

# Study of Air Flow on Natural Ventilation at Tawang Station Semarang

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## ABSTRACT

Tawang Station is a colonial building that still functions as it should, located in the city of Semarang. This building has wide and many openings to adapt to the local climate. The design of this building aims to achieve the comfort of the inner space. This study will examine air movement entry in a room with current climatic conditions. Data collection methods used are surveys, media, and related literature. After that, the data is processed by simulating the model with Autodesk Computational Fluid Dynamic (CFD) software. The analysis will show simulation air movement in the natural ventilation system in several sample rooms at Tawang Station. Then produce a description that is relevant to the theory. This simulation will prove that natural ventilation in each room is influenced by the direction of air movement, the surrounding atmosphere, and the placement of ventilation, which then also affects the comfort in the room.

**Keywords:** Air movement, Natural ventilation, CFD simulation.

## 1. INTRODUCTION

Indonesia has a humid tropical climate. This humid tropical climate is characterized by high humidity, high rainfall, high temperature and solar radiation [1,2]. If analyzed in the Olgyay theori diagram, the average city in Indonesia falls into a climate that requires wind movement. Therefore, air movement is one of the essential factors in designing a building that pays attention to the environment [3,4]. Air movement is obtained from a control system in the building. The ventilation in the design of a building is usually obtained from openings, such as windows, ventilation and doors. This concept is called passive design or natural ventilation system, then adapted by architecture in the colonial period to achieve comfort in space.

This ventilation is corroborated by the theory that colonial buildings in Indonesia have designs responsive to their tropical environment [5,6]. Several colonial buildings have wide openings on each side and high ceilings that respond to the climate and environment. One example is in the Old City of Semarang, namely Tawang Station. Tawang Station is a colonial building that still functions as it should. This station has the same design and has not changed much. Based on the survey,

the Tawang station still uses natural ventilation in public zones, such as waiting rooms and gift shops. The Tawang building has many openings on each side [7].

While ventilation with a mechanical system is a fan, exhaust-fan Air Conditioner (AC), and so on. In today's buildings, natural ventilation is less considered than mechanical ventilation in its design [8]. This ventilation also occurs in building designs that cannot adapt to the climate significantly, such as in private zones such as offices and VIP waiting rooms at Tawang Station, where an additional air conditioner (AC) is used. The use of air conditioning creates comfort in the room but provides heat to the environment [9,10]. However, it needs to be reconsidered because the design of the Tawang Station building must pay attention to the environment that utilizes a natural ventilation system that has been designed.

Therefore, in this study, we will examine air movement in the Tawang Station space, especially by utilizing natural ventilation using CFD simulation. This simulation will obtain the direction of the wind and the speed of the wind moving in the room at Tawang Station by using several samples of the room, which are divided based on zoning and function. Then the results

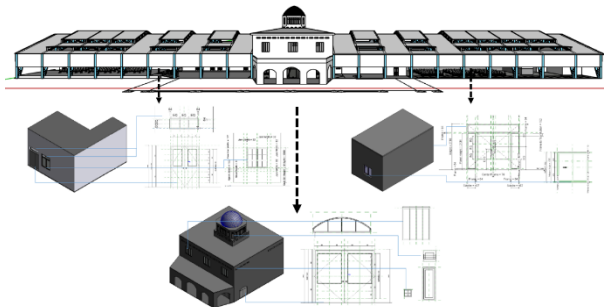
of this research are expected to be the basis for developing designs at Tawang Station and other Colonial Buildings in terms of the use of natural ventilation.

## 2. METHODS

This study uses quantitative methods. Where data is obtained from a sample room selected based on the division of zones and their functions, among others, in the following table 1:

**Table 1.** Zoning of sample room by functions

Zone	Room	Code
Privat	Office	A
Public	Waiting Room Hall	B
Semi Public	Souvenir shop	C



**Figure 1** 3D modelling revit of Tawang station.

The first data was obtained from a direct survey in the case study. The data taken include wind movement, openings in the room, and the room area. Then the data is calculated, which focuses on the ventilation.

Next, the sample room is modeled using Revit Autodesk (See Figure 1) and analyzed using Autodesk CFD. In Autodesk CFD, the model will be set material, temperature, air movement, and so on. Furthermore, the software will process and produce a visualization of the direction of the wind in space. The results of the simulation will provide an analysis based on the theory.

