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Optimization of Air Circulation through the Design of the Building Sheath in the Soaking Room of Pemandian Air Panas Bayanan, Sragen

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ABSTRACT
Air circulation is an aspect that must be considered as part of the principles in architectural design. Hot spring soaking room is a typology of the building that must pay attention to air circulation to maintain the temperature of hot springs and air movement in the room so that it can support the benefits of hot water soaking for its users. Pemandian Air Panas Bayanan, Sragen is one of the tourist attractions with the main attraction in hot spring rooms. Judging from the orientation and dimensions of openings on the building sheath, the current soaking room is not optimal in air circulation because it only has openings on two sides with an opening area of <20% of the room area. This research aims to find out the effectiveness of building sheath opening design against the optimization of air circulation or space conditioning. This study uses quantitative methods in the form of simulation software SimScale to identify the quality of air circulation or air conditioning in existing soaking rooms. The results of the simulation showed that the current hot spring soaking room is not by the standards of air circulation in the room. This became the basis for determining the alternative design of the soaking room through opening elements and shading on the building sheath.

Keywords: *Soaking room, Air circulation, Computer simulation.*

1. INTRODUCTION

Bayanan Hot Spring is one of the leading natural attractions in the Sragen Regency. Having natural hot springs as the main potential and tourist attraction that contains sulfur with a temperature of 33ºC-35ºC on the surface of the water has many health benefits. So, the circulation and distribution of air in the soaking room need to be considered to support the functions and benefits for users. The parameters of indoor air that are considered are the distribution of temperature, humidity, and air velocity. The selected airspeed is closely related to the amount of air circulation in meeting occupant comfort. While the outside air parameters that affect the system are temperature, humidity, direction, and speed [1]. Natural ventilation is the process of changing room air with fresh air from outside without involving mechanical equipment. Natural ventilation aims to provide fresh air into the room for the health of its users because it can reduce pollution levels in the air, help create thermal comfort for residents, help passively cool buildings, and save energy used in buildings [2]. Air infiltration with a natural ventilation system can be used to increase thermal comfort in spaces within the building [3].

Ventilation is defined as the exchange of air inside the building with the air outside the building. To achieve the desired replacement process, the building must have adequate ventilation holes in terms of sufficient dimensions, located in a windward position, and the shape or design is appropriate [4]. If a building gets a position that is not in the direction of the leeward wind, then additional elements in the window that allow wind direction deflection need to be considered [5].

Opening of the building greatly influences the effort to use the wind in air conditioning. The size of the opening can be adjusted according to the need for wind flow. The speed of airflow becomes larger when the air inlet (inlet) is smaller than the outlet [6].

Studied the ventilation performance of the Dupak Bangunrejo flat in Surabaya, with parameters of airflow rate and air change (ACH). The results show that the design of the opening needs to pay attention to the inlet and outlet because if the ACH is low, the internal air velocity will be low and thermal comfort is not met [4].

Substitution air per hour (ACH, Air Change per Hour) is the number of changes in all indoor air with fresh air from outside every hour.

Existing simulation results in openings and analysis of ACH numbers are carried out and see the results, if they do not meet the standards, an alternative design is needed by adding and/or expanding openings and including them again in the simulation program. Back to doing the Number of Exchange per Hour (ACH) analysis on the modified openings of alternative designs in the room so that they can determine the dimensions and orientation of the Bayanan hot spring bathing bath openings.

To meet the health requirements, a room must have ventilation of at least 5% of the room area and windows of 20% of the floor area as in the minimum requirements for SNI from the Ministry of Public Works to fulfill the function of openings for Health [7]. In the Bayanan Hot Springs bath, the window area is < 20% of the floor area of the room. This results in the air not being able to move properly so it feels stuffy [8,9].

Judging from the layout of the room there is only a bathtub in each soaking room at the Bayanan Hot Springs and it is not by the criteria (comfort standards) Minister of Tourism Regulation No. 27 of 2015 concerning The Standards of Natural Hot Spring Treatment [9].

The purpose of this study was to determine the effectiveness of the design of openings (inlets and outlets) in the building envelope on the optimization of air circulation, taking into account:

- Orientation of openings on the south and north sides (according to the wind direction at the site) and making openings more than 20% of the floor area.
- Make a floor plan of a soaking room according to the function based on the Regulation of the Minister of Tourism of the Republic of Indonesia Number 27/2015.
- Make design modeling and check air movement and circulation using web *SimScale.*

2. METHODS

2.1. Data to Collect

Hot Spring is located in Jambeyan village, Sambiejo sub- district, Sragen Regency. Located on the slopes of Mount Lawu with climatic conditions at site temperature 24ºC-32ºC, wind speed 1 m²/s - 3 m²/s, and humidity 63%-71%. Take advantage of the valley wind that moves from the north to the south (the location is north of Mount Lawu).

