THE DESIGN STUDY OF MVAC FOR SUBTROPICAL COUNTRIES BADMINTON HALL: THE NUMERICAL APPROACH

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Graphical Abstract
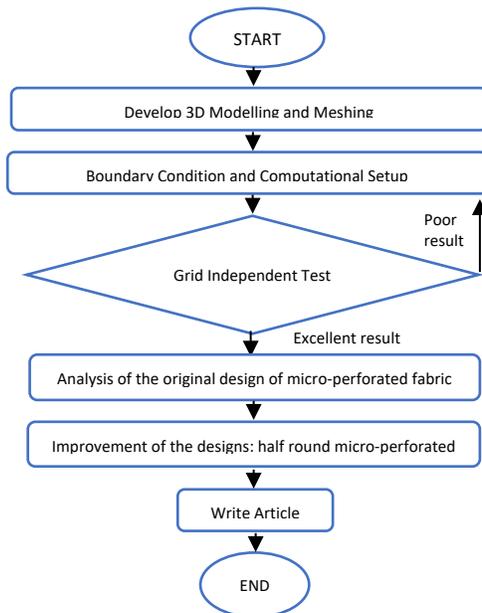
Abstract

The present paper describes the air velocity profile of MVAC using a micro-perforated fabric duct for badminton hall applications. The study has been conducted by FLUENT CFD code. The present simulation discusses the air velocity profile of the original design of the micro-perforated fabric duct and suggests the improvement of the design to fulfill BWF requirements. The flow regime was turbulent with incompressible flow since the air velocity was estimated very slow. The air ambient is set as 33°C and the wall heat convection was set as 3W/m²K. The result shows that the original design of MAVC was unable to fulfill BWF performance. Thus, the modified MVAC with the half-round micro-perforated fabric duct has been proposed. ACH also needs to be reduced. The result shows that the average plane air velocity at a height of 0.5m increases from 0.15m/s to 0.3m/s as ACH increases from 1.5 to 3.0. At the same plane height and ACH increment, the plane air temperature reduces to 22.7°C. The half-round micro-perforated fabric duct at Flow arrangement 1 for ACH of 2.5 shows the best MVAC design as it fulfills BWF requirements for air velocity and temperature.

Keywords: Badminton Hall; MVAC; Micro-perforated Fabric Ducting; BWF

1.0 INTRODUCTION

Thermal comfort and air velocity distribution inside the badminton court are two main characteristics in designing the MVAC of the badminton hall. Thermal comfort normally refers to the air temperature inside the building. The designer tried to reduce heat loss in order to reduce the cost of operation, especially electrical bills. The heat loss is normally related to the heat transfer mechanisms including conduction [1], convection [2], and radiation [3]. Therefore, all heat transfer mechanisms affect the building's room temperature. In badminton games, the Badminton World Federation (BWF) stated that the arena temperature must be between 18°C and 30°C [4]. However, the mean daily average maximum temperature is 33°C [5].

Therefore, the air conditioning system is employed to maintain comfortable indoor temperatures.

Since mechanical, ventilation, and air conditioning (MVAC) are involved in designing badminton halls, the air volumetric flow rate needs to be controlled in order to air velocity distribution inside the arena. The allowed maximum local air velocity is 0.2m/s, however, the minimum air change per hour (ACH) is not less than 1.5 [6]. Therefore, the application of computational fluid dynamics (CFD) has several advantages in designing MVAC for badminton halls including optimizing airflow and temperature distribution comprehensively. Traditionally, mechanical engineers use rules of thumb methods, calculations from standards or textbooks, and experience to design MVAC. Mechanical engineers face difficulty designing MVAC systems if

a new approach or method has been introduced, for example, micro-perforated fabric ducting.

Therefore, it is not possible to design MVAC for a badminton hall without the application of computational fluid dynamics (CFD). A new technique called fabric duct with micro perforating holes has been introduced to solve severe uneven air velocity distribution [7]. The size of the perforated holes is very small, which is 5mm or lower. It is expected that the air velocity becomes more uniform by using fabric ducts with micro perforating holes than conventional air conditioning systems.

The history of CFD dates back over 40 years ago. Now, CFD has proven it be excellent for designing building thermal comfort and mechanical ventilation. As a result, CFD becoming very popular among researchers in thermal comfort studies and mechanical ventilation. For instance, Catalina et al. [8] employed CFD as an alternative to traditional air conditioning systems called chilled cooling ceiling panels. The authors claimed that the thermal comfort conditions are satisfactory by using cooling ceiling panels. Moreover, the authors also stressed that the cooling ceiling has a lower vertical air gradient than traditional air conditioning.

In the literature CFD was not only used to design MVAC for sports areas and halls, but also helps engineers and designers in many applications including fire safety [9], microelectronic [10], aeronautic [11], water treatment [12], and water dam [13], etc. CFD has been used by many researchers and engineers in designing the thermal comfort of sports arena buildings. Losi et al. [14] employed CFD in predicting the MVAC system for football stadiums in the Middle East. The ambient temperature in the Middle East was approximately 48°C. As a result, the MVAC system of the stadium in the Middle East requires high power electric consumption, if the football match starts at noon to evening time. The application of a passive cooling system is very helpful in reducing the high temperature in the daytime. One of the methods is the application of a transparent roof in the football training center. Ismail et al. [2] utilized CFD in predicting football field temperature at noon with a transparent roof. The analysis shows that a single transparent roof was not enough to obtain desirable temperatures on the football field. Thus, the other suggested applying a double-layer transparent roof to reduce football field temperature. The CFD results predict that a double layer of transparent roof was enough to get the desirable temperature of the football field. The next CFD study for sports venues has been executed by Stamou et al. [15]. The authors evaluated the prediction mean vote and predicted the percentage of dissatisfied value characteristics. They claimed that the studied characteristics show the thermal comfort condition of the sport value was in excellent condition.

In an aquatic sports venue, the CFD study was conducted by Rajagopalan and Luther [16] to assess the thermal comfort condition of the aquatic center in Victoria, Australia. For the warm weather and high solar radiation, the air ventilation system was required to reduce air temperature and other parameters that cause thermal discomfort in the aquatic center. The authors also claim that the low location of the wall exhaust fan has better thermal comfort conditions than the roof exhaust fan. Then, Limane et al. [17] performed a 3D thermal comfort study in an indoor swimming pool building using OpenFOAM.

The study covered the air velocity, temperature, and relative humidity in the swimming pool area. The authors suggested that modifying air-blowing conditions has a possibility to improve indoor air quality and the thermal comfort of occupants. Then, Ismail and Che Jamil [18] predict the temperature and air velocity distribution inside the modular badminton hall using the FLUENT CFD code. The authors used a wall exhaust fan to control air velocity and temperature distribution. The CFD results show that the fan number and arrangements have a significant effect on the air velocity distribution. The maximum allowed air velocity was 0.2m/s, therefore, the fan selection and arrangements are crucial.