## 3. RESULTS AND DISCUSSION

The simulation was carried out using Autodesk CFD 2017 software using modeling using Autodesk Revit 2017 software. In this simulation, there are three spaces from the three-zone divisions. Zone A is the office room; zone B is the Hall room, and zone C is the souvenir shop. The whole room uses natural ventilation, using the door, window, Boven, and ventilation openings on the ceiling.

Before being simulated, input material on the exported model in CFD. Overall building materials adapted to the existing conditions of the room. The walls use brick material, the ceiling uses gypsum board,

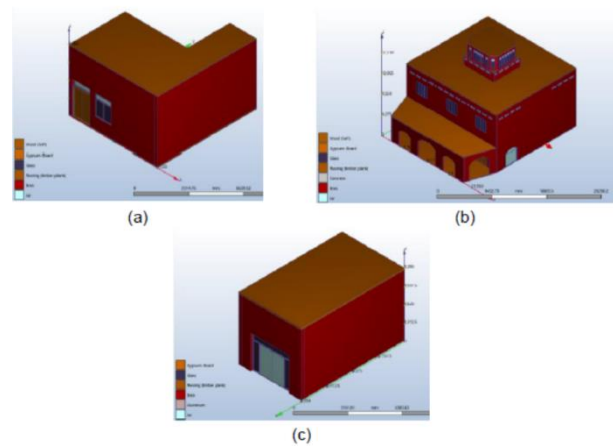
the floor uses flooring, the door frames use wood and aluminum, and the openings are conditioned using air material. This building material is determined to know the material properties in detail, including density, emissivity, transmissivity, and so on.

The settings needed for this condition are Volume Flow rate, Velocity, Temperature, Pressure, Film Coefficient. The following are the settings for the inlet, outlet, and building envelope (See Figure 2).

The settings at the inlet are as follows:

- The intake air temperature has an average of 30-35 degrees Celsius.
- Volume Flow rate is the standard air movement, according to ASHRAE Standard 62-2001 for classrooms and office buildings 15.4 m<sup>3</sup>/min.
- Normal velocity is 2 m/s.

The setting on the outlet is Pressure is the pressure at the input outlet opening is 0.

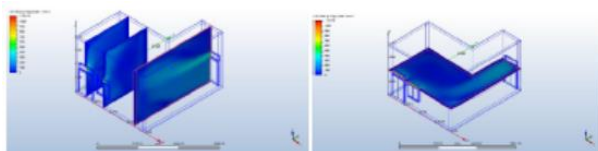


**Figure 2** 3D simulation CFD setting for sample rooms.

Setting the Ambience Condition is to select all surfaces than the Film Coefficient of 5 W/m<sup>2</sup>/K for still air and 20 W/m<sup>2</sup>/K for moving air. In comparison, the air temperature follows the surrounding air, 37 degrees Celsius. The film coefficient in the CFD simulation is the same as Convection; this is the value to determine the heat transfer of the entire building envelope.

### 3.1. Zone A Office

The Axonometric model of air movement in a room has an average speed of 100 mm/s. This simulation is visualized on a dark blue color scale. In the area around the outlet, it has a rate of 700-1000 mm/s, which is pictured in green and red scales.



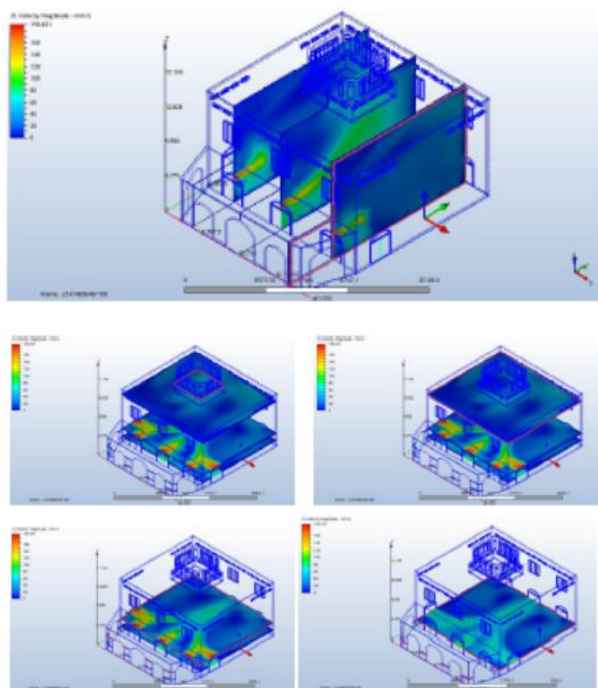
**Figure 3** Simulation results on zone A.

