NATURAL VENTILATION DESIGN OF UNHCR FAMILY TENT

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ABSTRACT

UNHCR Family Tent is one of the most common emergency shelter that being used in most of the refugee camps and during emergency cases. Most of people are living in the UNHCR Family Tent in a long period of time either in a few years or a decade. Most of the publications research nowadays that are related with refugee shelters, discussing more on the tensile strength and durability of the shelter instead of the natural ventilation. In this research, four case studies on different locations of openings like window openings, door openings and roof openings are studied in order to investigate and discuss the effectiveness of those openings in helping natural ventilation on the UNHCR Family Tent. As the temperature of the UNHCR Family Tent is related and correspond to the natural ventilation, this research study also discuss on the temperature of the UNHCR Family Tent in order to determine whether the UNHCR Family Tent is comfortable for living purposes This research is being done by using ANSYS Fluent, a Computational Fluid Dynamic software that simulate the similar situation of the UNCHR Family Tent. The simulation program is easy to be used and handle with precise details on the data. The data collected are mainly focus on the velocity pathlink, velocity magnitude and temperature. After simulating on the data, the case studies are being compared in order to find out the best situation and improvement that can be done by simply changing the openings. The results that are gained from the research shows that by adding in more openings at different locations will increase the velocity magnitude of the air that are entering into the UNHCR Family Tent and decrease the temperature of the tent.

Keywords: *Computational Fluid Dynamic, Natural Ventilation, UNHCR, Refugees, Tents*

ABSTRAK

Khemah Keluarga UNHCR merupakan salah satu tempat perlindungan kecemasan yang biasanya digunakan dalam kem pelarian ataupun sewaktu kecemasan. Kebanyakan orang pelarian biasanya tinggal dalam Khemah Keluarga UNHCR dalam waktu yang panjang sama ada beberapa tahun ataupun beberapa dekad. Kebanyakkan penerbitan penyelidikan yang berkaitan dengan tempat pelindungan pelarian berbincang tentang kekuatan tegangan serta ketahanan khemah bukannya tentang pengudaraan semula jadi. Dalam pemyelidikkan ini, sebanyak four kajian kes tentang lokasi pembukaan pintu, tingkap serta atap yang berbeza dibincangkan dan dianalisiskan untuk mengambil tahu tentang keberkesanan pembukaan pengudaraan di tempat yang berbeza dapat membantu kemasukan udara ke dalam ruangan khemah. Oleh sebab kekaitan suhu Khemah Keluarga UNHCR dengan pengudaraan semula jadi, penyelidikan ini juga berbincang tentang suhu dalam ruangan Khemah Keluarga UNHCR supaya dapat mencari keselesaan therma bagi Khemah Keluarga UNHCR. Penyelidikkan ini menggunakan pengisian ANSYS Fluent yang mencontohi situasi yang sama dengan kenyataan. Pengisian ini menggunakan simulasi untuk mendapatkan maklumat yang diperlukan bagi pengudaraan semula jadi serta suhu Khemah Keluarga UNHCR. Program pengisiaan ini mudah diggunakan dan mudah mendapatkan maklumat yang tepat. Maklumat yang didapatkan ialah arah halaju udara, magnitud halaju serta suhu Khemah Keluarga UNHCR. Selepas siapkan simulasi maklumat, kajian kes-kes dibandingkan untuk mencarikan situasi dan penambahbaikan yang berkesan. Keputusan dan analysis yang didapati daripada penyelidikan ini menunjukkan bahawa penambahan pembukaan perngudaraan akan meningkatkan halaju magnitude yang mengalir ke dalam Khemah Keluarga UNHCR lalu menurunkan suhu dalam Khemah Keluarga UNHCR.

Keywords: *Pengiraan dinamik mengalir, Pengudaraan semula jadi, UNHCR, Pelarian, Khemah*

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LIST OF ABBREVIATIONS

ANSYS: ANalysis SYStems

CFD: Computational Fluid Dynamic

HVAC: Heating, ventilation, and air conditioning

MRT: Mean Radiant Temperature

NGOs: Non-Government Organisation

NV: Natural Ventilation

UN: United Nations

UNHCR: United Nations High Commissioner for Refugees

CHAPTER 1: INTRODUCTION

1.1 Overview

A refugee can be referred as someone that are involuntarily leave their home nation due to expulsion, war or violence attack that cause harm towards their safety. They left their home due to the fear of their indifferent opinions towards race, religion, nationality, political opinion will cause their safety to be harm and affected. When they left their home, refugees have high possibility not able to return to their own home as their home is deemed as dangerous. However, they will be flee back to their hometown once their home are free from war and violence. (UNHCR, 2015)

According the Global Trend report 2016 that was published by UNHCR, 65.6 million displaced individuals worldwide were coercively removed from their hometown as they face life challenges that are caused by expulsion, war or violence attack. This number showcased the increasing number of 300,000 people comparing to 2015. This was mainly due to the increasing population of Syria refugees that were fleeing out from their home nation. In the period of 1997 till 2016, the number of people from that were involuntarily left their home nation has increased from 33.9 million to 65.6 million. The increasing number was mainly concentrating between 2012 and 2015 where wars were happening due to Syrian conflict that had cause the attention of the world. Not only the Syrian conflict that had cause the attention of the world, the religious and political war at Iraq, Yemen and sub-Saharan Africa had caused their citizens to left their home as they were afraid that their lives will be affected. However, after 2016, the growth of this population had started to slow down. As in 2016, 10.3 million people were newly located to new places. This number of population included 3.4 million people that sought protection outside their countries and 6.9 million people that were remained in their own nations even though they were forced to leave their home. Even though many were seeking outside protection, but there were still a portion of people including 550,000 refugees and 6.5 million internally displaced people (ICPs) that were seeking hope by trying to rebuild their lives at their origin nations. (UNHCR, 2016)

According to the Global Trend Report 2016, 5.3 million refugees from Palestine that were under UNHCR’s mandate out of 22.5 million of global refugee protection at the end of 2016. (UNHCR, 2016) A great effort is needed by the international community leaded by worldwide leaders to solve the issue of the large involuntarily displacement of populations that are forced to flee from their nations due to expulsion, war or violence attack. A precise forward plan that is drafted by using guidelines from international refugee, human rights and humanitarian law is proposed by UN Secretary General to solve the issue of this large involuntarily displacement of populations. The increasing number of the refugees and migrants that are crossing over the international borders due to the war has cause issues on countries nearby that are safe from those war issues. The displacement of the population of refugees and migrants has become a vital issue to affected countries as the population of refugees and migrants are unable to survive in their countries due to their status. They bring in problems such as life-threatening situations due to poverty and job competition among local citizens. They are fleeing out from their countries due to the shortages of job opportunities at their countries due to war. Their journeys towards other countries are often accompanied with different tragedies tales that are often feature in the headlines. After they arrive at the desired nation, then they face problems on surviving in those problems due to shortages of skills and experiences. Some of them even have hard time in communicating. The host nations are often burdened with their overwhelming number as those host nations are often unprepared with the necessary supply towards those refugees. They face the problems where this issue is not a temporary issue but an issue that can last for decades as war often happens in a long period of time. Many host nations are often not prepared with responsibilities that they should be distributed as some countries are still under economic growth. When those host nations are hosting the population, they have to ensure the growth of this population in terms of social, economic and political. This issue is highlighted by the UN system and NGOs in order to strengthen the collective response. As many UN members are being affected by the large number of the population that involuntarily displaced, they are cooperating closely to share responsibility, deciding on high level plenary conference in discussing and addressing on those refugees issues' at their nations.

UNHCR is playing role as the middleman in between a mandate where this non-political organization is being responsible towards governments but this humanitarian organisation has to depend on donors from all parts of the world in solving the refugee's issue that occurs around worldwide. Since 1950, UNHCR activities had contributed to processes of decolonization, development and globalization of many nations that are affected by war. After the Second World War, the purpose of the development of UNHCR's office in 1950 is to assist in building new lives for millions of Europeans that had fled or lost their homes due to the war. 200,000 Hungarian fled to neighbouring Austria during the Hungarian Revolution in 1956. UNHCR took an effort in resettle those Hungarian refugees, showcasing the performance on how a humanitarian organisations should deal with refugee crisis. Then, the decolonisation of Africa has produce numerous continent refugee crisis that UNHCR had helped in settling those refugees in 1960s. Not only Africa and Europe, UNHCR also played a role in helping people that have demolished home and life due to religious war in Asia and Latin America over the past two decades. The commitment of UNHCR towards refugees over the past decades by emphasizing the evaluation and supporting organisational accountability, learning and growth of improvement in addressing issues regarding on refugees' needs on protection and assistance. UNHCR's role in providing worldwide refugees' care, safety and assistance is mandated by the UN General Assembly. A powerful and complete evaluation on the usage and roles of UNHCR is based on The UNHCR Evaluation Policy 2016 that discuss on the policies of independence, equality, integrity and service that are given. The development of UNHCR over the last 65 years has showcase the effectiveness on helps towards major refugee crises in several continents like Asia and Africa.

Refugee camps are brief living spaces for uprooted people that are departing away from assault and expulsion from their respective nations. Even though the settlements, services and utilities are meant for short term usage, however the issue on displacing those refugees take longer duration, therefore they consider the temporary refugees camps as the permanent living spaces before moving away to countries that they are sorted to. Based on the New York Times, the average period for refugee to stay at the refugee camps is 12 years. Many refugee camps are facing troubles and problems due to the maintenance of those refugee camps' facilities. Those maintenance on refugee camps are high due to the increasing amount of refugees, therefore those camps are usually facing troubles on insufficient fund in maintenance on the refugee camp and supporting refugee's needs. Those refugees always face problems on insufficient amount of food, clean water and clean sanitarian. Those unsatisfactory surrounding situation on the refugee camps has led to health issues like chronic malnutrition and spreading on viruses. This has increase the opportunities for refugees in suffered from different illness and disease. Even though UNHCR has suggested on the daily basis usage of a person in the camp should be minimum 20 litters, but many camps are unable to meet those standards. As those refugees face the problems on having clean sanitary, they are exposed to diseases. Gap between refugee resettlement needs and places available widens. UNHCR said today that the number of refugees that are seeking for resettlement on living at a third country was expected to reach 1.9 million in 2019, 17 per cent higher than in 2018, while the number of resettlement places globally had dropped by more than half to just 75,000 in 2017.(UNHCR, 2017) This research is able to help refugees to stay in a better and comfortable space while investigating the issues that are faced by the regular UNHCR family refugee tent that is provided by UNHCR. It is vital for refugees to stay in a comfortable space as this will be their home for the few decades before settling to other nations. Therefore, this research is using simulation data in analysing the ventilation flow and thermal condition inside the UNHCR refugee tent.

1.2 Problem Statement

UNHCR had been constructing on protective covers around tents in the Jalozai camp with the help of European Commission to lower temperatures of existing UNHCR Family Tent on July 2012. As Pakistan face the issues on drought problems, UNHCR offers the solution by layering shade over the canvas tent that is shown in Figure 1.1. The tent shelter provides a simple solution for those refugees to relief from different weather and high winds. The root cause of the layering of the shade is due to the existing UNHCR Family Tent that is unable to release heat and ventilation inside the tent. (Q.K.Afridi, 2012) Therefore, in this research, there will a study on the natural ventilation and thermal comfort of the refugee tent. The problem statement on this research will be on what are the problems of the existing UNHCR Family Tent in terms of ventilation and thermal comfort? The research will be discussing on what are the condition of the UNHCR Family Tent in terms of the ventilation inside the tent? The research also will be discussing on what are the condition of the thermal comfort inside the UNHCR Family Tent? The research also discuss on what are the conditions of the ventilation and thermal comfort after the addition of openings on the UNHCR Family Tent?

1.3 Research Objectives

This aim for this research to study and find the problems of the existing UNHCR Family Tent in terms of ventilation flow and temperature inside the tent.

Objectives of this research:

a. This research is to investigate the optimum ventilation flow inside the UNHCR Family Tent based on different situations by using CFD simulation program.
b. This research is to investigate the optimum temperature inside the UNHCR Family Tent based on different situations by using CFD simulation program.
c. This research is to explore on the improvements of UNHCR Family Tent in terms of ventilation flow and temperature after the addition of the openings.

1.4 Scope

This research is based on analysis of CFD simulations for the different situations and modifications on existing UNHCR Family Tent that is frequently used by UNHCR organization. The simulation analysis is done by using ANSYS (Fluent) 2018 to investigate the optimum ventilation flow and temperature of six different case studies of UNHCR Family Tent with modification in different locations of openings. The different locations of openings will show the results on the effectiveness on whether the ventilation and temperature conditions of the UNHCR Family Tent are improved.