More than that, CFD has the capability to predict thermal comfort performance using natural ventilation. In 2012, Hussain and Oosthuizen [19], utilized the FLUENT CFD code to study the thermal comfort performance of natural ventilation in the atrium. As the dimensions of the atrium were large, the flow was expected to be turbulent. Therefore, the authors employed k-omega shear stress transport as a turbulent airflow model. The results indicate that a higher chimney height provides a better thermal comfort performance for natural ventilation. Then, Nada et al. [20] conducted a simulation CFD study on the temperature distribution and thermal comfort in the theatre hall. They employed the underfloor air-conditioning system because the theatre hall ceiling was very height. The thermal characteristics of the study include air temperature, air velocity, space height, and number of diffusers. To enhance the reliability of the simulation data, the authors have validated the CFD results and available experimental data, and all CFD data show acceptable agreement with the experimental data. Afterward, Guo et al. [21] evaluated the possibility and performance of natural ventilation in a gymnasium room in a subtropical country. The authors employ the CFD code to predict the performance of the natural ventilation thermal comfort. The gravity equation has been ticked on and the density of the air has been changed from constant to ideal gas to activate the thermal buoyancy effect. The results show that the thermal buoyancy influences the air change per hour and the air velocity distribution.

Since BWF rules that the maximum air velocity in the badminton court vicinity must be less than 0.2m/s and the maximum temperature should be between 18°C and 30°C, the application of MVAC in badminton halls especially in the subtropical county is unavoidable. A new ducting technique called micro-perforated fabric ducts has been introduced in many sports arenas including the badminton hall. This ducting has hundreds even thousands of the small-perforated holes. The advantages of micro-perforated fabric ducts include low and uniform air velocity to the badminton court [22], and improved thermal comfort of spectators and players [23]. This technique is still new, therefore, it is difficult to get performance information on micro-perforated fabric ducting for badminton halls in the literature. This paper has described the CFD application in predicting air velocity distribution of micro-perforated fabric ducting, and its improvement to fulfill the requirement of BWF that the local air velocity in the court vicinity must be less than 0.2m/s.

2.0 METHODOLOGY

The 3D-geometric modeling, dimension, information of meshing, the types of boundary conditions, and the details of the computational setup are discussed in the section.

2.1 Assumption of the Study

Before the simulation study was conducted in the present simulation work, there is some assumptions were made including:

- The dimensions of the studied badminton hall were large, and the estimated air jet velocity from the perforated flow was higher than 10m/s, therefore the flow regime was assumed to be turbulent.
- No external wind has been assumed. Therefore, the natural convection between the external concrete wall building and outside air has been assumed and set as $3W/m^2K$, This value is similar to previous studies in the literature [2].
- The effect of the solar radiation is negligible because the Hicondek40 OSM roof with thick heat insulator Rockwool has been used in the present study. The overall heat transfer coefficient of this roof was $0.627W/m^2K$. The roof has been modeled as homogenous.

2.2 Geometric Modelling and Dimension.

The design of the badminton hall and micro-perforated fabric duct were proposed by NHK Ultimate Consultant. The building has total dimensions of 74m in length, 39m in width, and 14.6m in height. The badminton hall consists of an office, toilet, equipment storage room, spectator seat, prayer room, physiotherapy room, etc.. However, in the present study, the domain has been focused on spectator seater and badminton court vicinity for simplification. The present modeling simulation study consists of the roof, the wall, the micro-perforated fabric ducting, the badminton court, and the spectator seater. Figure 1 illustrates the components of the badminton hall. Figure 2 shows the dimension of the 3D modeling of the study which has a length of 40.5m, 39m width, and 14.6m height. Gambit pre-processor was used to develop a 3D badminton hall building.

As shown in Figure 1, two different diameters of the fabric duct were used in the present study. The larger fabric duct has a diameter of 1.2m and the diameter of the smaller fabric duct was 5 mm. The total length of the larger fabric duct and smaller fabric duct were 46m and 8.5m, respectively. Therefore, the total volume of the badminton hall was 19935m³. The material of the fabric duct was polyester.
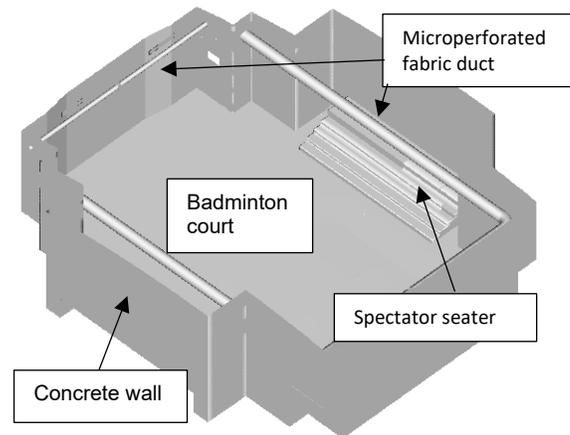

Figure 1 The list of the studied badminton hall components

Top view of the Badminton Hall

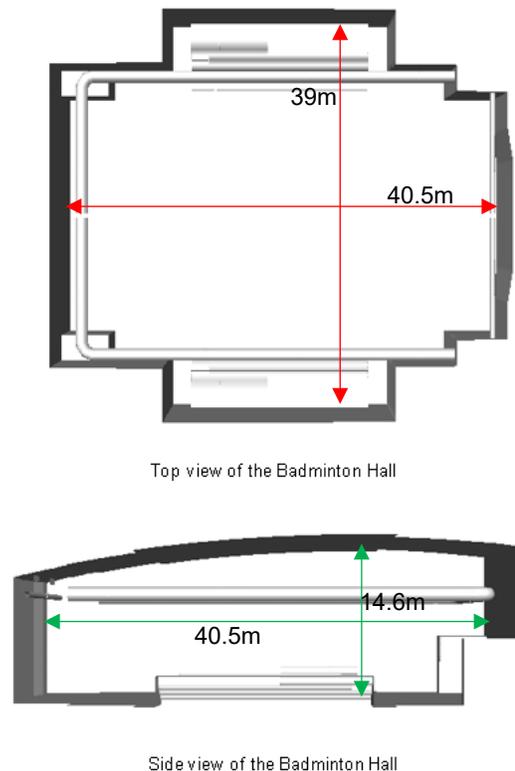Side view of the Badminton Hall

Figure 2 The Dimension of the Studied Badminton Hall

Figure 3 illustrates the schematic drawing of micro-perforated holes on the fabric duct. The L-shape bracket and aluminium profile attached to the L-shape bracket were used to hold the fabric duct. The fabric duct has 4 total rows of holes, and the spacing and row was 40mm. The spacing between 2 holes in the same row was 20mm. The diameter of the micro-perforated holes was 5mm each.