From the simulation result, the office room shows that the movement of air in the room can spread (See Figure 3). However, from the vertical image, it can be identified that the air movement vector leads from the inlet (opening towards the platform) to the outlet (opening in the direction of the waiting room). The speed of air movement is pretty even, between 100-200 mm/s, except in the inlet area, which is 400 mm/s, which is the area where the air movement enters.

After that, the air velocity increases at the proper outlet area as the air moves outward. This velocity is because the outlet area is smaller, the room's design has an L shape, the opening does not have cross-ventilation, and other openings such as doors do not work because they are permanently closed. Therefore, the movement of air in this room is slow.

### 3.2. Zone B Hall Waiting Room

An axonometric model of the behavior of air movement in a room moving with an average speed of 120 mm/s on a light green and turquoise color scale. The inlet area moves at a rate of 100-190 mm/s, visualized with a green and red color scale.



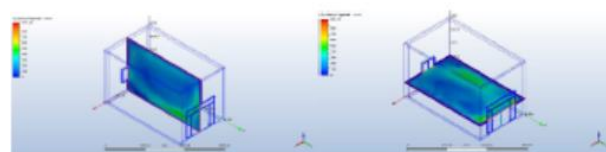
**Figure 4** Simulation result on zone B.

From the simulation, it can be identified that the air movement in the room is well spread (See Figure 4). The resulting indoor air velocity is quite variable, and the indoor average is 60-120 mm/s. The inlet area has the fastest air movement, which is up to 190 mm/s, while the outlet area is relatively evenly distributed, which is 60 mm/s.

The image shows that the air movement moves from the inlet direction (the area near the drop off) to the outlet (the opening in the ceiling and the opening towards the platform). There is a lot of air entering this room. This movement is because this space is quite spacious and has a high ceiling distance. In addition, this room has a good cross ventilation system. The openings in this room are also used optimally.

### 3.3. Zone C Hall Waiting Room

The axonometric model of air movement behavior in the souvenir shop room has an average speed of 300 mm/s, which is visualized with a turquoise color scale. In the area around the inlet and outlet, the rate is 500 - 700 mm/s in green and orange color scale.



**Figure 5** Simulation result on zone C.

The simulation results show that the air movement in the room is relatively evenly distributed (See Figure 5). The image of the section can be identified as the movement of air from the inlet (opening towards the platform) to the outlet (opening in the direction of the waiting room). The resulting air velocity in the room is 300-600 mm/s. The area around the inlet and outlet has strong winds of up to 700 mm/s.

In both areas, as the air inlet and outlet areas, the value of air movement entering this room is relatively high. This movement is because this room has good cross-ventilation, and the openings in this room are also used optimally.

The Autodesk CFD program is beneficial in knowing the movement of the wind, especially in the indoor space of the building, using both natural and artificial ventilation in more detail. Several rooms at Tawang Station are currently using artificial ventilation. Overall, the air movement in each room is pretty even and spread out, but the value of the movement is very slow. The air spreads evenly only in the waiting room (zone B). This is because it has more openings compared to other rooms. In addition, the placement of the inlet and outlet positions is appropriate so that it helps the movement of air around the room.

#### 4. CONCLUSION

The overall picture of air movement at Tawang Station in each room is pretty even and spread out, but the value of movement is very small. The air distribution is quite good only in the waiting room (zone B) because the openings are more than in other rooms. Meanwhile, the low air velocity value in the office space is due to the shape of the room, which has an L shape, and air movement cannot cross.

The three simulations of the samples for each zone have proven the description of air movement patterns that affect wind conditions in the main building of Tawang Station. The CFD simulation shows the number of openings in the room (in the waiting room/hall) which results in the rapid entry of air because the placement of the proper inlet and outlet positions can help air movement around the room can be spread evenly in the room.

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