Things that must be considered to get optimal air circulation in the bathing room are the direction and distribution of air, the ratio of openings, Air Change per Hour. Making modeling of existing soaking rooms and alternative designs of soaking rooms using SketchUp, then simulating using web SimScale to find out the direction, distribution, and speed of air in the room. Air Change per Hour.

To find out the distribution pattern, a simulation method will be carried out using SimScale web software. In general, the stages in this simulation among others, pre-processing; entering several variables needed so that they are ready for processing (processing) which then results in the value of the exhaust gas content being analyzed [10].

2.2. Data Processing and Analysis Instrument

Making an alternative design of the bathing room plan by adding the functions of the rinsing room, dressing room, dressing room, and bath. Change the direction and dimensions of the opening according to the wind direction at the site. Then compare the existing design with alternative design A and alternative design B. The difference between alternative designs A and B is the floor plan (space area) and opening size (same opening orientation) (Figure 1 and 2).

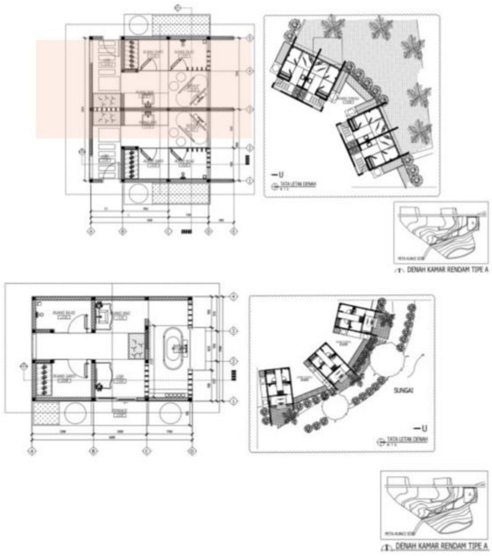


Figure 1 Soaking room plan types A and B.

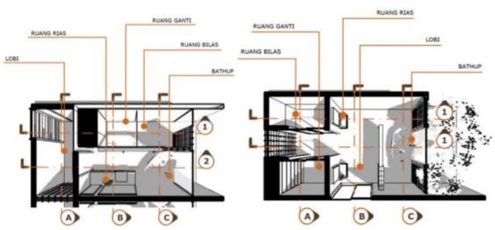


Figure 2 Wind distribution pieces soak room types A and B.

Determine the x-axis (a, b, and c) and y-axis sections (1 and 2) on the plan to see a graph of the wind distribution in each room in the bathing room.

Analysis of the instruments used include:

- The opening ratio is more than 20%of the floor area.
- Make a floor plan design that meets the criteria for hot water baths by the Regulation of the Minister of Tourism of the Republic of Indonesia Number 27/2015.
- The ACH number is SNI 03-6572-2001, **which is 10 for ACH in the bathroom**.

The analysis process uses a web SimScale by paying attention to the results of air distribution, wind direction, and speed on the existing 3D modeling with alternative 3D modeling A and B. Then compares the ACH results from the three with the ACH SNI numbers 03-6572-2001.

3. RESULTS AND DISCUSSION

Checking ACH on existing buildings using the ACH formula where the higher the ACH value, the higher the wind speed in the room. The volume also affects, the greater the volume, the more air is stored in the space and the air velocity will be greater. The cross-sectional area of the opening also plays an important role in manipulating the internal wind speed. With the ACH formula as follows:

$$ACH = \frac{Q}{V} \times 3600 \qquad (1)$$

Q = 0.025 x A x v

Q = natural ventilation rate (m^3/s) V = room volume (m^3)

A = opening area (m^2)

v = wind speed at opening (m/s) and 0.025 is a multiplier

Figure 3 3D Modeling of an existing.

Here is a 3D modeling of an existing building with a floor area of 3m x 3m and a building height of 3m, so the volume of the building is 9m³ (Figure 3). There are openings on the front side with a total area of 0.45 m² and rear openings with a total area of 0.60 m². The minimum opening area is 20% of the floor area, which is **1.80 m²**, while the total opening for the existing building is **1.05 m²** (< 20% of the floor area).

There are no walls in the Bayanan hot spring bathroom (only a bathtub). SimScale simulation results on 3D modeling of existing buildings look like the picture below with an average wind speed of 1.353 m/s, a maximum speed of 5.196 m/s, and a minimum speed of 0 m/s (Figure 4). Judging from the picture, the wind distribution with maximum speed is only near the opening and the minimum speed in the part that is not close to the opening makes it difficult for air to move.

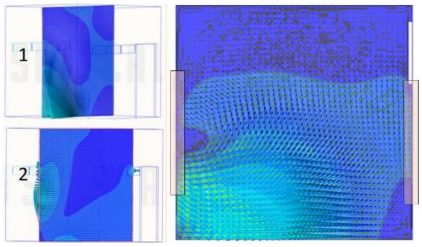


Figure 4 Simulation 3D modeling of an existing.