The selection of the roof was quite crucial in order to reduce the loss and save electrical costs. In the present design, the Hicondek OSM roof [24] type has been applied on the roof of a

badminton building. This rood has three different layer materials including zink, glass wool, and aluminium. The overall heat transfer coefficient of the OSM roof type is 0.627W/m²K.
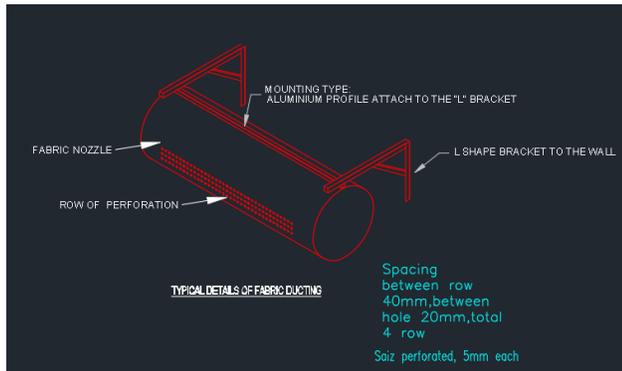

Figure 3 The schematic drawing of the micro-perforated holes

2.3 Meshing and Boundary Conditions

Next after the 3D geometric modeling of the badminton hall was complete, the hybrid tetragonal and hexagonal meshing were developed using Gambit. The quality of the meshing is excellent and acceptable with a scale of 0.82, which is much lower than 0.97, as mentioned by the FLUENT tutorial guideline. This type of meshing has several advantages including being easier to apply in complex geometry and lower computational cost if compared to polyhedral mesh. Figure 4 shows the meshes of the present CFD modeling.
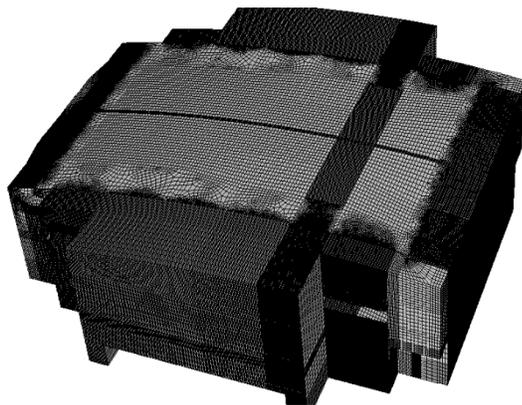

Figure 4. The Meshing of the CFD Modeling

2.4 Boundary Conditions

Figure 5 and Figure 6 illustrate the boundary conditions of the study. As shown in Figure 5, the wall has been applied for the roof, seater, concrete, and floor. The floor was set as a homogenous polyurethane rubber badminton court. Therefore, the floor was assumed an adiabatic condition due to the low thermal conductivity of polyurethane material. The structure of the spectator seater was also assumed in adiabatic condition because it has very thick concrete cement under the chair. As mentioned earlier, the homogenous roof has been applied in the

present study with an overall thermal transfer coefficient of 0.627W/m²K. Meanwhile, the heat transfer coefficient of the concrete wall and outside air was 3W/m²K [2, 24].
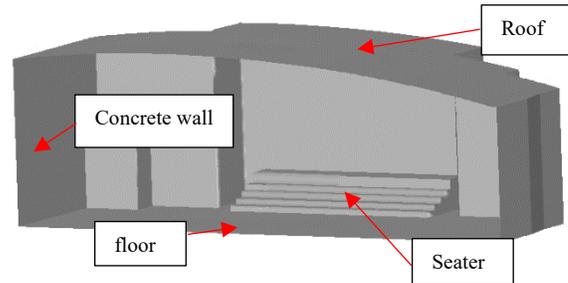

Figure 5 Wall Boundary Conditions

Next, the boundary conditions have been applied to the MVAC system. In the present simulation, the wall, inlet, and outlet of air have been set on the model. Velocity inlet boundary condition was applied on the larger fabric duct and the smaller fabric duct inlet entrance surface to control the air volumetric flow rate entering the badminton hall. The pressure outlet was used to let exhaust air exit from the building on the red colour surface. The fabric duct has been set as the wall, and the perforated hole has been created on the fabric duct to allow air to flow from the MVAC to the building. The velocity inlet, denoted with blue colour surfaces, for the larger fabric duct, was set as 6.2m/s, and 6.5m/s for the smaller fabric duct. The temperature of both air velocity inlets was 16°C. The total air change per hour of the building was approximately 3.3 ACH. The ambient pressure was set as 0Pa, and the ambient temperature was 33°C. In the solution method, the second-order upwind was applied to the momentum and energy equation in order to obtain good reliability of the simulation results. In the residual monitor, All the equations including continuity, x-velocity, y-velocity, z-velocity, k, and epsilon were set as 0.001. However, for the energy equation, the absolute criteria were set as 1 x 10-6. The rest were set as default.
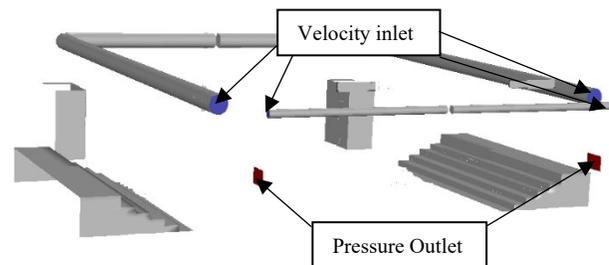

Figure 6 Inlet, outlet fabric ducts boundary conditions

2.5 Grid Independent Test

The number of meshing is important in CFD analysis. The higher number of meshing provides better and more reliable results than the lower number of meshing. However, the disadvantage of the high number of meshing is it requires a longer time to complete. Therefore, the grid-independent test was conducted for optimization of the number of meshing in the present work. A workstation with processor AMD Ryzen 9 9500X 12 core

processor and RAM of 64GB has been used to conduct simulation study of the badminton hall.

Four different numbers of meshing have been used in the study. The finding of the grid independence test has been illustrated in Figure 7. Table 1 shows the detailed number of meshing in the present study from 4.8 million to 6.0 million. The ACH of 3.3 has been set in boundary condition for the grid independence test.

Table 1 Meshing Element Number

Name	Number of element
Very Coarse Mesh	4,822,211
Coarse Mesh	5,247,923
Fine Mesh	5,657,959
Very Fine Mesh	6,045,586

Figure 7 shows that all numbers of mesh show a similar trend. The high air velocity exits from perforated holes. The air flows all over the building space. As shown in the figure, the coarse mesh underestimates air velocity inside the black rectangular area. Inside the black rectangular area, very coarse mesh predicts air velocity around 0.7m/s, which is 30% lower than Coarse mesh, Fine mesh, and Very fine mesh. Therefore, Very coarse mesh was out of the choice.
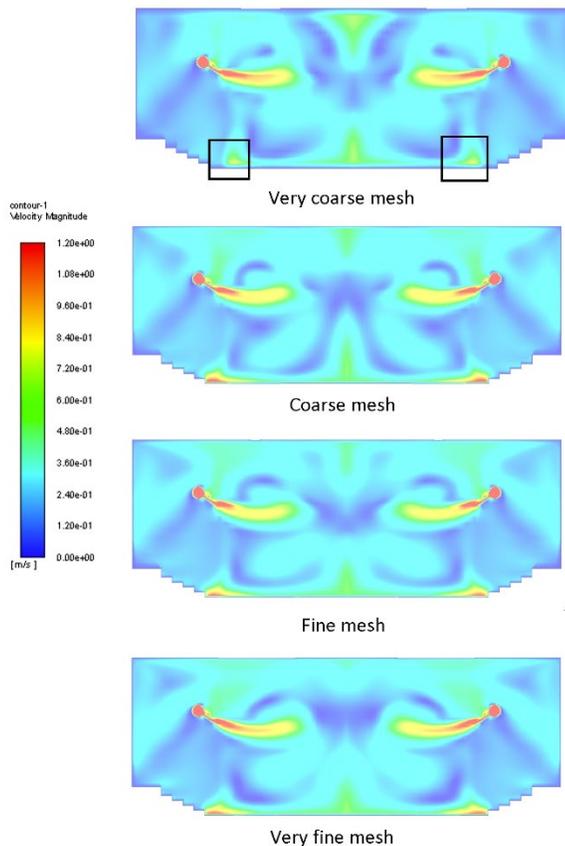