1.5 Significant of Study

This research is hoping to help and act as a reference for UNHCR or researchers in developing a more advanced and comfortable living shelters for refugees. This research will discuss on the natural ventilation and temperature of the UNHCR Family Tent that is simulated using simulation software.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

A refugee can be referred as someone that are involuntarily leave their home nation due to expulsion, war or violence attack that cause harm towards their safety. They left their home due to the fear of their indifferent opinions towards race, religion, nationality, political opinion will cause their safety to be harm and affected. When they left their home, refugees have high possibility not able to return to their own home as their home is deemed as dangerous. However, they will be flee back to their hometown once their home are free from war and violence. (UNHCR,2015)

2.2 Convention and Protocol

Convention is a formal agreement between states and is usually acted as tools for negotiation under an international organisation whereas protocol is a used for the modification of the convention and. Convention and protocol for refugees were first stated on the Article 14 of the Universal Declaration of Human Rights 1948. This convention was meant to identify asylum's rights on seeking help from other countries after they escape from their nations that were in war. This United Nation Convention was grounded in 1951 to seek the status of refugees. This convention was acting as the main protocol for asylums in seeking their rights as a legal refugees at other countries. It was referred as the main protocol for international refugee protection until nowadays. After the United Nation Convention in 1951, 22 April 1954 was the date where the convention was starting to be enforced. Then, it was amended on 1967 in order to abolish the limitation on geographic and temporal. This happened due to the previous convention that happened on 1951 had limit the acknowledgement on refugees that were fleeing before 1 January 1951 inside Europe. The removal of these limitations gave second acknowledge opportunities for refugees that were outside Europe and after the second war. This has become a vital element in the liberal growth development of international human right law that gives second chance for asylum that are fleeing out from their countries due to religious or political war post Second World War. (UNHCR, 1954)

Figure 2.1: The 1951 Refugee Convention and 1967 Protocol

2.3 History on Refugees' Resettlement

International Refugee Organisation, an organisation which dealt with refugee issues due to the World War II was founded on 20 April 1946. However, this organisation then was taken over UNHCR, an organization that in charge in dealing refugee issues worldwide on 1952. Refugees' settlement issues was the most vital issue in international refugee protection as this issue will deal with the settlement on refugees at other countries while providing them another living environment. The settlement issue had been developed by UNHCR as they made thorough and broad solutions in resettlement starting from the World War II for those refugees fleeing away inside Europe. Then, UNHCR had started to develop three durable solutions that tackle from local integration, resettlement and voluntary rehabilitation. This efforts had affected governments in facilitating this non-profit organization in helping those refugees. (UNHCR, 1952)

2.4 Refugee Settlement Issues

A clear policy on the resettlement of refugees should provide flexible solutions for refugees to go back to their own nations or remain countries that they were resettled on. It is significant for UNHCR to resettle refugees that do not have immediate protection concerns on host countries where they are refuge. The consideration on using the resettlement option should be based on comparative prognosis. Other durable solutions should be analyzed by taking the option of evaluating the resettlement. A thorough framework on responding the abundant challenges that United Nations faced, was provided to set a rule and guidelines regarding on refugee matters while identifying UNHCR's role in responding and taking action on refugees' issue. This agenda has provide the development and freedom on resettlement issue as this agenda can acts as a long lasting answer for resettlement and security. This agenda also enhance the sharing on responsibilities in between nation, requiring the cooperation between nations. (UNHCR, 2016)

2.5 Refugee Camp Issues

Refugee camps are brief living spaces for uprooted people that are departing away from assault and expulsion from their respective nations. Even though the settlements, services and utilities are meant for short term usage, however the issue on displacing those refugees in a suitable country that accepts them has taken a long duration until those refugees have been using those temporary shelters as the permanent living spaces before moving away to countries that they are sorted to. Based on the New York Times, the average period for refugee to stay at the refugee camps is 12 years. Many refugee camps are facing troubles and problems due to the maintenance of those refugee camps' facilities. Those maintenance on refugee camps are high due to the increasing amount of refugees, therefore those camps are usually facing troubles on insufficient fund in maintenance on the refugee camp and supporting refugee's needs. Those refugees always face problems on insufficient amount of food, clean water and clean sanitarian. Those unsatisfactory surrounding situation on the refugee camps has led to health issues like chronic malnutrition and spreading on viruses. This has increase the opportunities for refugees in suffered from different illness and disease. Even though UNHCR has suggested on the daily basis usage of a person in the camp should be minimum 20 litters, but many camps are unable to meet those standards. As those refugees face the problems on having clean sanitary, they are exposed to diseases. (UNHCR,2017)

2.6 Refugee Tents

Tents are widely used as an alternative for UNHCR for refugees before resettling them to other countries that are willing to provide a new life to them. Therefore, tents are used as a temporary shelters for refugees and often those tents are used for a long period of time. Dadaab is a site where UNHCR refugee camps like Dagahaley, Hagadera, Ifo, Ifo II and Kambioos are located. This site is the largest refugee site in the world, hosting 245,126 refugees that is taking charges by UNHCR. In this site, tents are being used due to the simplicity in transporting, construction and lower cost comparing to other options. However, refugee tents are not being used for a longer life span, therefore, UNHCR and governments that are hosting those refugees have to spend a lot of funding in maintaining those shelters. This crisis has become an issue where researchers are aiming to solve this crisis by providing a better option for refugees. For instance, UNHCR collaborates with IKEA in Better Shelter program to provide a stable shelter for refugees to live in. This IKEA Flatpack Refugee Tent is studier and able to withstand all sorts of climate with a long life span comparing to the other UNHCR's shelter options like UNHCR Family Tent and UNHCR Tunnel tent. However, the safety and fire resistance, high manufacturing and transportation cost of the IKEA Flatpack Refugee Tent are design flows that causing management from various refugee camps hesitate to use this shelter option. Most of the refugee camps are prone to use the UNHCR Family Tent due to the low cost and easier to build. Issues on dealing with the adaptation of the refugee tent in different climate and technological of suitable design are concerns of UNHCR in providing a better living space for refugees. Therefore, in this research will discuss mainly on the ventilation and temperature concern on UNHCR Family Tent that is widely used by UNHCR. (G. Salvalai.2017)

Figure 2.2: Haiti Earthquake Camp

Figure 2.3: Exterior View of IKEA Flatpack Refugee Tent

Figure 1.4: UNHCR Tunnel Tent that is being used widely at Kamanyola refugee camp

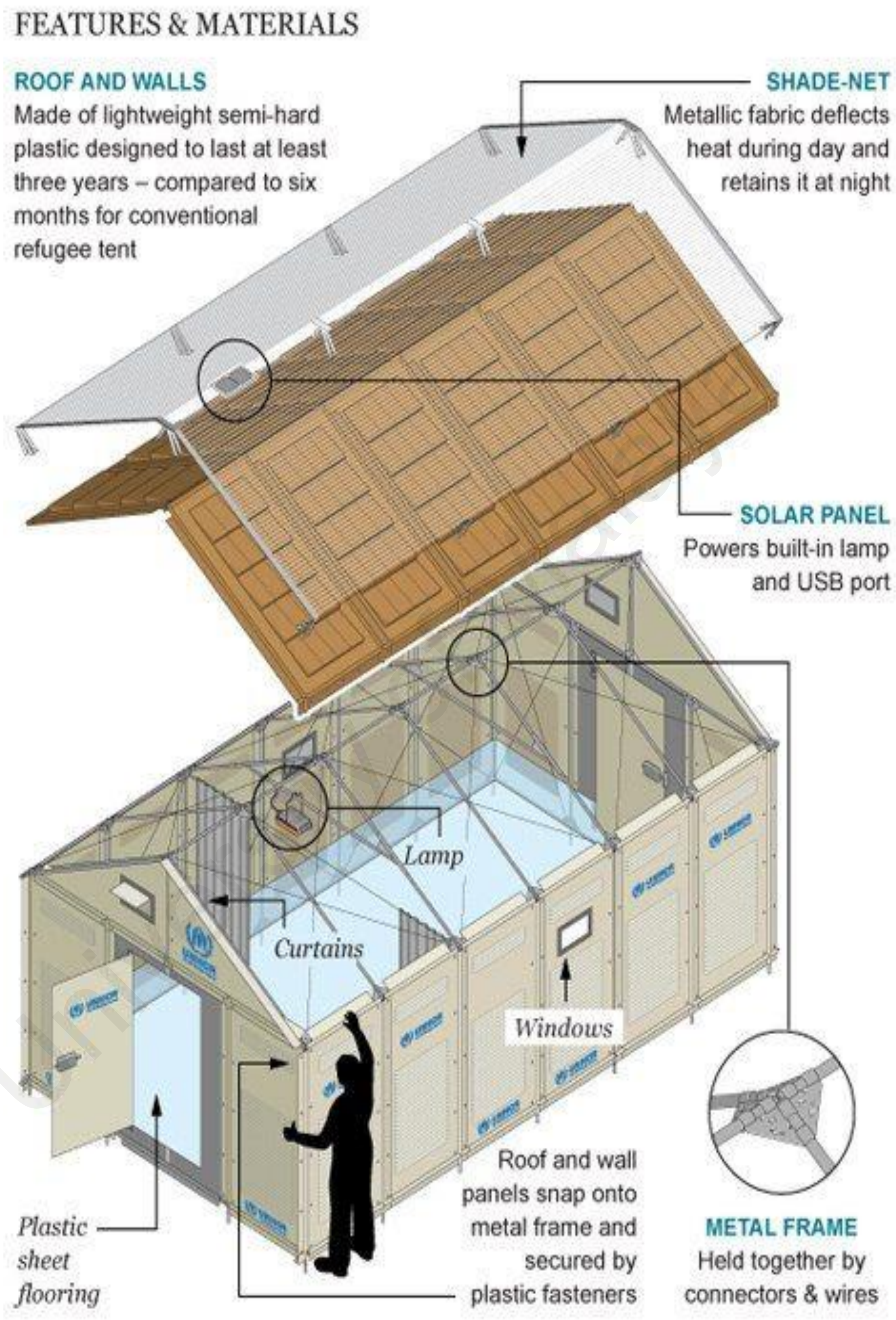

Figure 2.5: IKEA Flatpack Refugee Tent

Figure 2.6: UNHCR Refugee Tent that are being used at Zaatari Refugee Camp

2.7 UNHCR Family Tent

This UNHCR Family Tent is used by UNHCR since June 2014, aiming to be occupied by a family of 5 people. This tent has been done according to the standards like ISO 1833, ISO 3801, ISO17229, ISO 13934-1, ISO 9073-4, ISO 811, ISO 5912, ISO 7771, ISO 1394-1, EN13823 and CPA 184. This refugee camp occupy floor area of 16 m2, having two vestibules that are 3.5m2 respectively at the roof top of the tent and total area of 23m2 of ground floor area. This refugee tent can be used for hot or cold climates. However, it is suggested that a person should occupy minimum 3.5m2 of living area in hot and humid climates. The information regarding on the specifications of the refugee tent can be obtained at Supply Management Service department at UNHCR Headquarters in Budapest. (UNHCR, 2014)

Classifications	Required minimum values
Composition of the tent fabric according to ISO 1833	Poly-Cotton with the percentage of 40% cotton and 60% of polyester
Colour	Original white colour without undergoing any dying process.
Tensile strength (N) of the refugee tent according to the ISO 13934-1	Tensile strength is tested by applying on 10 pieces of plain canvas and 5 pieces of fabric material with seams that are cut from the tent. The tensile strength should be recorded on at least 850N
Weight (g/m^2) according to ISO 3801	350 g/m^2 ±15% after finishing with the manufacture of the product
Flame retardant under EN 13823 and CpAI84	Tents must fulfil CPAI84 sections 5 and 6 within 10s after the flame is reaching average state
Permeability of water particles according to ISO 17229	At least 2000 g/m^2/24hr

Table 2.1: Specifications of UNHCR Family Tent

UNHCR Family tent is meant to be used as a short period of solution to refugees before they are transferred to countries that are going to refuge them. Therefore, shelter specialist designed the tent to support emergency solutions instead of a long term usage. However, the increasing number of refugees at the camp caused the shortage of the refugee tents as the refugees that stayed there are not yet transferred to the host countries that are going to refuge them. Shelter specialists design the tent to have a year life span while being water resistance and able to withstand different weather without much maintenance. Even though the life span of tent is short, but the shelf life span of the tent can be extended to minimum 5 years under normal condition where the environment is dry, clean and well ventilated. As tents are sensitive to rain and moisture when packed, the manufacture has to keep the tent in a dry area.