3.1. Alternative Design of Type A

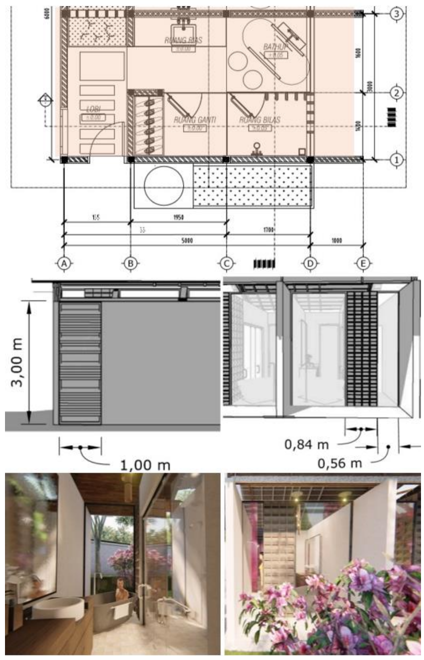


Figure 5 3D modelling alternative A.

Soaking room Type A is a smaller unit than the soaking room Type B with 2 soaking rooms in one building. The ventilation of each soaking room comes from the roof gap and 2 openings. The opening vast northern side of 2.52 m² and wide openings on the south side is 3 m². With a total area of openings is 5,52 m² more than 20% of the floor (15 m²) where the floor area is 3 m² (Figure 5).

3.2. Alternative Design of Type B

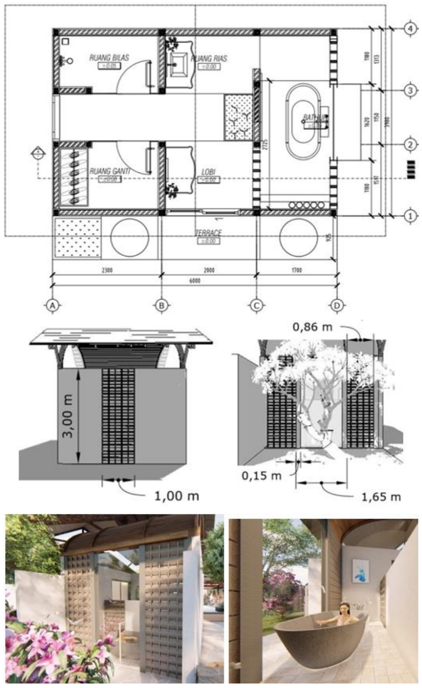


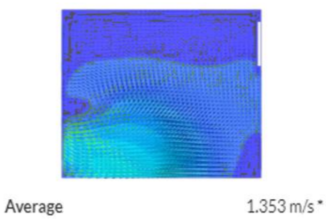
Figure 6 3D modelling alternative B.

Bathroom Type B is a larger unit with one-bedroom units to soak in one building with an area building 24 m². The ventilation of the Type B wading room comes from the roof gap and 2 openings. The area of the opening on the north side is 5.16 m² and the area of the opening on the south side is 3 m². With a total opening area of 8.16 m² which is more than 20% of the floor area (< 4.8 m²) (Figure 6).

3.3. ACH (Existing, Alternative A and B)

The results of ACH calculations on the existing 3D Modeling, alternative A and alternative B designs:

3.3.1. 3D Modelling Existing



Q = 0.025 x A x v

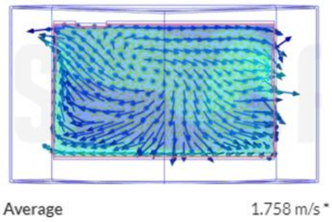
Q = 0.025 x 1.505 x 1.353

Q = 0.0355 m³/s

$$ACH = \frac{Q}{V} \times 3600$$

ACH = 4,73

3.3.2. 3D Modelling Alternative A



Q = 0.025 x A x v

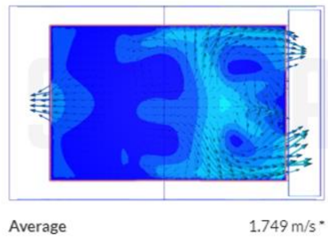
Q = 0.025 x 5.52 x 1.758 = 0.243 m³/s

$$ACH = \frac{Q}{V} \times 3600$$

ACH = 12,15

(close to standard bathroom ACH numbers 10)

3.3.3. 3D Modelling Alternative B



Q = 0.025 x A x v

Q = 0.025 x 8.16 x 1.749 = 0.357 m³/s

$$ACH = \frac{Q}{V} \times 3600$$

ACH = 11,27

(closest to standard bathroom ACH numbers)