Figure 7 Badminton hall air velocity contour for various numbers of mesh.

Figure 8 shows the air temperature profiles against height for the coarse, fine, and very fine mesh. As shown in the figure, all profiles show a similar trend. The temperature from Point A significantly decreases to Point B. Then, the air temperature decreases gradually until Point C and becomes constant. At Point D, the air temperature increases robustly until the height of 14.47m, or Point E. Between Point C and Point D, the coarse mesh overpredicts air temperature by 0.15°C, however, the fine mesh shows similar temperature with very fine mesh. The fine mesh required 3 hours to complete one case, however, the very fine mesh needed 4.5 hours to complete, Meshing D, and Meshing E show similar average temperatures. Therefore, the fine mesh was selected for the study.
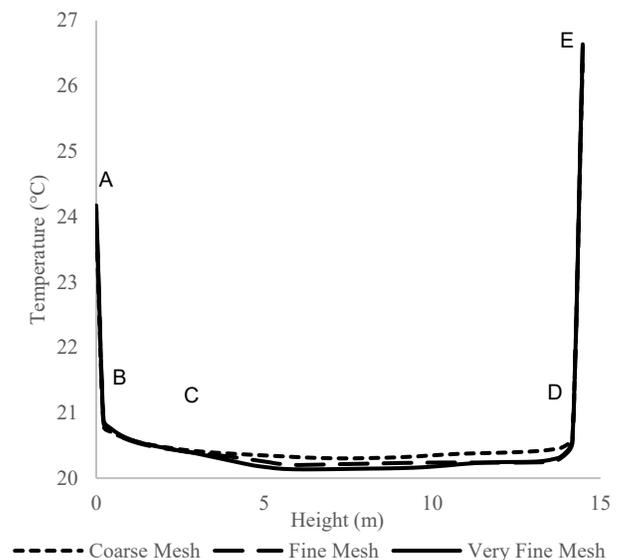

Figure 8 Temperature profile against height inside the badminton hall

3.0 RESULTS AND DISCUSSION

Results and discussion elaborate the CFD predictions data of the original design micro-perforated holes fabric duct. Then, the discussion suggests two methods to improve air velocity distribution of MVAC; half round for micro-perforated hole fabric duct and reduced air change per hour (ACH).

3.1 Original Design Micro-Perforated Holes Fabric Duct

Figure 10 and Figure 11 show the air temperature contour of the badminton field for the original design micro-perforated fabric duct. The airflow direction from the fabric duct is illustrated in Figure 9. As shown in Figure 10 and Figure 11, the highest air temperature occurs in the vicinity of the building wall. The maximum wall temperature is approximately 25°C, as illustrated in Figure 11. However, the air temperature far from the wall is approximately 20°C, meanwhile, the inlet air temperature on the fabric duct entrance is 16°C.

According to the simulation data, the heat transfer from the building outside to the building inside is approximately 108kW. Therefore, it can be deduced that the heat from outside

transfers inside the building in two ways, convection and conduction. The ambient condition has a higher temperature than the outer wall of the badminton hall. Thus, the heat from the ambient has been transferred to the outer wall of the badminton hall by convection. Then, the inner wall of the badminton hall has a lower temperature than the outer wall of the badminton hall. As a result, the heat transfers from the outer wall to the inner wall by conduction. Finally, the heat from the inner wall is transferred to the air inside the badminton hall because the inner wall of the badminton hall has a higher temperature than the air inside the badminton hall. The average air temperature is 20.6°C, fulfilling the requirements from BWF.
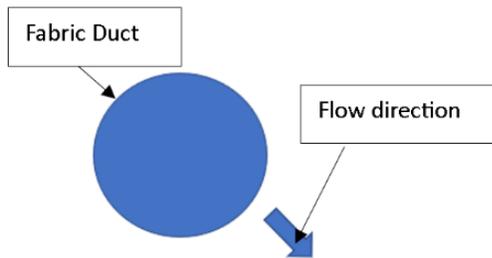
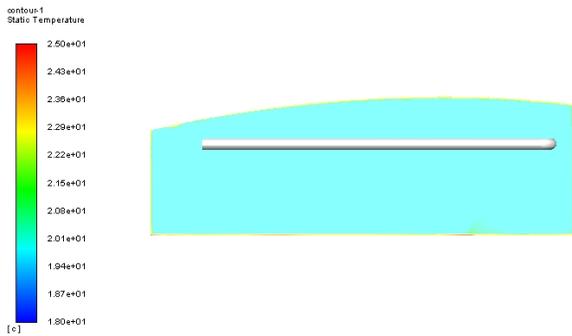

Figure 9 The direction of the airflow

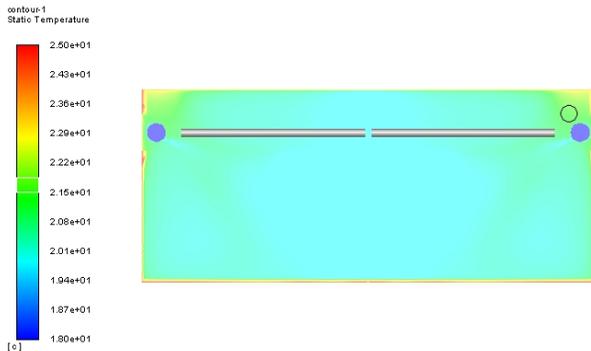**Figure 10** Side View of Air Temperature Contour

Figure 11 Front view of air Temperature Contour

Figure 12 and Figure 13 show the velocity contour of the badminton hall in front view and top view, respectively. In general, the fresh jet air from the perforated holes has a very high velocity due to the high air pressure inside the fabric duct. Subsequently, the jet air velocity decreases as it flows away from the perforated holes because the high jet air velocity transfers its momentum to the stagnation adjacent air inside the building.