Figure 2.7: Exterior View of UNHCR Family Tent

Figure 2.8: Refugees outside UNHCR Family Tent

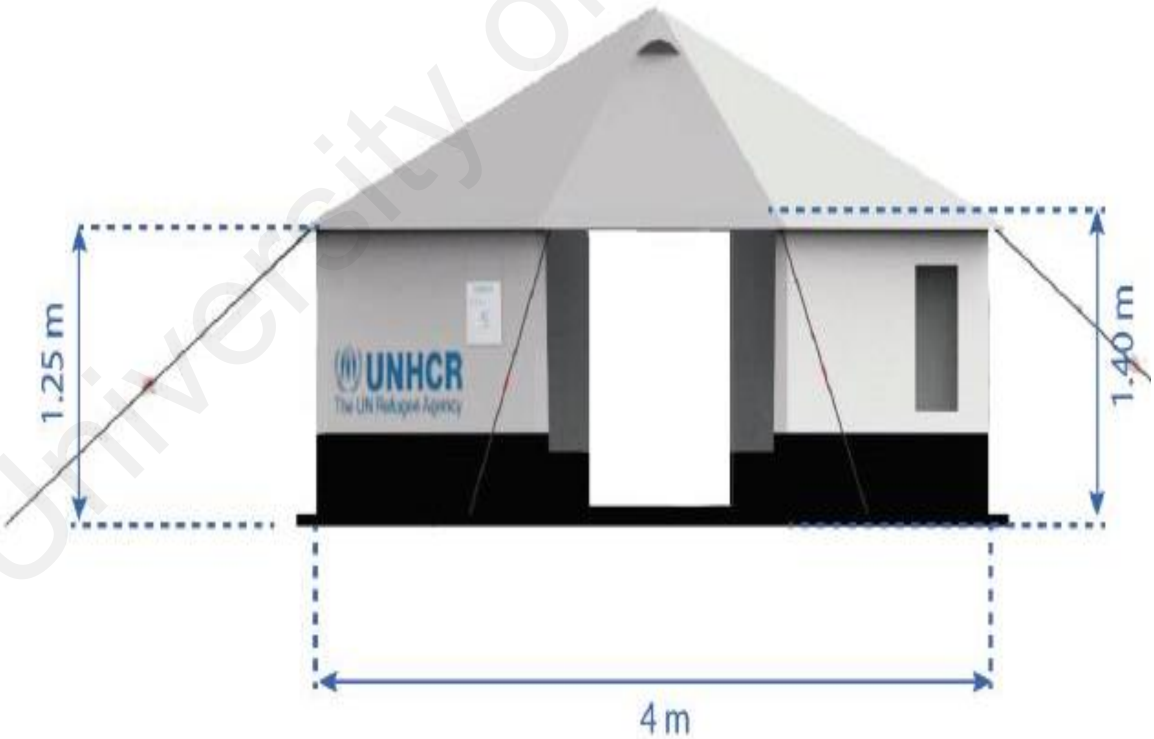

Figure 2.9: Front Elevation of the UNHCR Refugee Tent

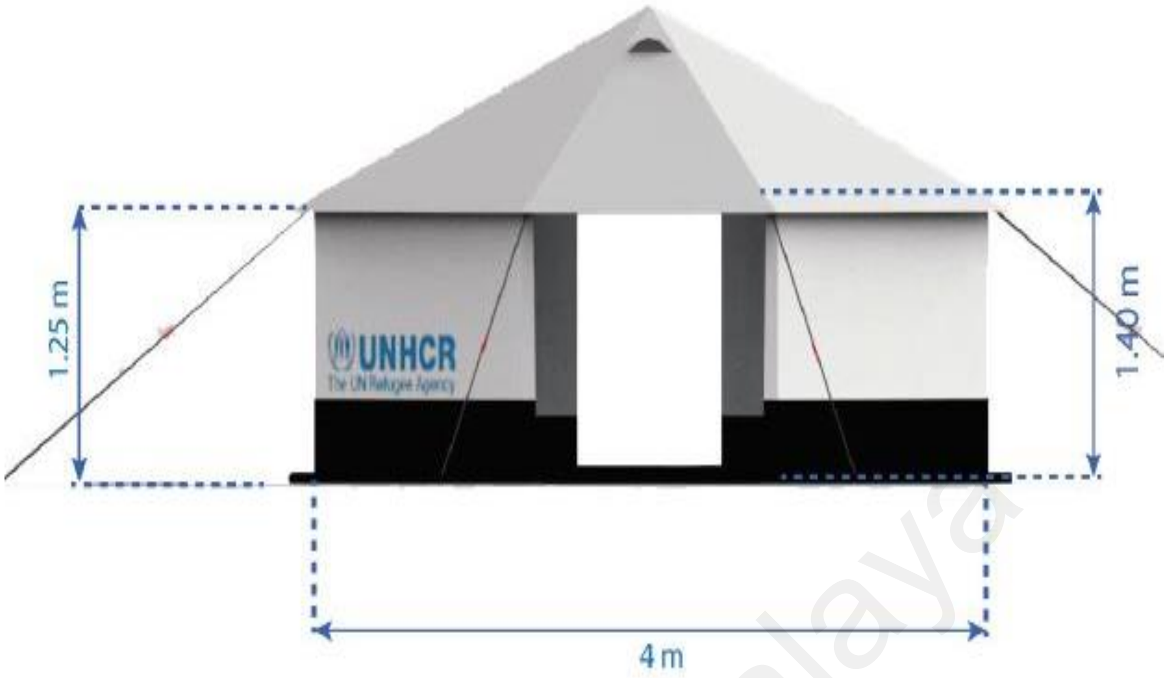

Figure 2.10: Rear Elevation of the UNHCR Refugee Tent

Figure 2.11: Side Elevation of the UNHCR Refugee Tent

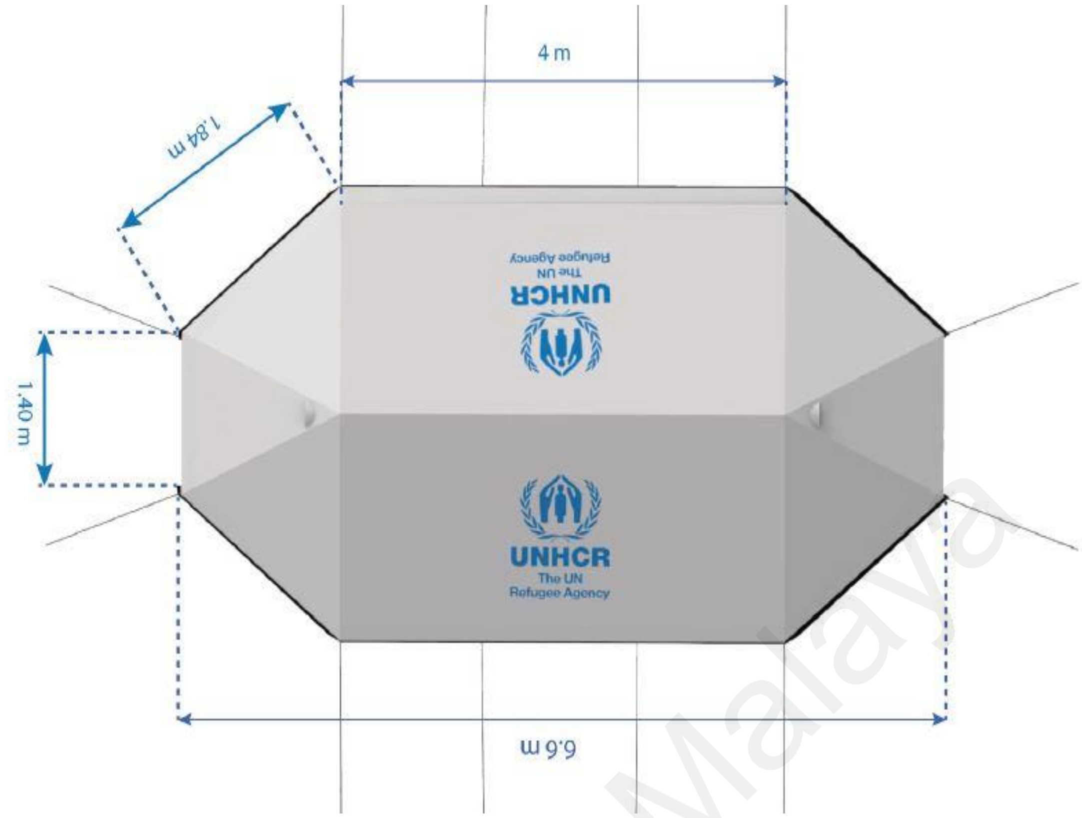

Figure 2.12: Roof Elevation of the UNHCR Refugee Tent

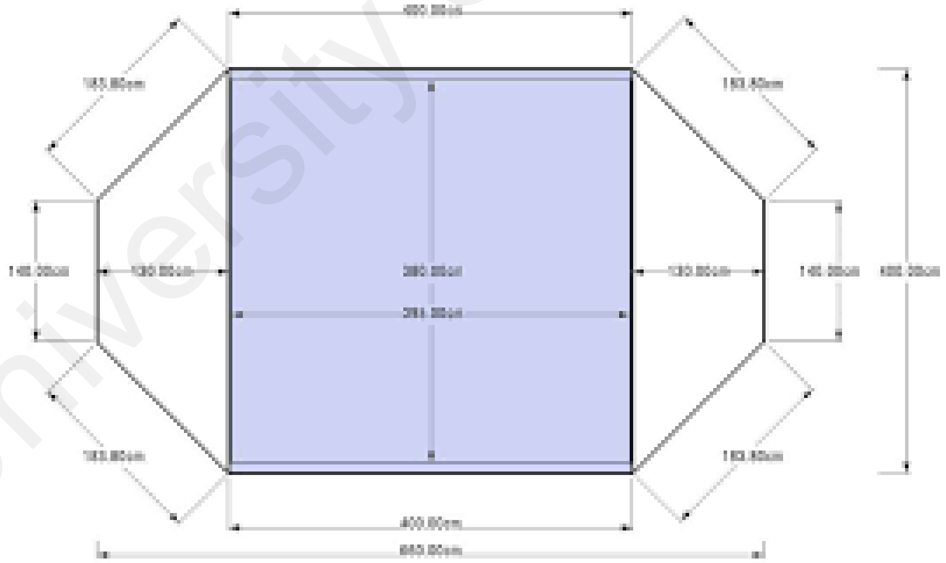

Figure 2.13: Floor Plan of the UNHCR Refugee Tent

Figure 2.14: Door of UNHCR Family Tent

Figure 2.15: Exterior View of Vent Openings for UNHCR Family Tent

Figure 2.16: Interior View of Vent Openings for UNHCR Family Tent

Figure 2.17: Exterior View of Window Openings for UNHCR Family Tent

2.8 Ventilation

The movement of air surrounding the space of a building is called as natural ventilation. Natural ventilation is significant in designing any spaces as it will directly affect the temperature performance of the space. When the temperature performance are poorly done, the thermal comfort of the human being that is living inside the space will be affected. Natural ventilation also helps in bringing fresh air inside the space, cooling up the space without the necessity of using outer machinery or HVAC to decrease the temperature of the space. (X.Yu, 2015) As human bodies not only reacting on the high temperature, but also the wind environment. Therefore, it is vital to take note on the wind environment as it is affecting in designing green building. (W. Guo, 2015) Moreover, the boundary conditions of natural ventilation at night are including the air flow rates, heat transfer coefficients, building structure and climatic conditions of the location of the buildings (E. Solgi, 2018)

In order to save up the energy usage, the most effective way in reducing the heat and increasing the ventilation flow inside the tent is improvement on natural ventilation design of the building as it proven to be effective in cooling and ventilating the building. There are two option that can be used in investigating the natural ventilation of a building including empirical method or simulation method. Nowadays, proper simulation method is often and commonly used by architects and engineers in investigating the thermal and ventilation performance of a building in order to improve their design of the building and optimize their building's ventilation and thermal performance. (Z.Q.Zhai, 2011)

There are several types of ventilation that can be occur inside a space. The first type of ventilation is single sided ventilation as this involves one opening that allowing air to enter to the space. As this single sided ventilation has a limitation in terms of opening's zone, therefore architects and engineers often opt out this type of ventilation in their design as single turbulence effect and bi- directional flow are all happening at one opening. The restriction in calculating the ventilation flow decrease this choices in creating spaces for buildings. (H. Wang, 2015) The limitation of air flow will decrease the overall ventilation flow and indoor air quality of the space. When the ventilation flow decreases, the temperature performance of this space will also decrease as only one opening that allows air to flow in and out. The second type of ventilation design is two sided- ventilation where two or more openings are designed in the space, allowing air to flow in and out from various directions. This type of ventilation design is more often used by architects and engineers as this type of ventilation design will increase the performance of the indoor air quality of the space. Moreover, it covers a larger zone of performance for ventilation and temperature. When the overall performance of the air ventilation improves, the thermal performance of the space will also be improving. Two sided ventilation also be known as cross ventilation which can be used in many spaces not matter the capacity and sizes with a higher ventilation rate. The third type of ventilation design is stack ventilation. Stack ventilation involves different height of those spaces' openings. When those openings have different heights, those air movement will be driven by a greater force of buoyancy and creating a larger ventilation flow. These openings can be done by placing different locations of those openings either on the roof, by the door or the window. When the air movement occurs in between those openings, pressure inside the space will increase.The fourth ventilation is passive ventilation where natural forces are being used to bring in and out the air inside a building's openings. This phenomena is occur when there are different stack and wind pressure as fresh air will be bring in. In this type of ventilation, indoor air temperature is maintained. Factors that are influencing including the speed and pressure of the air, stack pressure, characteristics and dimensions of those openings. Those factors will directly influence the ventilation flow's performance and thermal performance of the spaces. (X.Liu, 2015)