3.3.4. Air Flow and Air Distribution

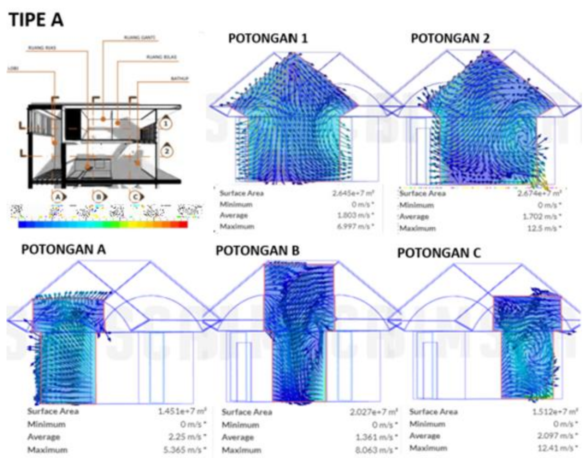


Figure 7 Simulation air flow and air distribution modelling alternative A.

The simulation results on the alternative type A design show that the wind can enter and exit well, which is indicated by blue-Tosca arrows which have an average speed of 1-2 m/s (Figure 7). In addition to the movement of air, it can also be seen that the wind can be spread evenly in every room because the room divider in the type A soaking room uses a roster and glass.

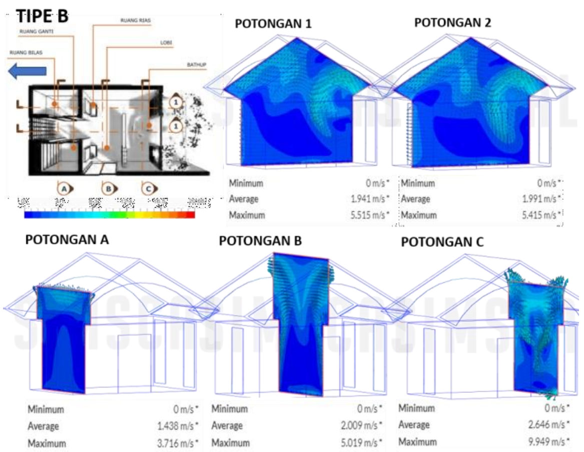
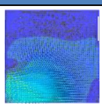
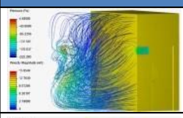
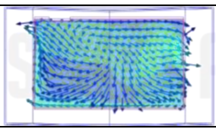
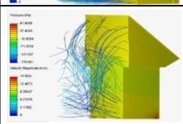
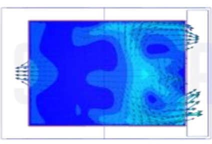
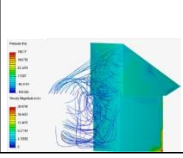


Figure 8 Simulation air flow and air distribution modelling alternative B.

The simulation results on the alternative type B design are that the wind can enter and exit well as seen from the blue- Tosca arrows of which have a speed of 1-2 m/s (Figure 8). However, the distribution of air in the dressing and rinse rooms is not as tight as the bath and dressing room areas, because there is a wall with a height of 3 m as a barrier.

3.3.5. Simulation Results

Table 1. Comparison of simulation results

Type	Air Flow	Air Distribution	ACH
Existing			4,73
A			12,15
B			11,27

In existing buildings, the air cannot flow in and out properly. In addition, the air also cannot be dispersed properly and the air velocity is uneven and relatively low. So that the air in the **room feels stuffy** (trapped air).

Type A has a narrower space with a smaller north side inlet compared to alternative B (Table 1). This causes the incoming wind speed to be faster and **the air to spread well in the type A** design layout. Due to the relatively high wind speed, the value of the ACH number in the type A soaking room is greater with a **value of 12,15.**

Type B has a wider floor plan and has a dividing wall in the shower room and dressing room. This causes dispersal of air with lower wind speeds in the shower and dressing rooms. Meanwhile, in the bath and make-up area, the air spreads at a higher wind speed. In addition, the inlet on the north side is wider than alternative A, so the wind speed is lower and the ACH value in the type B soaking room with a **value of 11.27 is the closest to the standard ACH** value for the bathroom, which is 10.

4. CONCLUSION

Air circulation in existing buildings is not optimal because air cannot enter and exit properly. After all, the openings are too small so that air is trapped in space (feels sucker). Air circulation on type A and B modeling can flow (in and out) according to the layout with wind speeds of 1,758 m/s and 1,740 m/s. The air distribution in type A and B modeling is evenly distributed with the intensity of wind speed affected by the dimensions of the inlet on the building (type A has smaller inlet dimensions so that the wind moves faster). ACH in type A and B modeling is close to SNI ACH, but ACH Type B with a value of 11.27 has only a difference of 1.27 from the ACH standard (closest to the standard ACH bathroom figure).

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