As a result, the stagnation air starts to flow and is entrained by the high jet air velocity. According to Figure 12, the minimum air velocity is approximately 0.25m/s. Meanwhile, Figure 13 shows the maximum local air velocity is 0.7m/s. These two results indicate that the original design micro-perforated fabric duct is unable to comply with the requirements from BWF, which is the maximum local air velocity must be less than 0.2m/s. The modification of the MVAC must be made to comply with requirements from BWF. The increasing number of perforated holes is one way to reduce the maximum local air velocity.
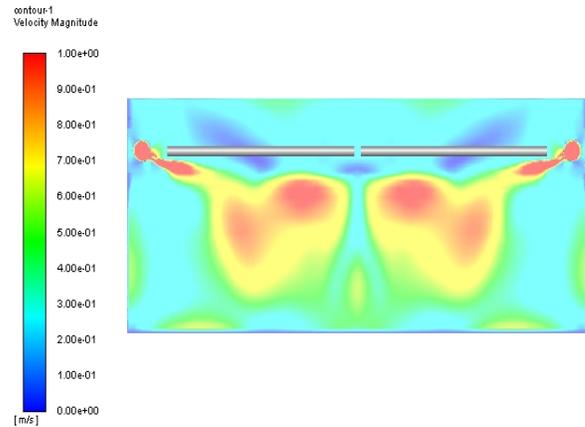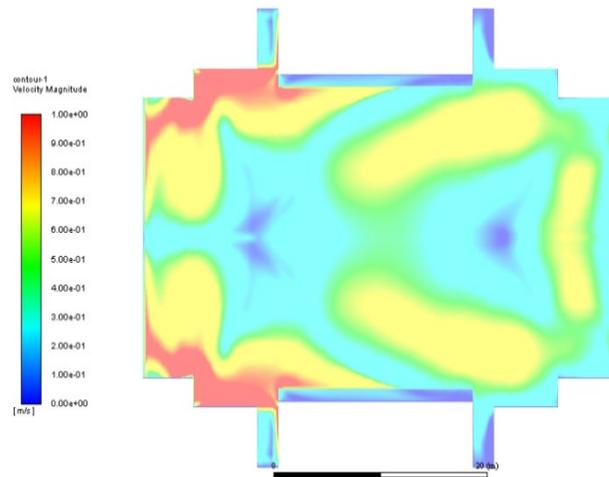

Figure 12 Front View of Air Velocity Contour

Figure 13 Top View of Air Velocity Contour at height 0.5m.

3.2 Half Round Micro-Perforated Fabric Duct.

The simulation data shows that the original design micro-perforated fabric duct unable to comply requirement for maximum air velocity inside the badminton hall. Therefore, a half-round micro-perforated fabric duct has been suggested in the present study. This method provides double the number of perforated holes on the fabric duct. Figure 14 shows the schematic air flow concept of the half-round micro-perforated fabric duct. In the present study, double half-round micro-perforated fabric ducts have been used to replace the original design micro-perforated fabric duct. The flow direction plays an

important role in the air velocity distribution inside the badminton hall. Therefore, the present work studies the effect of air jet flow directions for 4 different flow arrangements. Figure 14 shows the schematic drawing of the studied airflow direction.
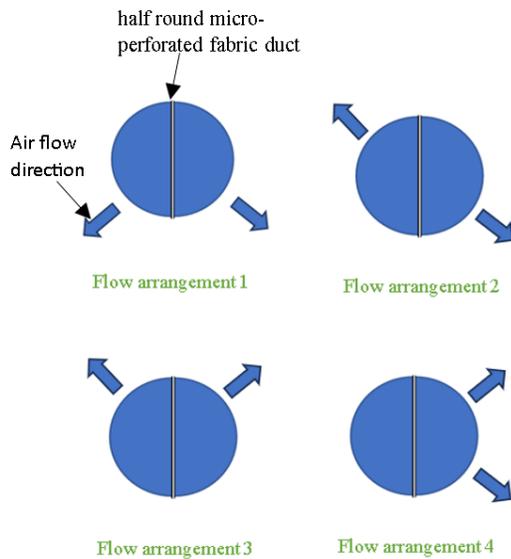

Figure 14 The airflow direction arrangements of the half-round micro-perforated fabric duct.

Figure 15 shows the air velocity distribution for four different directions. As shown in the figure, Flow Arrangement 3 and Flow Arrangement 4 produce very high local air velocity on the floor, denoted by Rectangular A and Rectangular B, approximately 0.65m/s. Therefore, Flow Arrangement 3 and Flow Arrangement 4 are out of the option. Only, Flow Arrangement 1 and Flow Arrangement 2 produce low air velocity adjacent to the floor, between 0.2m/s and 0.25m/s.

The air velocity contour in the top view at heights of 0.5m and 3.0m for Flow Arrangement 1 and Flow Arrangement 2 are illustrated in Figure 16. Although Flow Arrangement 1 produces higher air velocity than Flow Arrangement 2 at a height of 0.5m, the air velocity at the building center is low and acceptable. At the height of 3.0m, the area of high air velocity of Flow Arrangement 2 seems larger than that of Flow Arrangement 1, as depicted in Rectangular C and Rectangular D. Therefore, Flow Arrangement 1 has been selected as MVAC in the present study.
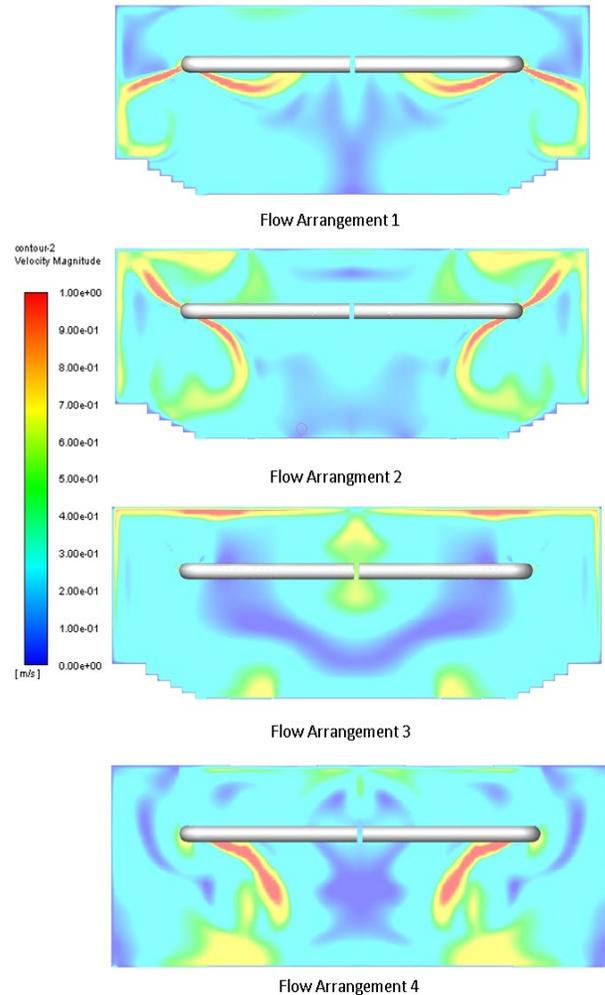

Figure 15 The front view of air velocity contour at four different airflow directions