2.9 Importance on Openings and Ventilation

There are a lot of studies that prove that natural ventilation is a vital role in providing a quality performance of indoor air, thermal comfort and cost of energy. If architects and engineers are designing spaces or buildings in well ventilated situation, energy consumption will be reduced and cost for the energy consumption will be decreased. Natural ventilation is the best method in reducing the cost as natural ventilation is efficient in reducing the temperature of the space and buildings. (F.Muhsin, 2017) Natural ventilation can be spread through numerous openings from the space of buildings such as roof vents, doors and windows. The well ventilated spaces will improve the quality performance of the indoor air and thermal comfort. When human beings are experiencing a well ventilated space, they are very unlikely to be exposed to pollutants and germs as those pollutants and germs will be flowing out from the space. In terms of thermal comfort, a well ventilated space will not need artificial HVAC that increase the cost assumption. In countries that are experiencing extreme heat or tropical climate, those architects and engineers are often considering natural ventilation as their main factor in designing spaces as clients will experience optimum ventilation and thermal performance through passive design. (A. Aflaki, 2015) Natural ventilation design requires the involvement of knowledge in predicting the air flow, therefor designers are often using simulation software to predict the accurate data for the ventilation and thermal performance. (M.E.Mankibi, 2015) The geometry and position of openings for the air movement will greatly impact on the cross ventilation of the space while influencing the ventilation performance. (H. Montazeri, 2018) Natural ventilation plays a role in green and sustainable building design. As architects have to consider the ventilation rate for those spaces of the buildings. (James O.P,2011) When ventilation and thermal performance are able to be archieve especially during summer or tropical climate, the overall cost of energy consumption will be decreasing. (T. Schulze, 2013)

2.10 Mean Radiant Temperature (MRT)

There are several parameters that will influence the indoor environmental quality including the indoor air quality, thermal comfort, visual comfort and acoustics. Indoor environmental quality is often influenced by the thermal comfort.(S.Omrani, 2017) The measurement that is often used to measure the thermal performance of the thermal comfort is named as Mean Radiant Temperature (MRT). This is an element that analyzing the temperature performance of the indoor for a space. This element is often affected by the ventilation flow and air temperature which can be called as humidity. (Zhihua Zhu, 2015) The HVAC performance of a space will directly influencing the thermal performance of the space.(Emanuele Naboni,2017) In Malaysia, a tropical country that is experiencing heat and humidity all year round has the annual temperature of 27.0 ^{0}C and 80%, of humidity. (S. A. Zaki, 2017) As Malaysia is located at near the equator, the weather climate of Malaysia is hot and humid with an average rainfall of 250cm a year. The roof of Malaysia's building often experiencing 40 ^{0}C comparing to the wall that experiencing 27^{0}C. The tropical conditions in Malaysia has greatly affected the condition of indoor environmental equality of spaces at Malaysia. (P.H.Shaikh,2017)

The study that is conducted on a residential building at Malaysia shows that the temperature of the roof surface will increase up to 10 ^{0}C (K. T. Zingre, 2015) As Malaysia's tropical climate weather is suitable to be experiment and analyzing since Malaysia experiencing hot and humid climate, the boundary condition of this research is set using Malaysia's weather.

2.11 Thermal Performance of Shelter Modelling

For refugees that are living in a refugee camp, they are often living in tents that are commonly used as emergency shelter. Those emergency shelter are often in an uncomfortable conditions for occupants as those emergency shelter has very weak performance in terms of durability and natural ventilation. There are a lot of researchers that are often discussing on durability of the shelter instead of the natural ventilation. Natural ventilation is a key element in affecting the occupants' comfort while they are living inside the tent. Based on the research that documents the thermal performance of UNHCR Family Tent, UNHCR Family Tent has shown poor performance in terms of ventilation and temperature. This research shows improvement that can be done for the UNHCR Family Tent by changing the geometry and other constructive aspects. However, this research only can act as reference as the climate is different from the extreme conditions like Malaysia. This research is being done at Belgium that experience four seasons. Many of the refugee camps are built at places with hot and humid climate. Therefore, the thermal behavior of this research might not be as extreme as Malaysia. Moreover, the research is being done by experimenting the different position of thermocouples. Those results from the thermocouples shown that the overall thermal condition of the UNHCR Family Tent is unsatisfied. (S. Obyn, 2015)

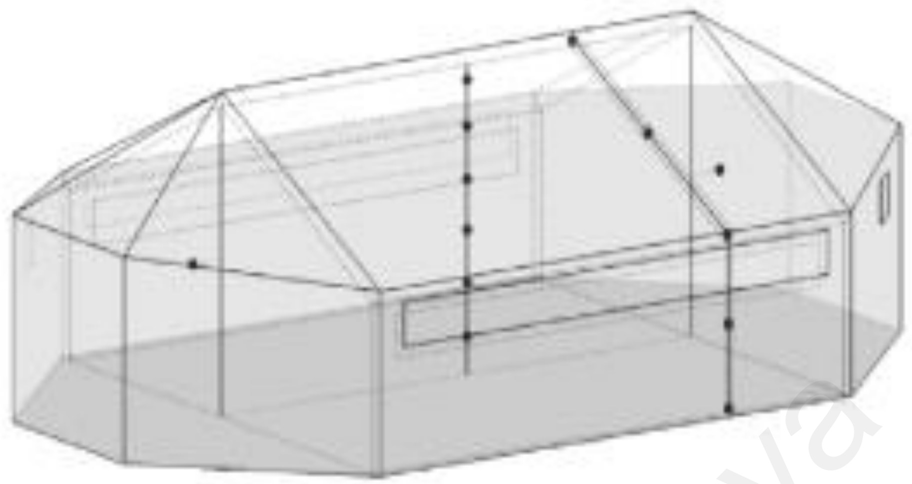

Figure 2.18: Position of Thermocouples

2.12 3D Software Programs

Sketchup 2018 is used to construct 3D models of the structure. It is widely modelling software to study on the building information as it compatible to most software. Other type of 3D modelling software are Rhino, Solidwork and Sketchup. Those 3D models are acted as sampling for simulation purpose.

2.13 Computational Fluid Dynamics Programs (CFD)

In order to imitate the real condition of the UNHCR Family Tent, simulation softwares are being used to simulate the 3D Model from Sketchup. Those softwares are able to analyse the condition of the natural ventilation. Those simulation softwares are being known as Computational Fluid Dynamics (CFD). CFD is a numerical software that analyse the 3D Model based on the process flow. CFD often analyse the velocity magnitude, velocity flow, temperature and so on. (H.Sacht, 2017) This software predict the situation of the fluid mechanics based on the numerical data that are given. The prediction data is often accurate as it is being drafted by computerised 3D Model. 3D Models are often being meshed so that boundary conditions can be set up. Then, the simulation begins and solves the equations of the model. After the program solves the situation of the model, results is stated and analysis will be done according to the data given. There are a few options regarding on CFD such as Autodesk CFD, ANSYS Fluent, DesignBuilder, EnergyPlus and Phoenix. Architects and engineers are often using CFD simulation in order to evaluate the effectiveness of their passive design on ventilation flow and temperature performance. Users are able to handle the software easily by setting up accurate data for boundary conditions. As those 3D models are very sensitive to the numerical parameters, therefore precise data are easily gained for further studies. (R. Ramponi, 2012) CFD is a technology that brings convenience towards users when they are able to create a better design for ventilation flow. They are able to analyse the performance of their design based on the data. (W.Guo, 2015)

2.14 ANSYS Fluent

ANSYS Fluent software is used to analyse the wind environment of the indoor and outdoor space by using numerical data. This program has a heavy duty computing power that simulates different situations by using the numerical simulation method. It contains mesh flexibility that can works through flow problems. ANSYS is a free program that is used worldwide in order to give detail data and information for users when simulating the 3D Model. ANSYS is able to get a lot of detailed information like air movement, air pathline, velocity of air, temperature of air, density and pressure. The data that is gained from the simulation is often depend on the boundary conditions that are set by users. The prediction of the mesh 3D Model will be based on the assumption data that is being record into the software. The software is generally being widely used. This software is commonly used as shown in a lot of publications in various subjects. It is widely used especially in investigating the boundary conditions of air movement and temperature. This is a very useful tool for architects and engineers to simulate and evaluate the performance of their design. (V. Garcia-Hansen, 2017) There are a lot of studies that show the increasing usage of ANSYS Fluent in research that involve the relationship between ventilation and temperature. ANSYS Fluent is a great analysis software that predicting the flow of air inside the indoor and outdoor openings.. (T. V. Hooff, 2017)

2.15 Autodesk CFD

Autodesk CFD that is easier to be available with other Adobe software. This program can be done by comparing different situations of the model with probe monitoring. This software is usually used together with Autodesk Revit as it is useful in simulating green building design where data such as thermal comfort and ventilation is needed to improve the design of the green building while optimising the architectural design. This program is useful as it also simulate both indoor and outdoor wind environment of a building and therefor can provide a more precise data for architects and engineers to improve their design. However, this software requires a precise 3D Modelling with details materials and space. The results from the software is not as complete and detailed as ANSYS Fluent. Comparing ANSYS Fluent with Autodesk CFD, ANSYS Fluent is easier to handle.

2.16 Phoenix

Phoenix software, a rare simulation program that is being used to study the building's ventilation. It is used to study the performance of the building's thermal comfort in a short period of time. If comparing ANSYS Fluent and Autodesk CFD with Phoenix software, the period of time for the thermal performance is shorter in Phoenix software comparing to the other two programs. Other types of building software such as Building Energy Simulation can analyse and simulate a longer thermal performance while reducing the excessive usage of computing time.

2.17 EnergyPlus and Design Builder

EnergyPlus is a software that is developed by United States in order to simulate the energy flow. This software is suitable for users that are experimenting on real objects instead of computerized 3D softwares. This software integrate the building loads and HVAC systems (L.P.Wang). It is being for analyzing the MRT that are experienced through different openings. As this software is developed by United States government, this program is not widely used as this program also focus mainly on calculation for MRT without much analysis on the openings. However, Design Builder is a software that calculate the thermal comfort performance of spaces with analysis on openings. The calculation involves the buoyancy effect and turbulence effects. Those effects can be controlling the air movement and entilation flow. (G. Elshafei, 2017)

2.18 Comparison between Empirical Evidence and Simulation Programs

Empirical evidence is firstly in architectural practices to analyse the building wind environment through wind-rose figures requirements on climate's zone. This method is used by architects in earlier stage according to their experience. This method is not as accurate and precise as experiences of architects might have error. The development of technology has brought in the simulation software that is based on the numerical data. The analysis based on the simulation software is more precise and accurate as computers are set into the desired situations. Those CFD software are able to be simulate according to the site under the desired boundary conditions such as velocity of the wind and temperature of the surrounding. CFD is widely used by architects and engineers nowadays in order to analyse their buildings and fluid mechanics. They are able to have a better prediction on situations and easier to describe the wind environment by using the graphical figures that are shown on the software. By using those graphics, they are able to make comparisons and opt for different solutions and advancement on their designs. (W. Guo, 2015)

2.19 Retro-reflective materials

Retro reflective materials is a good option to reduce the sunlight radiation as this materials is highly reflective towards solar radiation. As tents are constantly under sunlight, therefore retro- reflective materials is able to reflect the thermal effect from the sunlight. The common materials, polycotton that is used on tent is unable to reflect the sunlight effectively, causing the indoor temperature environment to be higher and less ventilation flow. Whereas retro reflective material is a materials where they have high reflectivity against the sunlight radiation from the sun. It is proven to be effectively reduce the outer surface temperature. (L.Zhang, 2017)

CHAPTER 3: METHODOLOGY

3.1 Introduction

The optimum ventilation flow and temperature of the UNHCR Family Tent are being studied in order to find out whether the UNHCR Family Tent has poor performance of ventilation flow and temperature. This research is being done by using ANSYS Fluent simulation software to imitate the exact situation of UNHCR Family Tent with different locations of openings.

3.2 Schematic Layout

In the schematic layout of the UNHCR Family Tent, there are two roof vents, one door and window opening on the side of the door. There are two layers of UNHCR Family Tent. The outer layer which is made from Poly-Cotton where there are 60 percent of polyester and 40 percent of cotton. The façade of the tent is supported by three poles with two at the each end of the ridge bean and on at the center. The outer layer of the tent is maintained with the ridge pipe and closed by using Velcro tape that is 100mm long at the end of the ridge. The side of the tent is supported with six side poles that have metal hook in order to hook on the webbing band on the top of the wall. The hook for the poles are placed flat. Then, the front and rear side of vestibules are being supported with two poles that are placed at the doors' corners. The outer layer of the tent has two long windows that are covered with mosquito net and rain flap. The dimensions for the windows are 3500mm x 300mm. The outer layer of the tent has two ventilation openings. The roof of the tent has two triangular shape vents that are having dimensions of 250mm x 300mm. However, the roof vents are often closed by using 25mm Velcro tape. The dimension for the door is 1.4m x 1.6m. The whole UNHCR Family Tent is made from poly ester that are water resistant.

