the roof to overcome the problem of solar heat coming from the top of the building becomes dominant. The roof covering of a relatively thin material such as the precarious will receive the sun's heat and in short time will channel into the space below it.

In some tropical region countries, “wind scoops” have been used for hundreds of years to induce natural interior ventilation. These wind scoops rise above the roofs of houses to create pressure areas that pull the air into downstairs rooms, either down the scoop when the wind blows from one direction, or into windows and out of the wind scoop when the prevailing wind is from opposite direction. Wind scoops do not push or force the air down the tower. Acting as Bernoulli’s theory describes, air movement into the interior is created by pressure differences that result from wind blowing over the Wind scoops and the building. A similar construction also used in tropical region to induce natural airflow is the “venting tower” (see Figure 2). Here, the tower rises above the building roof to interrupt the wind and create a low-pressure area, regardless of the direction of prevailing winds. The low pressure over this venting tower pulls air into the building from higher pressures below. This system may require opening of the lower windows toward a high-pressure area. If air moves by applying cross the ventilation system, it moves from the opening area on wall to the other side (horizontal movement) (E.Prianto, at al 2000).
The passive cooling is often required simply because a building’s unprotected window orientation or uninsulated roofs turn it into a “solar oven,” collecting more heat than is needed or tolerable. Natural ventilation can provide comfort in all seasons, especially in summer when it can reduce or eliminate the high air temperature in tropical climates (Szokolay, 1980). When temperatures and local breezes create comfort conditions outside, design that ignores its climatic context will result in a building that is both uncomfortable and waste energy.

The wind speed coming into the Joglo’s house through the roof openings, ranging from the 0.55 m/s, then fell at a speed of 0.45 m/s, with a value of 27.5% of the percentage of the amount of wind speeds in the Joglo’s house as a whole. And the wind flow inside the Joglo’s house, indicating the existence of the leeward on the outside of roof, with a speed of 0.25 m/s, or a difference of 0.65 m/s from the initial speed. The principles here are able to guide an architect to design a naturally ventilated building. When complex building forms are developed, the resulting pressure differences and air flow patterns will be difficult if not impossible to predict. The best approach is to test the proposed design with a scale model, introduced into a steady wind stream and analyzed with “smoke tracers” or other tell-tales. Best modeling results are achieved in a boundary-layer steady-flow wind tunnel as may be
available at research laboratories and universities. Research citations and design application guidelines can be found in the references.

Figure 4. 3D Picture of velocity of wind of Joglo’s house with opening the roof
Source: 3D picture of CFX-5

Figure 5. Velocity of wind of the Joglo’s house with opening of roof
Source: Analysis of 3D picture of CFX-5

4. Conclusion
An important removal mechanism for contaminants is called ventilation. By replacing the air in a space periodically, the contaminants generated in the space are kept to lower concentrations. One air exchange the supply of a volume of air equal to the volume of the space - will generally result in the removal of about two-thirds of the concentrations of the air contaminants. Thus, more than a single air. To reduce concentrations to near zero is need the exchange. Therefore, whenever contaminants are generated at a point source, such as an appliance or an activity of an occupant, it is most effective to apply exhaust ventilation at that point. This prevents the contaminant from mixing in the air generally in the space. The form of Joglo’s roof and its opening are capable of producing additional air velocity and capable of lowering the temperature in the room even though all the windows are closed. With a decrease in air temperature in the room the amount of energy used to it and will also reduced and that is mean the efficiency of energy used is increasing. According to Koenigsberger et.all (1973), to referring to the conditions contained in the laws of thermodynamics that the air flows from areas of high air pressure to areas of low air pressure.
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