3.3 Air Changed per hour (ACH) Analysis

In fact, the ACH original design of 3.3 is quite high. It is difficult to achieve a maximum air velocity of 0.2m/s, as required by BWF. Thus, the ACH needs to be reduced to an acceptable value that complies with BWF requirements. In the present simulation study, the effect of ACH on the air velocity and temperature distribution has been analyzed. The ACHs that have been covered in the present work are 3.0, 2.5, 2.0, and 1.5. According to the Design Guidance Note from Sport England [6], the ventilation rate of 1.5 ACH is enough for four court sports halls. Then, the present work study is limited to a minimum ACH of 1.5.
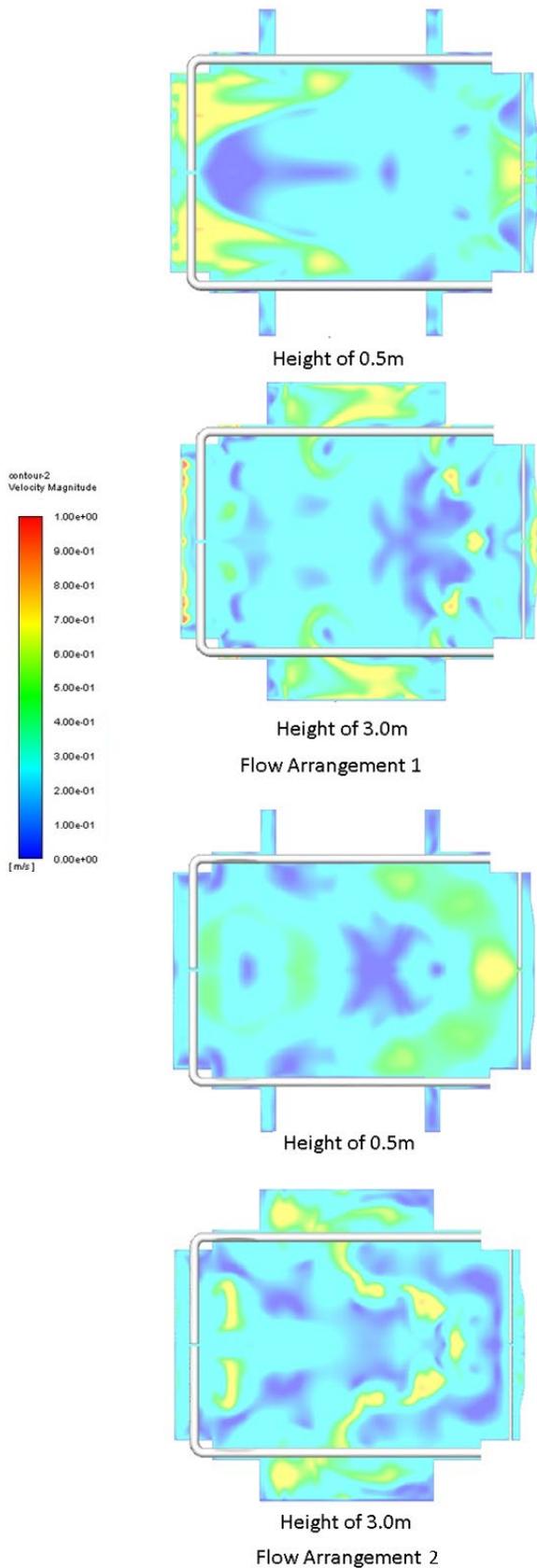
Height of 0.5m

Height of 3.0m

Flow Arrangement 1

Height of 0.5m

Height of 3.0m

Flow Arrangement 2

Figure 16 The top view of the air velocity contour for Flow Arrangement 1 and Flow Arrangement 2

Figure 17 shows the air velocity contour at a height of 0.5m for various ACHs. As shown in the figure, the air decreases as the ACH decreases. The maximum air velocity has been shown at ACH of 3.0, where the maximum air velocity is approximately 0.7m/s at the right badminton court. The ACH of 2.5 produces the highest air velocity of 0.25m/s at the right wall, quite far from the right badminton court. Both ACH of 2.0 and 1.5 produce the air maximum air velocity of less than 0.2m/s. At the height of 3.0m, as illustrated in Figure 18, the high air velocity spot has been detected at the right side wall, which is quite far from the badminton court for ACH of 2.5 and 2.0. No high air velocity spot has been detected for ACH 1.5 at the height of 3.0m. However, the high air velocity spot has been detected close to the right badminton court. Figure 19a shows the top view of the air velocity contour at 6m. As shown in the figure, ACH of 3.0 shows three high-velocity spots at this height, two spots inside the left badminton court, and one spot at right badminton. No spot of high air velocity is shown by ACH of 2.5, ACH of 2.0, and ACH of 1.5.