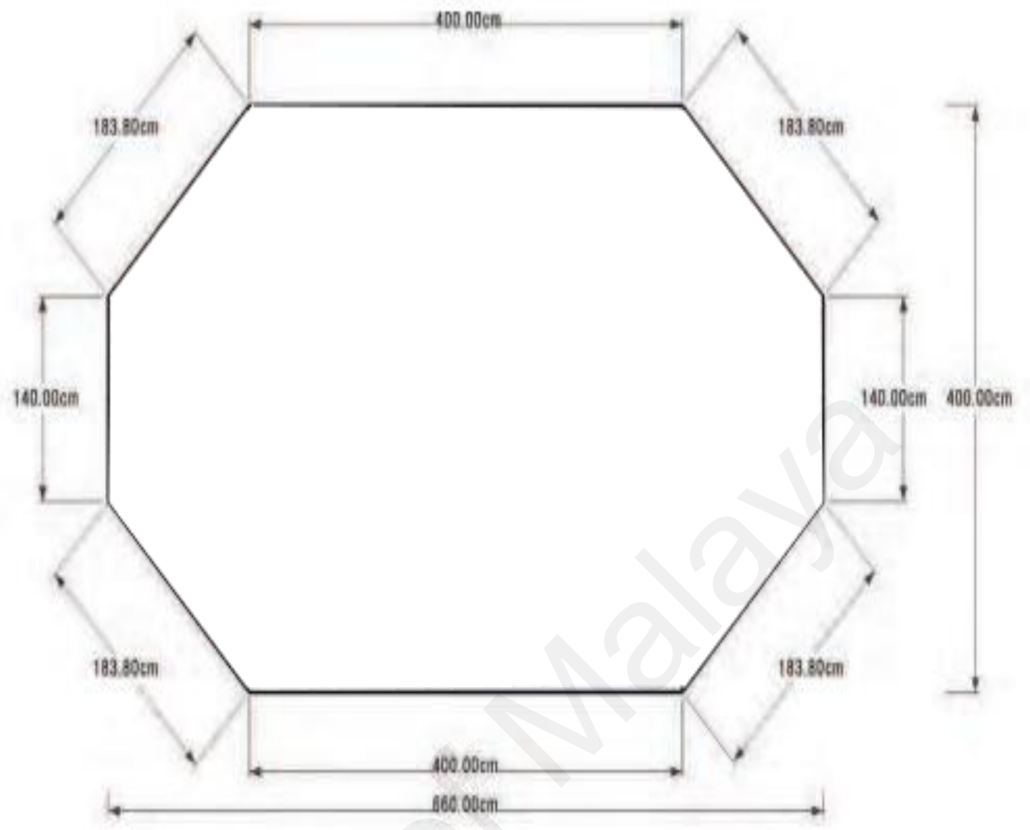

Figure 3.1: Schematic Layout of UNHCR Family Tent

3.3 Defining Case

The ventilation flow and temperature inside the UNHCR Family Tent are being simulated in different situations where the openings are located in different places such as wall, roof and door.

3.3.1 Case 1: 3D Model of UNHCR Family Tent with closed openings except for a door

The 3D Model 1 of UNHCR Family Tent is imitating the situation where there is no ventilation at all walls and roof except one door.

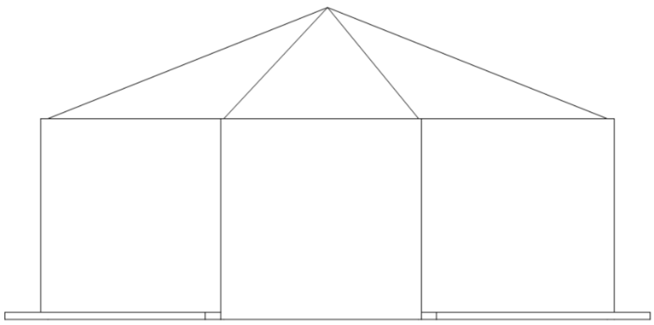

Figure 3.2: Front Elevation of 3D Model 1 (Scale:1: 20)

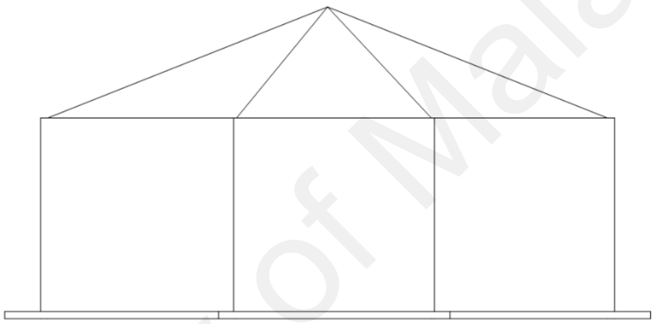

Figure 3.3: Rear Elevation of 3D Model 1 (Scale:1: 20)

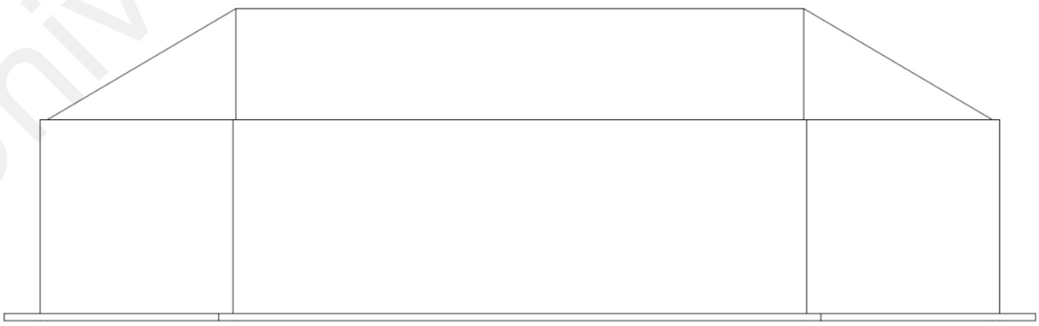

Figure 3.4: Left Elevation of 3D Model 1 (Scale:1: 20)

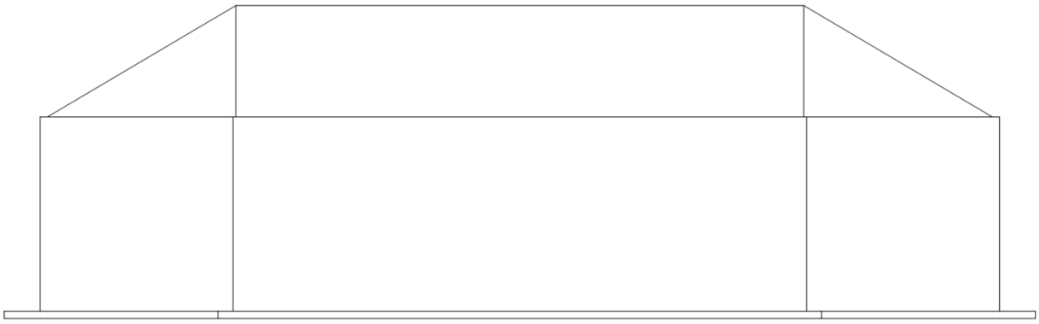

Figure 3.5: Right Elevation of 3D Model 1 (Scale:1: 20)

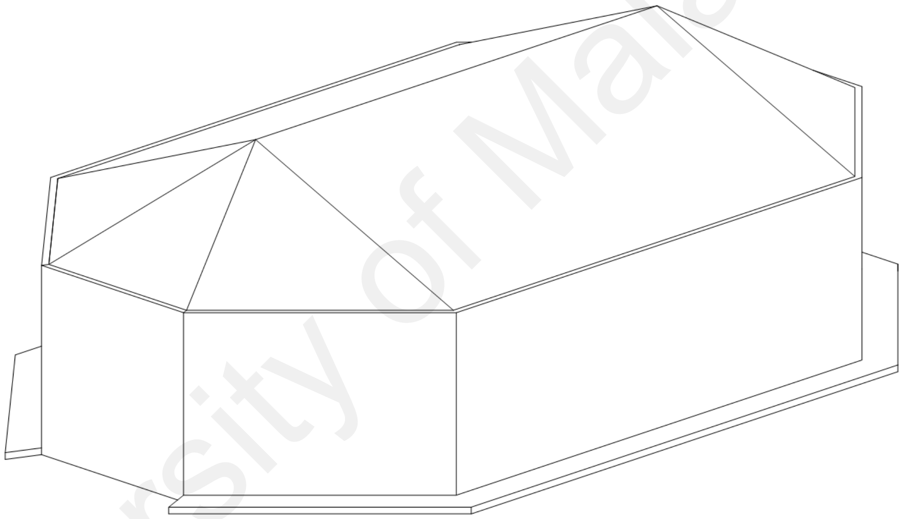

Figure 3.6: Isometric View of 3D Model 1 (Scale:1: 20)

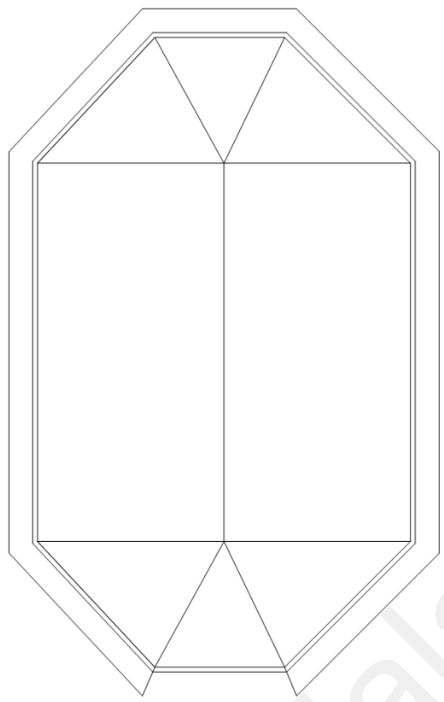

Figure 3.7: Top View of 3D Model 1 (Scale:1: 30)

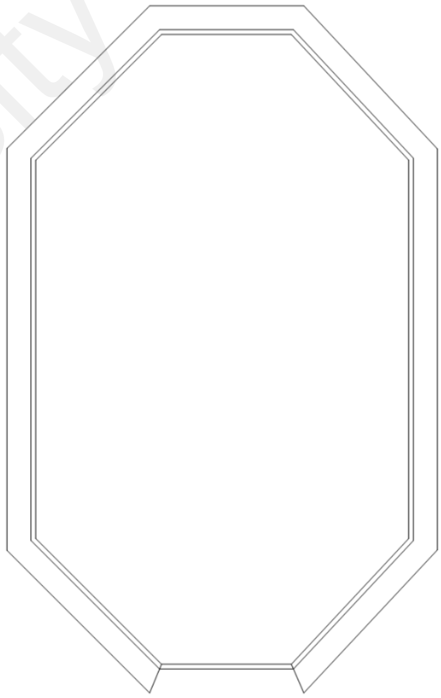

Figure 3.8: Bottom View of 3D Model 1 (Scale:1: 30)

3.3.2 Case 2: Addition of Window Openings to Case 1

The 3D Model 2 of UNHCR Family Tent is imitating the situation where there are window openings at the side of the 3D Model 2 with a door at the front.

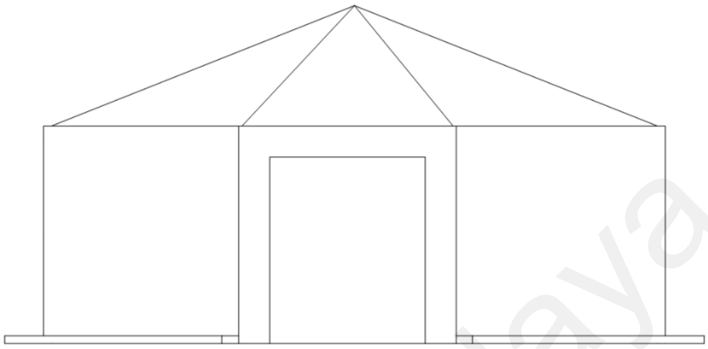

Figure 3.9: Front Elevation of 3D Model 2 (Scale:1: 20)

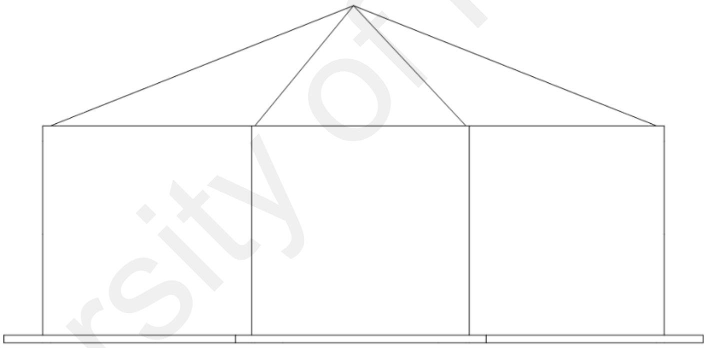

Figure 3.10: Rear Elevation of 3D Model 2 (Scale:1: 20)

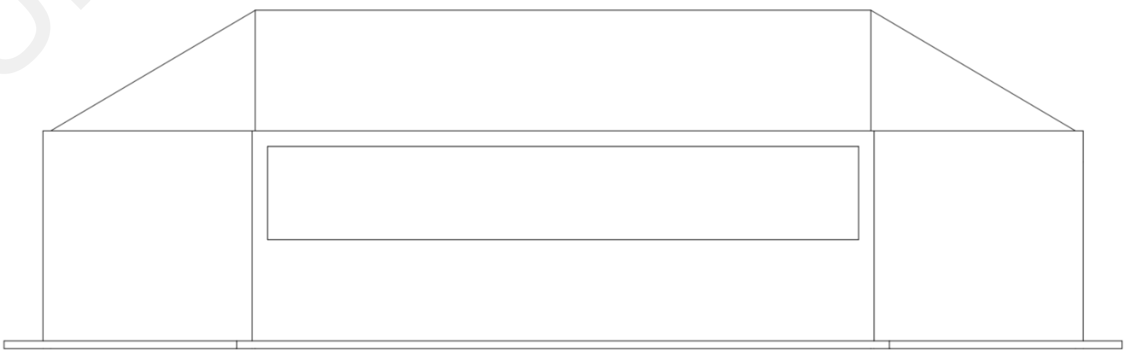

Figure 3.11: Left Elevation of 3D Model 2 (Scale:1: 20)