The plane average air velocity at the given planes for ACH of 3.0, ACH of 2.5, ACH of 2.0, and ACH of 1.5 have been summarised in Figure 19b. These given planes have been described to elaborate the information of the average air velocity profile against the height. The limit of the height is 6m because it is the critical height in the badminton game. As shown in the figure, the average air velocity at the height of 0.5m for ACH 3.0 is approximately 0.3m/s. Then, it decreases gradually to the lowest value at the height of approximately 2.5m to 3.0m, Afterwards, it increases gradually until the height of 6.0m. These patterns are similar for all ACHs of the study. Moreover, the figure also shows that the average air velocity increases as the high increases. ACH of 3.0 shows the highest average air velocity, around 0.3m/s at the plane height of 0.5m. Then, the average air decreases to 0.2m/s ACH of 2.5 at the same plane height. Afterward, the plane's average air velocity reduces further to 0.18m/s at an ACH of 2.0. The lowest plane average velocity is produced by ACH of 1.5. Figure 16 to Figure 19b show that ACH 3.0 is not suitable to use in the present badminton hall because ACH of 3.0 produces at least three high-velocity spots inside the badminton court area. ACH of 1.5 until 2.5 does produce a maximum air velocity of less than 0.2m/s. Therefore, these ACH values are appropriate to employ in the proposed badminton design.
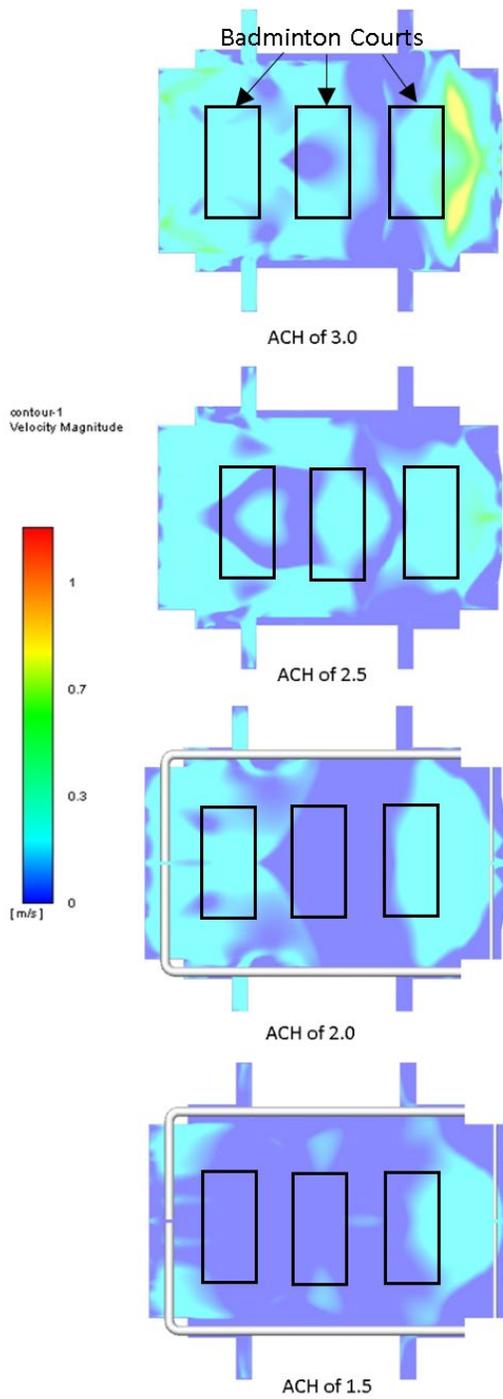
Figure 17 The top view of air velocity contour at the height of 0.5m for ACH between 1.5 and 3.0
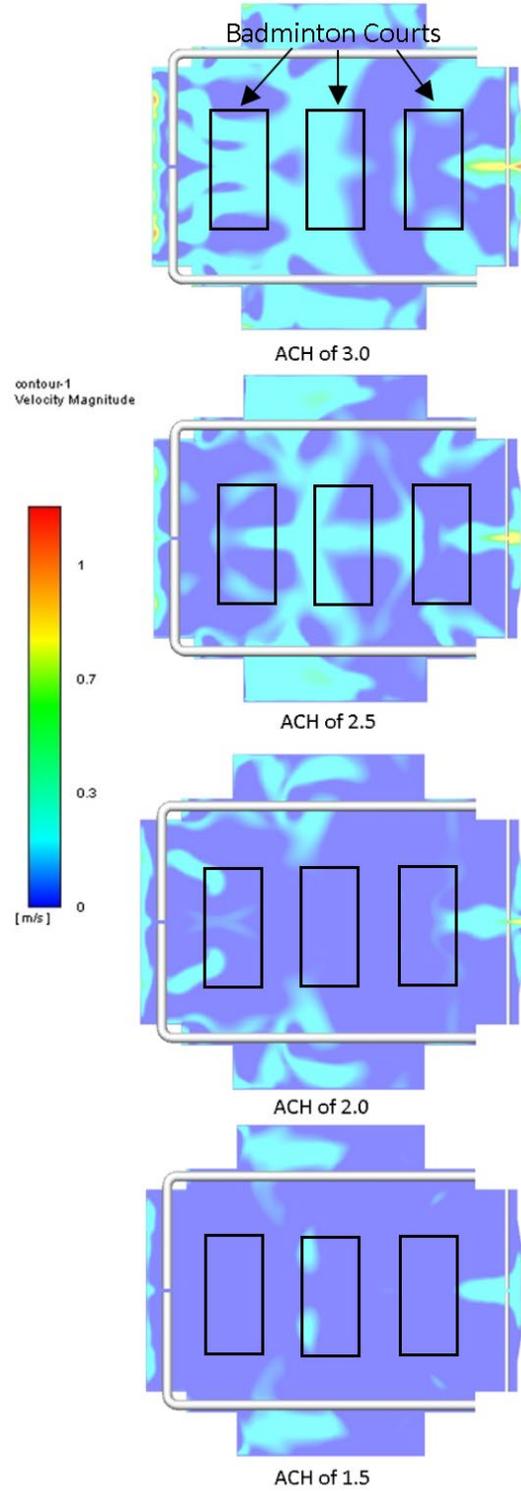

Figure 18 The top view of air velocity contour at the height of 3.0m for ACH between 1.5 and 3.0
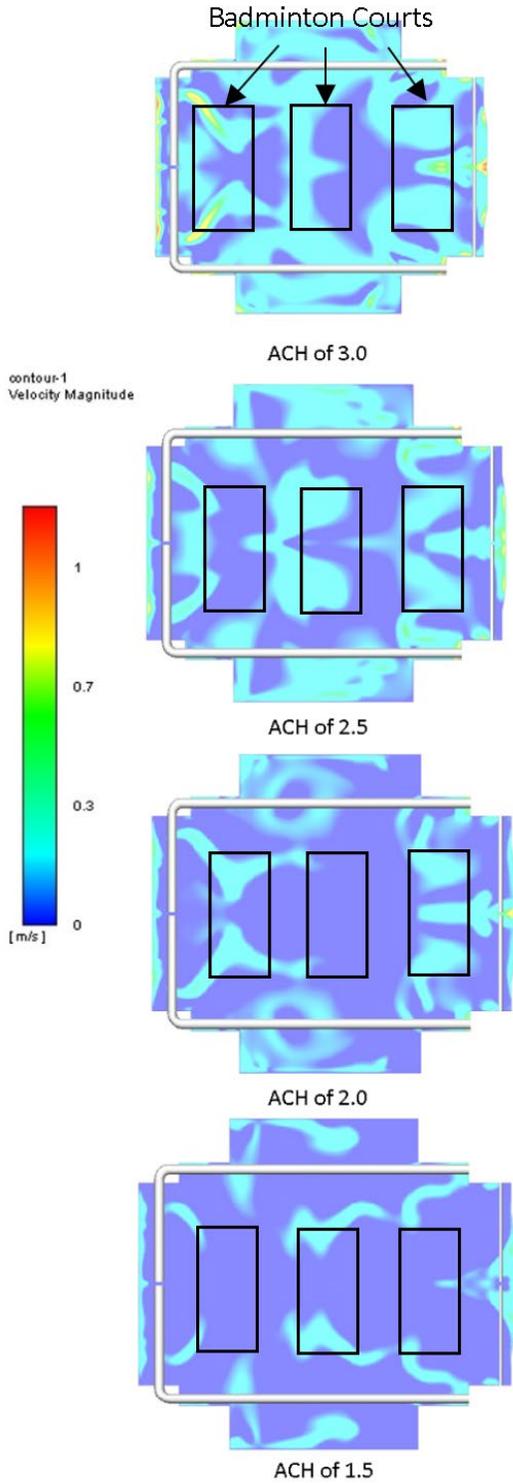
Figure 19a The top view of air velocity contour at the height of 6.0m for ACH between 1.5 and 3.0
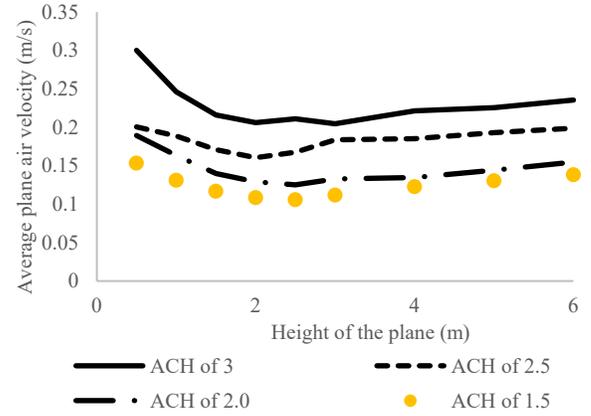

Figure 19b The average air velocity of the plane at the given height for various ACH

Figure 20 shows the top view temperature contour at the height of 1.5m. Overall, the wall-building temperature for all studied ACH is in the range between 30°C and 32°C. According to the figure, the air temperature range inside the badminton court falls between 21.8°C and 23.4°C for an ACH of 3.0. Meanwhile, for ACH of 2.5, the air temperature contour inside the badminton area is in the range between 22.5°C to 24.0°C. ACH of 2.0 produces air temperature inside the badminton court from 22.8°C and 24.4°C. The highest air temperature of the present study has been produced at an ACH of 1.5.

The average plane air temperature at the different heights has been summarised in Figure 21. In general, the air temperature decreases gradually as the plane height increases. That phenomenon happens because the fabric duct is located 8 to 9m above the floor. The average plane temperature decreases as the ACH increases, which contradicts with average plane air velocity in Figure 19b. It happens because ACH of 3.0 produces the highest fresh air mass flow rate from the fabric duct to the building. Thus, the fresh air at ACH of 3.0 absorbs the highest heat from the building. As a result, ACH 3.0 produces the lowest air temperature inside the building. According to the figure, ACH of 3.0 produces an average plane air temperature between 22.4°C and 22.7°C. The second lowest air temperature has been produced by ACH 2.5, which is in the range from 22.7°C to 23.2°C. The highest average plane temperature in Figure 21 has been shown by ACH of 1.5. ACH of 1.5 has the average plane air temperature between 23.6°C and 24.1°C.

Figure 16 to Figure 21 reveal that the best ACH of the present simulation has been produced by an ACH of 2.5. ACH of 2.5 produces air velocity inside the badminton court area less than 0.2m/s. At the same time, an ACH of 2.5 shows the average plane air velocity against height at 0.2m/s and lower. ACH of 2.5 also generates air temperature in the range between 22.5°C and 24°C, which is the temperature of thermal comfort in Malaysia. The average plane air temperature is less than 23.2°C.
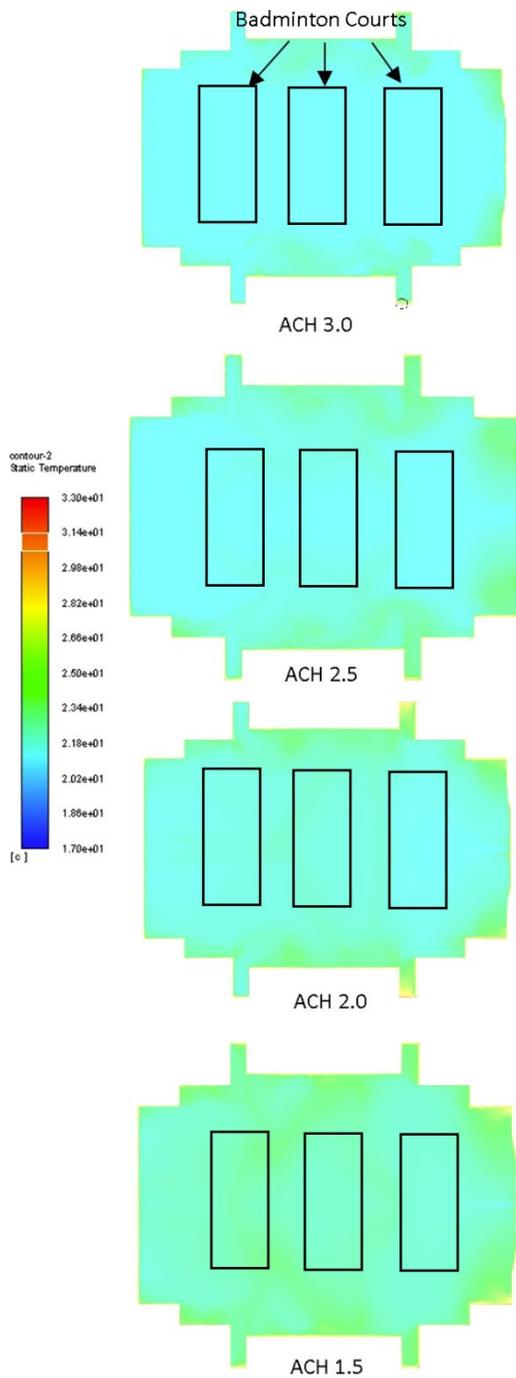
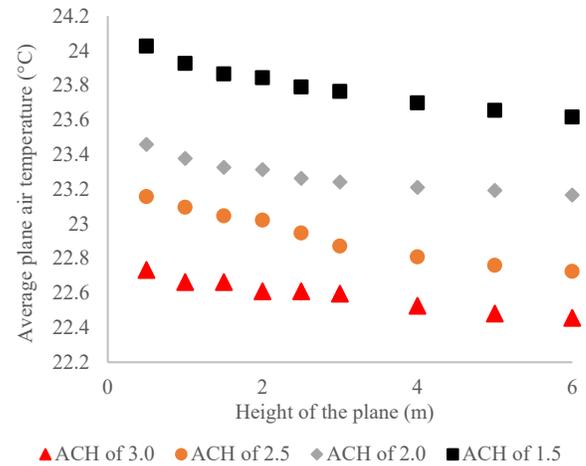**Figure 20** The top view of air temperature contour at the height of 1.5m for ACH between 1.5 and 3.0

Figure 21 Average plane air temperature against height of the plane.

4.0 CONCLUSION

The simulation study analyses the badminton court air velocity and temperature. The present simulation utilized FLUENT CFD code to predict the velocity and temperature of the air inside the badminton hall. In the first step, the performance of the original design micro-perforated holes of MVAC has been examined. The results show this design unable to fulfill the air velocity requirement from BWF, which is less than 0.2m/s. Half round micro perforated fabric duct has been suggested and Flow arrangement 1 shows the best performance of the present study. ACH of 3.3 was unable to fulfill the air velocity requirement, as a result, the study conducted the ACH study. The lowest temperature has been produced at ACH of 3.0 at 21.8°C. However, ACH of 3.0 is unable to fulfill air velocity requirements at heights 0.5m and 6.0m. On the other hand, the ACH of 2.5 fulfills the air velocity requirement, which is 0.2m/s and below. The air temperature for ACH of 2.5 is in the range between 22.5°C and 24°C, which is the optimum thermal comfort in Malaysia. In conclusion, the half-round micro-perforated fabric duct at Flow Arrangement 1 with an ACH of 2.5 has been recommended in the proposed badminton hall.

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Conflicts of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper

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