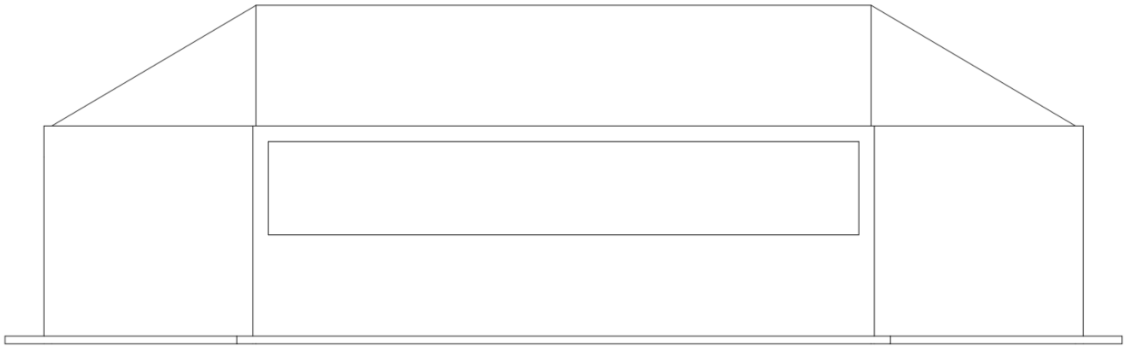

Figure 3.12: Right Elevation of 3D Model 2 (Scale:1: 20)

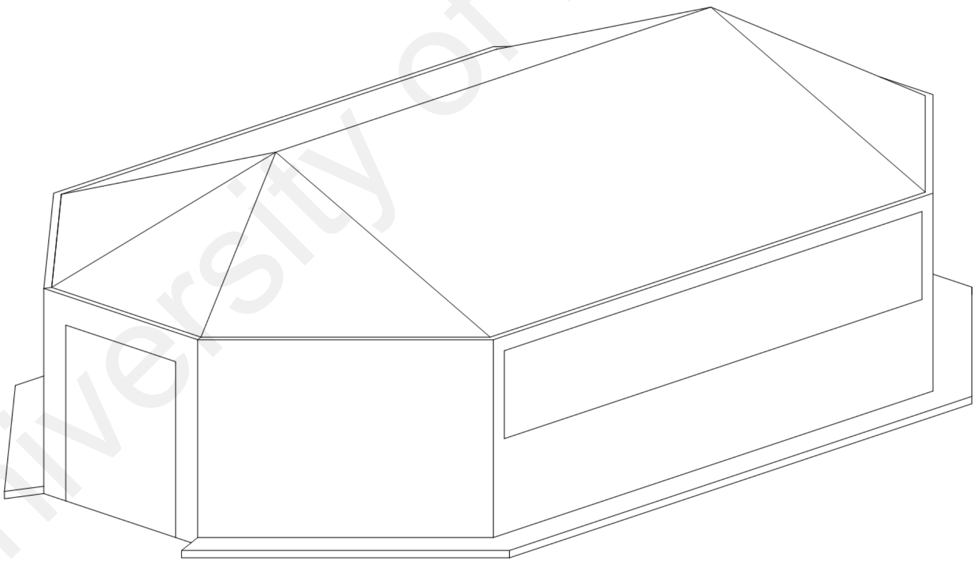

Figure 3.13: Isometric View of 3D Model 2 (Scale:1: 20)

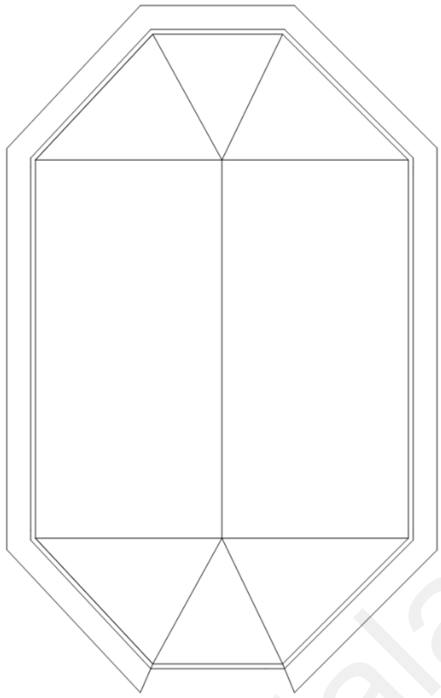

Figure 3.14: Top View of 3D Model 2 (Scale:1: 30)

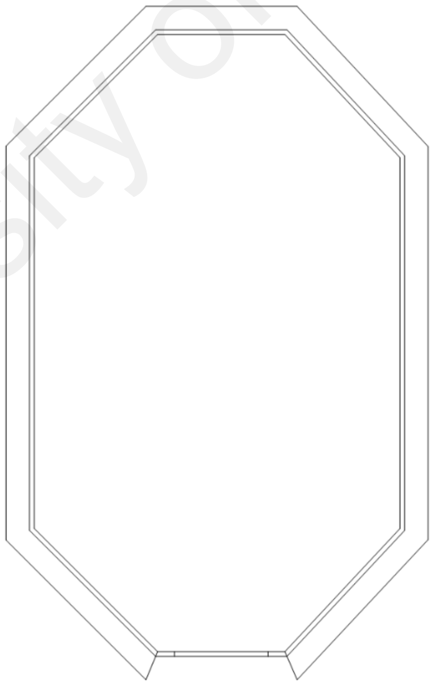

Figure 3.15: Bottom View of 3D Model 2 (Scale:1: 30)

3.3.3 Case 3: Addition of Rear Door to Case 2

The 3D Model 3 of UNHCR Family Tent is imitating the situation where there are window openings at the side of the 3D Model 2, two doors at the front and rear side.

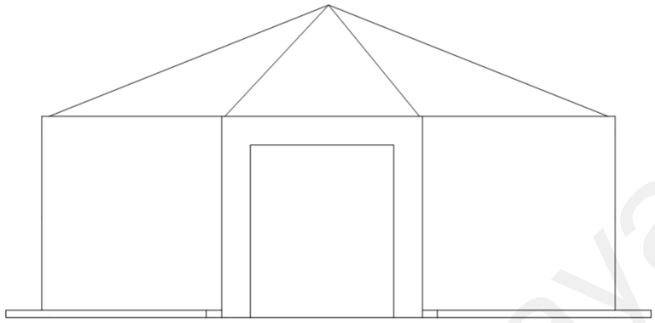

Figure 3.16: Front Elevation of 3D Model 3 (Scale:1: 20)

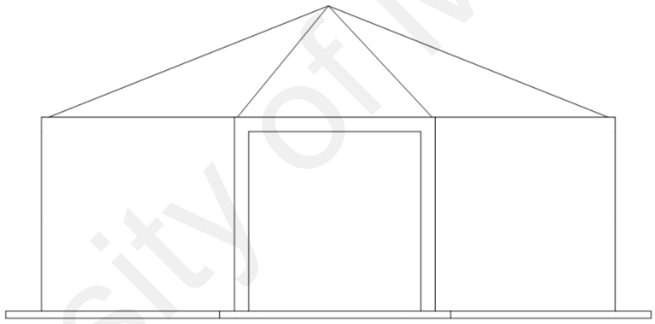

Figure 3.17: Rear Elevation of 3D Model 3 (Scale:1: 20)

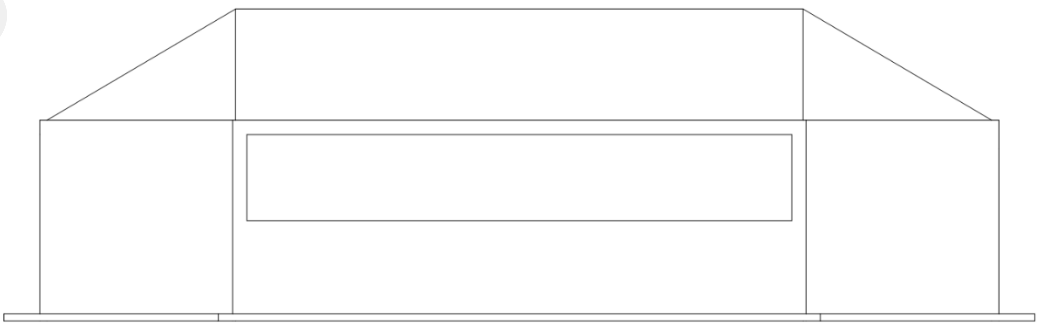

Figure 3.18: Left Elevation of 3D Model 3 (Scale:1: 20)

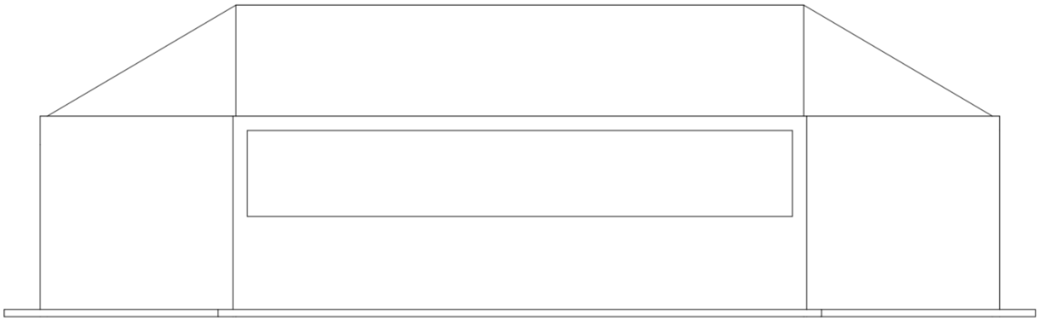

Figure 3.19: Right Elevation of 3D Model 3 (Scale:1: 20)

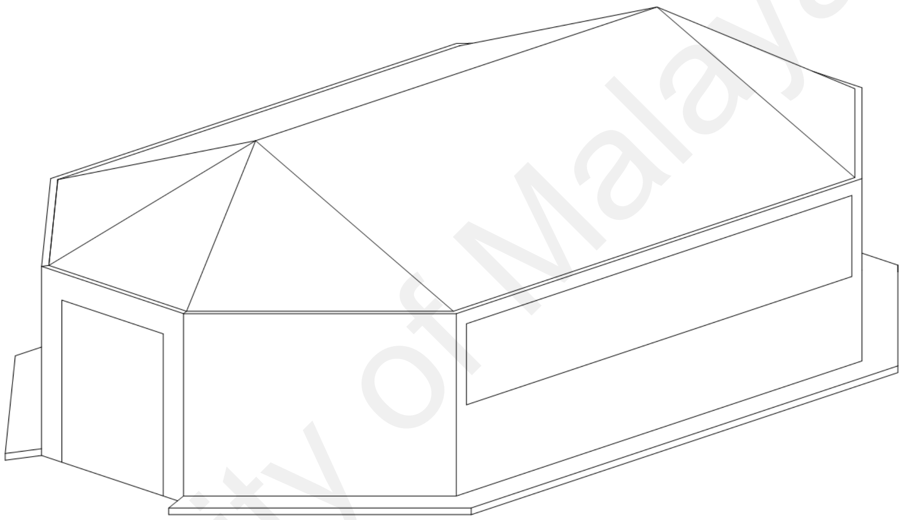

Figure 3.20: Isometric View of 3D Model 3 (Scale:1: 20)

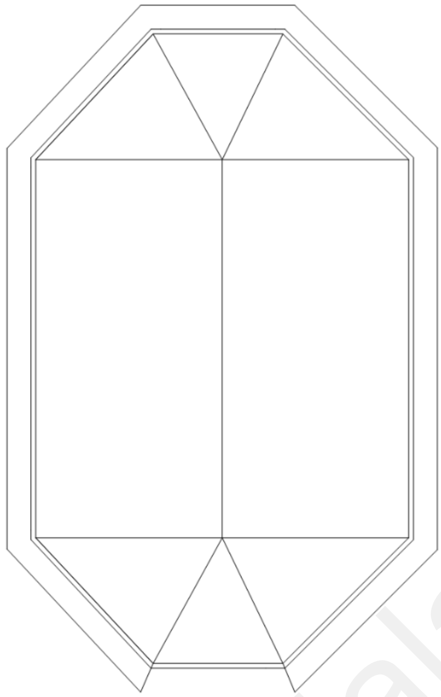

Figure 3.21: Top View of 3D Model 3 (Scale:1: 30)

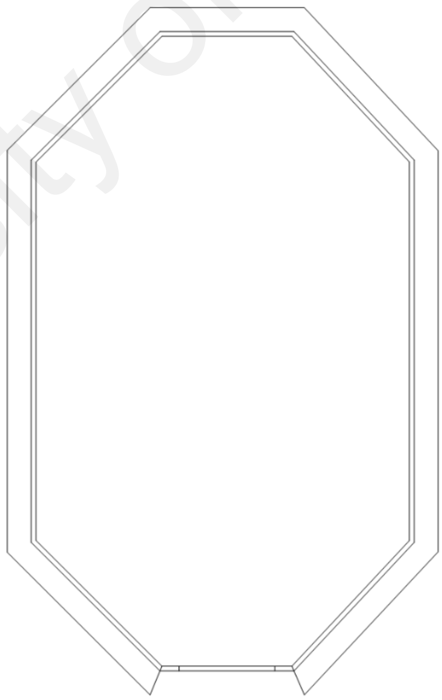

Figure 3.22: Bottom View of 3D Model 3 (Scale:1: 30)

3.3.4 Case 4: Addition of a Roof Opening to Case 3

The 3D Model 4 of UNHCR Family Tent is imitating the situation where there are window openings at the side of the 3D Model 3, two doors at the front, rear side and a roof opening.

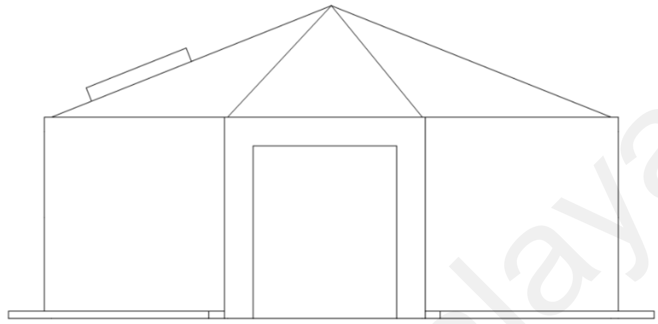

Figure 3.23: Front Elevation of 3D Model 4 (Scale:1: 20)

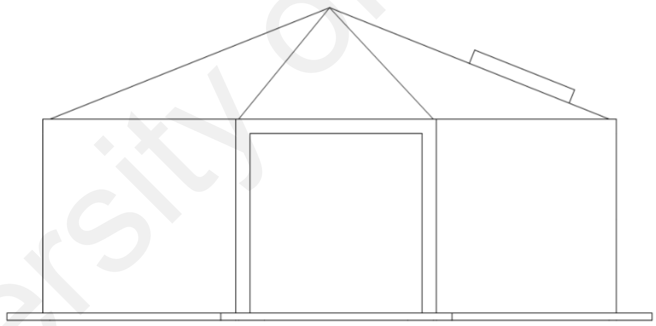

Figure 3.24: Rear Elevation of 3D Model 4 (Scale:1: 20)

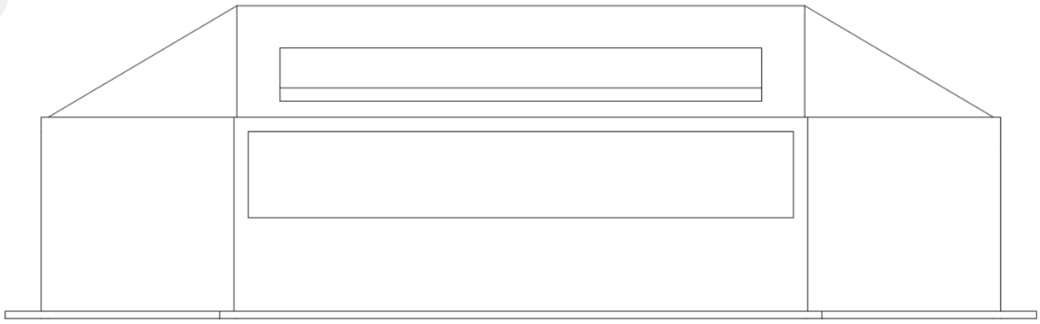

Figure 3.25: Left Elevation of 3D Model 4 (Scale:1: 20)

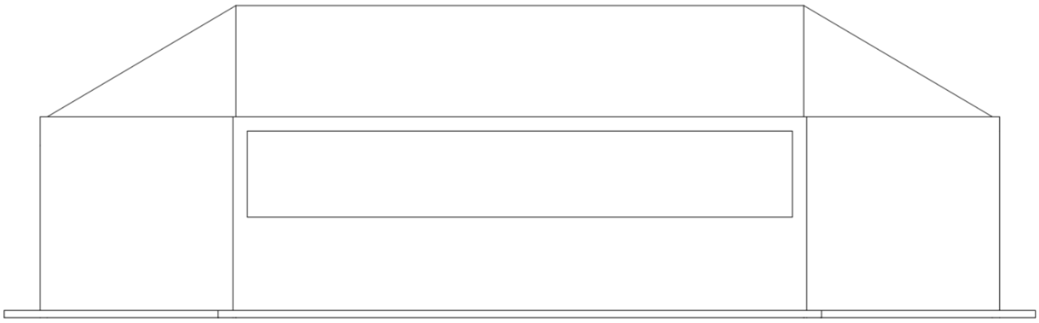

Figure 3.26: Right Elevation of 3D Model 4 (Scale:1: 20)

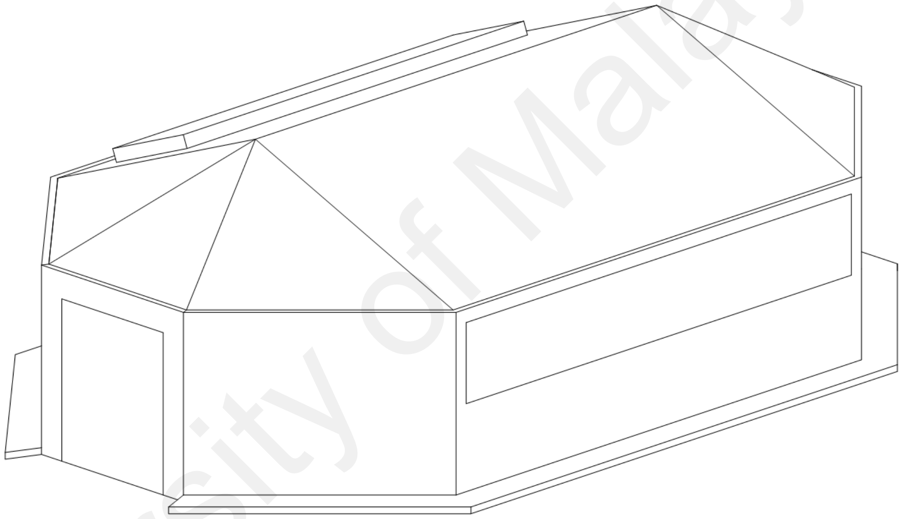

Figure 3.27: Isometric View of 3D Model 4 (Scale:1: 20)

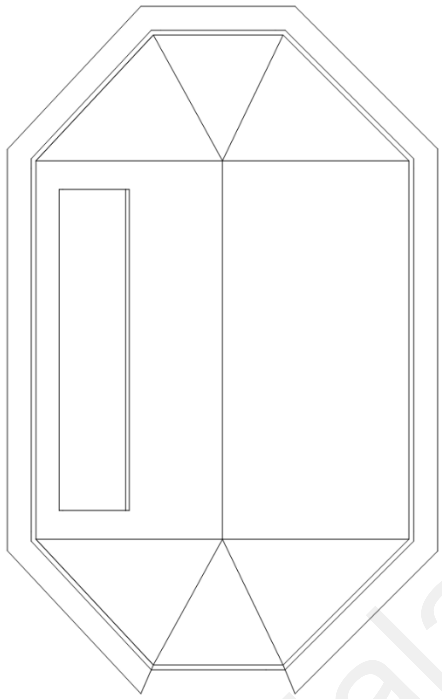

Figure 3.28: Top View of 3D Model 4 (Scale:1: 30)

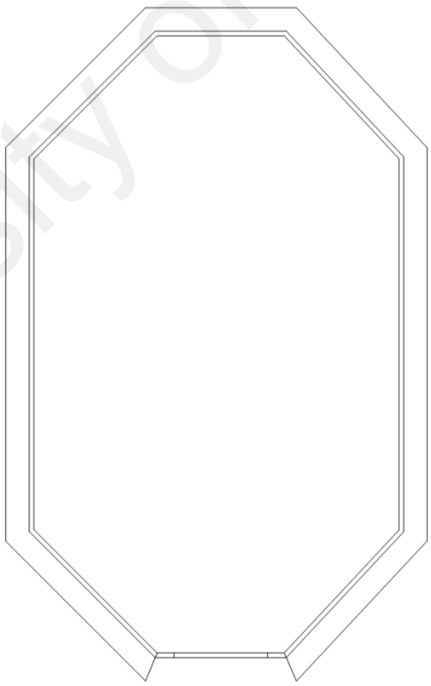

Figure 3.29: Bottom View of 3D Model 4 (Scale:1: 30)

3.4 ANSYS Fluent

In this research study, ANSYS Fluent is being used to simulate different behavior on ventilations and temperature when different openings are added to the UNHCR Family Tent. The ANSYS Fluent will simulate the different case studies to find the optimum ventilation and temperature for the UNHCR Family Tent. By looking at the simulation data, the data are being analysed in order to find the effectiveness in placing the openings in different locations.

3.5 Geometry

The first step of the study is draw the 3D models for 4 different case studies by using Sketchup 2018. The 3D Sketchup models are then imported into the ANSYS Fluent in order to mesh the 3D models. The 3D models' dimensions are following the dimensions of the schematic layout.

3.6 Meshing

After finishing with the 3D models, meshing has to be done inside the ANSYS as the second step in order to set up the data and entering value for each parameter.

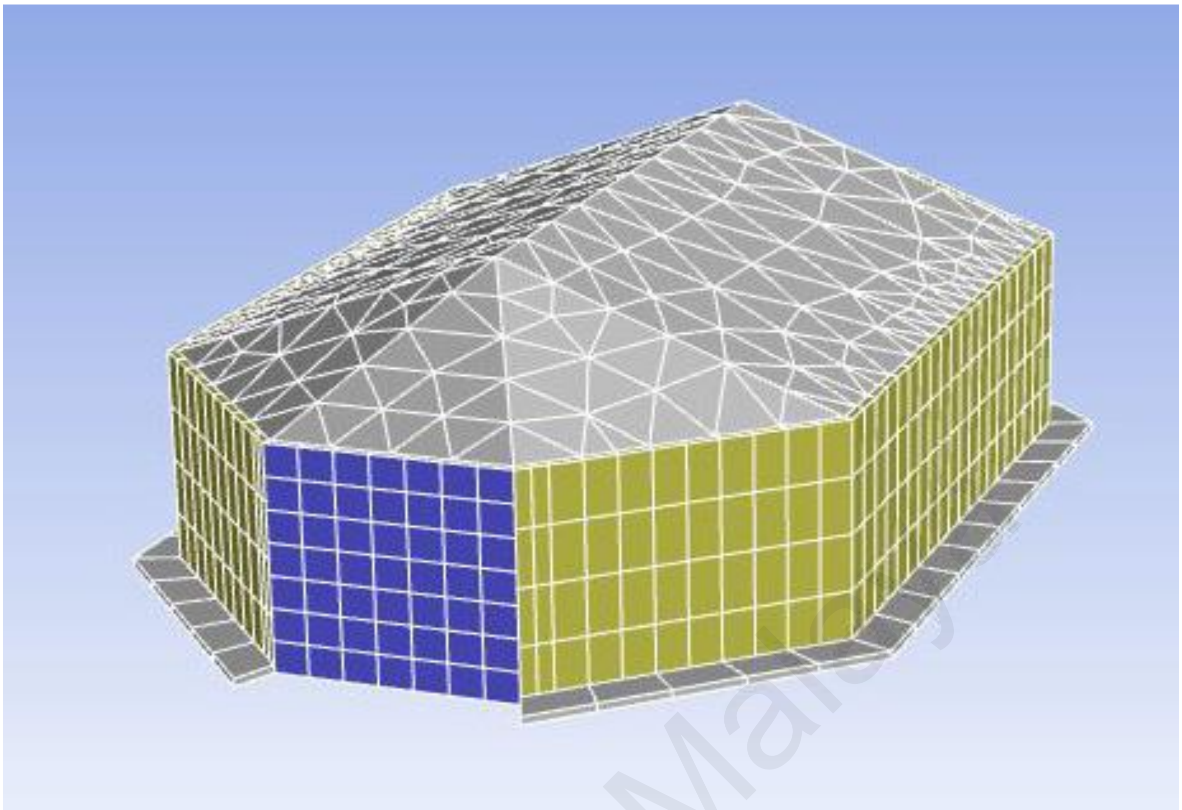

Figure 3.30: Mesh View of 3D Model 1

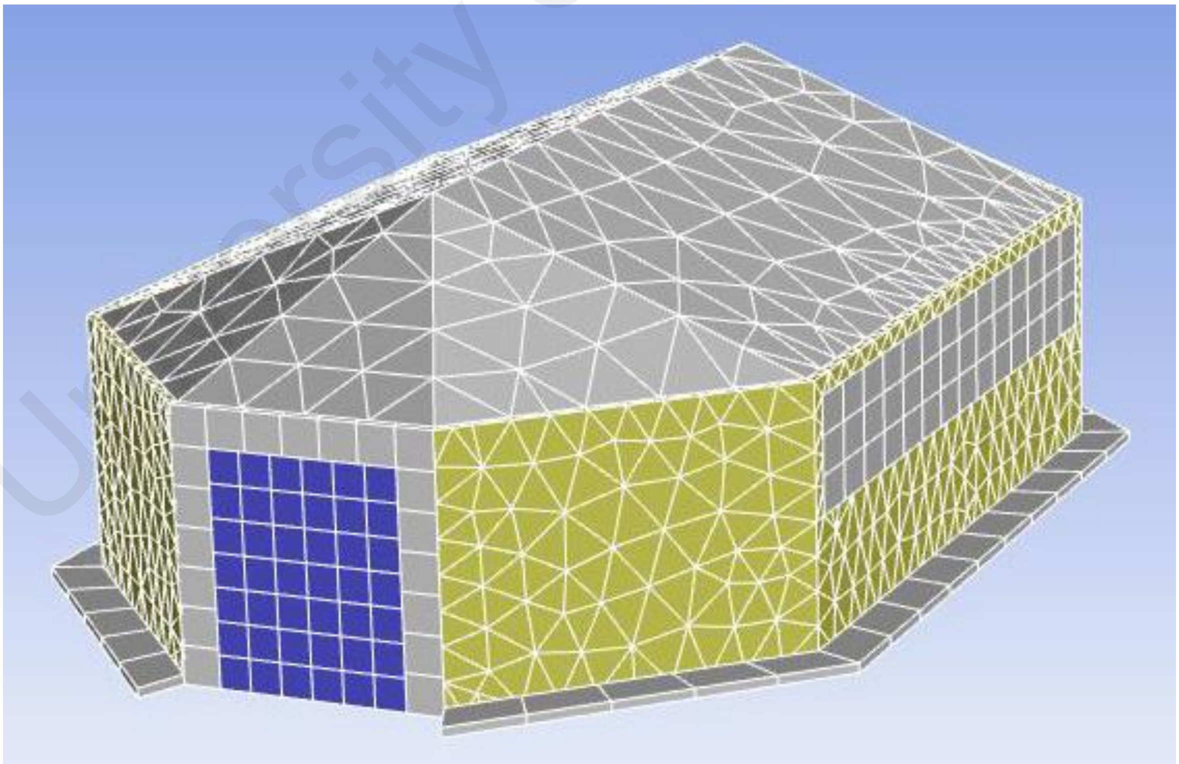

Figure 3.31: Mesh View of 3D Model 2

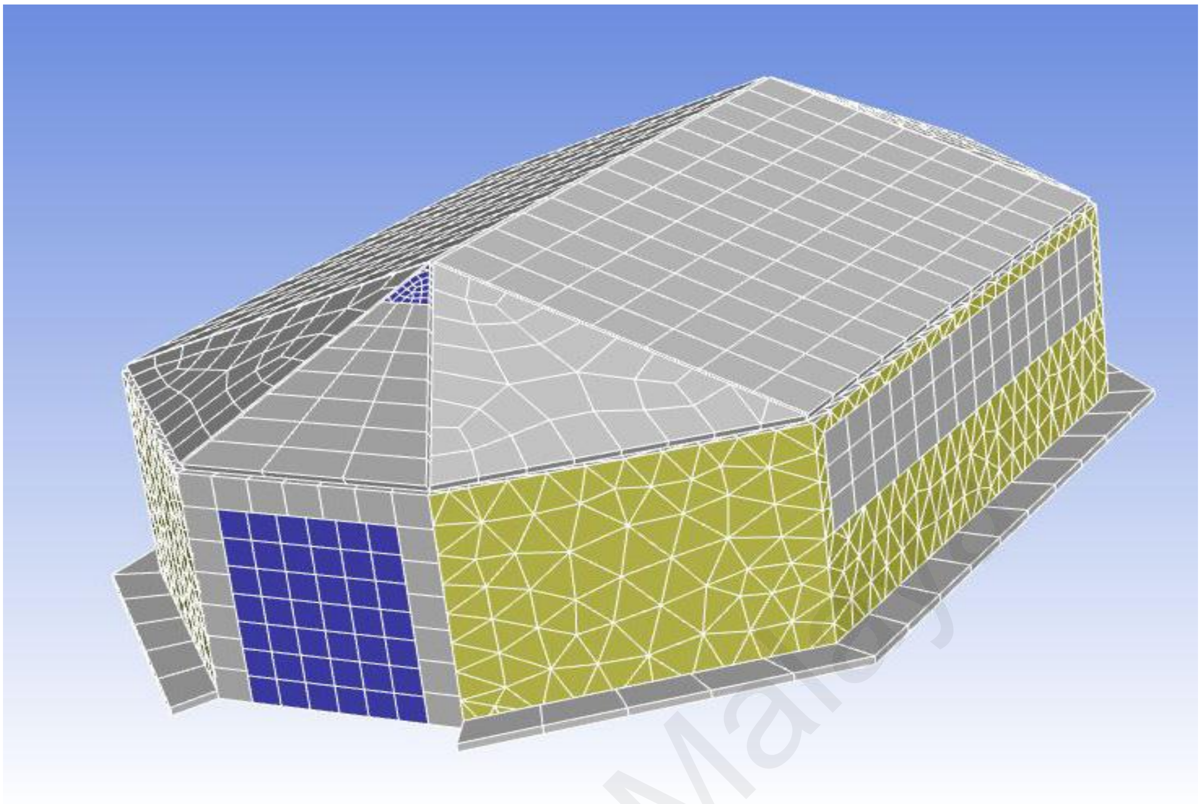

Figure 3.32: Mesh View of 3D Model 3

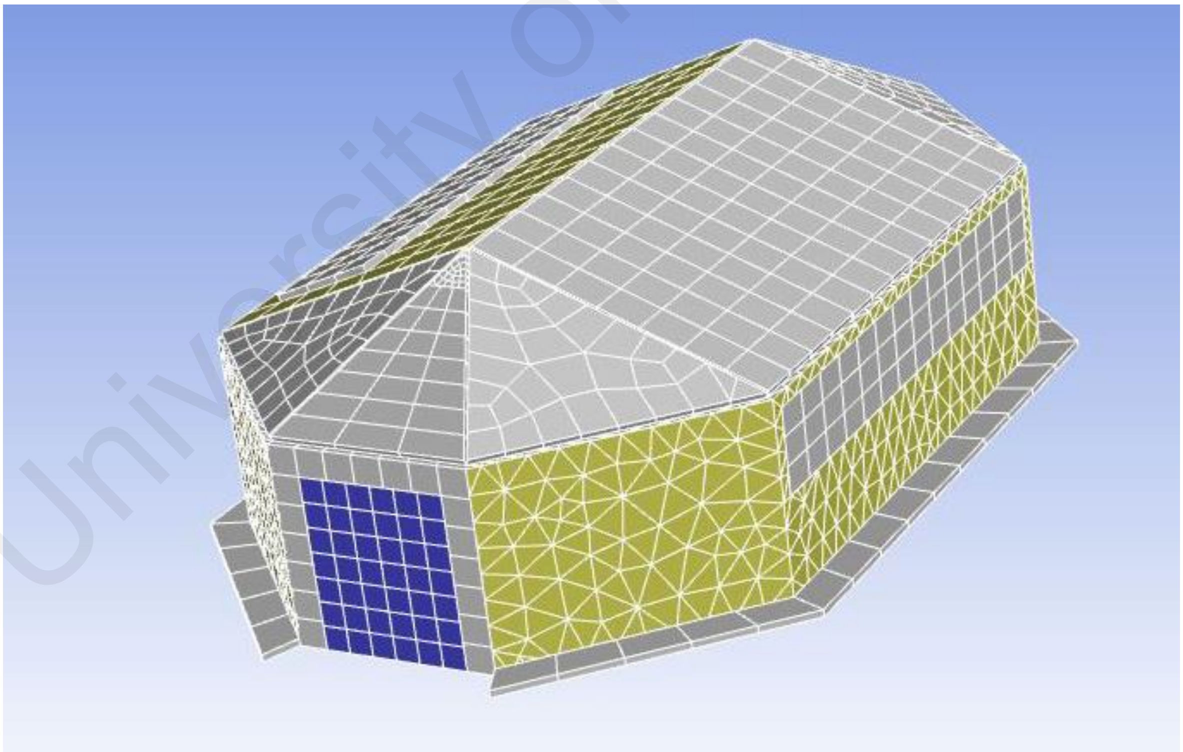

Figure 3.33: Mesh View of 3D Model 4

3.7 Setup

After finishing with the meshing of the 3D models, data are being setup and parameters are being inserted into the ANSYS Fluent in order to simulate for ventilation and temperature data.

No	UNHCR Family Tent Parts	Boundary Conditions.
1	Tent's Roof	Thermal Conditions: Mixed Heat Transfer Coefficient: 33 w/m2-k Free Stream Temperature: 40c External Emissivity:1 External Radiation Temperature: 42c Wall Thickness:0.001m
2	Tent's Wall	Thermal Conditions: Mixed Heat Transfer Coefficient: 33 w/m2-k Free Stream Temperature: 36c External Emissivity:1 External Radiation Temperature: 38c Wall Thickness:0.001m

Table 3.1: Boundary Conditions of Scenario 1 for 3D Model 1

No	UNHCR Family Tent Parts	Boundary Conditions.
1	Tent's Roof	Thermal Conditions: Mixed Heat Transfer Coefficient: 33 w/m2-k

		Free Stream Temperature: 40c External Emissivity:1 External Radiation Temperature: 42c Wall Thickness:0.001m
2	Tent's Wall	Thermal Conditions: Mixed Heat Transfer Coefficient: 33 w/m2-k Free Stream Temperature: 36c External Emissivity:1 External Radiation Temperature: 38c Wall Thickness:0.001m
3	Tent's Openings	Thermal Conditions: Mixed Heat Transfer Coefficient: 23 w/m2-k Free Stream Temperature: 26.8c External Emissivity:1 External Radiation Temperature: 28c Wall Thickness:0.001m

Table 3.2: Boundary Conditions of Scenario 2 for 3D Model 2

No	UNHCR Family Tent Parts	Boundary Conditions.
1	Tent's Roof	Thermal Conditions: Mixed Heat Transfer Coefficient: 33 w/m2-k Free Stream Temperature: 40c

		External Emissivity:1 External Radiation Temperature: 42c Wall Thickness:0.001m
2	Tent's Wall	Thermal Conditions: Mixed Heat Transfer Coefficient: 33 w/m2-k Free Stream Temperature: 36c External Emissivity:1 External Radiation Temperature: 38c Wall Thickness:0.001m
3	Tent's Openings	Thermal Conditions: Mixed Heat Transfer Coefficient: 23 w/m2-k Free Stream Temperature: 26.8c External Emissivity:1 External Radiation Temperature: 28c Wall Thickness:0.001m

Table 3.3: Boundary Conditions of Scenario 3 for 3D Model 3

No	UNHCR Family Tent Parts	Boundary Conditions.
1	Tent's Roof	Thermal Conditions: Mixed Heat Transfer Coefficient: 33 w/m2-k Free Stream Temperature: 40c External Emissivity:1 External Radiation Temperature: 42c

		Wall Thickness:0.001m
2	Tent's Wall	Thermal Conditions: Mixed Heat Transfer Coefficient: 33 w/m2-k Free Stream Temperature: 36c External Emissivity:1 External Radiation Temperature: 38c Wall Thickness:0.001m
3	Tent's Openings	Thermal Conditions: Mixed Heat Transfer Coefficient: 23 w/m2-k Free Stream Temperature: 26.8c External Emissivity:1 External Radiation Temperature: 28c Wall Thickness:0.001m

Table 3.4: Boundary Conditions of Scenario 4 for 3D Model 4

3.8 Data Collection

3.8.1 Case 1: 3D Model of UNHCR Family Tent with closed openings except for a door

In this case, data for the pressure inlet which is the door opening is analysed and studied. This is to find the relationship between the velocity flow and the thermal condition of the door with the space.

3.8.2 Case 2: Addition of Window Openings to Case 1

In this case, data for the pressure inlet which are the door opening and the window openings are studied in order to find out the relationship between the velocity flow and the thermal condition. This case study will be able for us to study on the ventilation flow inside the UNHCR Family tent. This can helps in analyzing the effectiveness of the openings in influencing the dynamic ventilation flow.

3.8.3 Case 3: Addition of Rear Door to Case 2

In this case, data for the pressure inlet which are the door openings, roof vents and the window openings are studied in order to find out the relationship between the velocity flow and the thermal condition. In this case study, we are able to see whether adding in another door at the rear side of the UNHCR Family Tent are able to increase the dynamic flow of ventilation inside the tent.

3.8.4 Case 4: Addition of a Roof Opening to Case 3

In this case, data for the pressure inlet which are the door openings, roof vents, a roof opening and the window openings are studied in order to find out the relationship between the velocity flow and the thermal condition. In this study, we are able to study whether adding in one roof opening can increase the dynamic flow of the ventilation and decrease the temperature inside the UNHCR Family Tent.

3.9 Hypothesis

The condition for the UNHCR Family Tent is poor in terms of ventilation and thermal performance. The ventilation flow of the UNHCR Family Tent is limited and poor ventilated. The thermal performance of the UNHCR Family Tent is poor and hot. The increasing number of openings will increase the air movement and velocity magnitude of the UNHCR Family tent and also decreasing the overall temperature of the UNHCR

Family Tent. Thus, Case 4 with the most number of openings at different locations will have the best result among all those case studies.

CHAPTER 4: RESULT AND DISCUSSION

4.1 Introduction

As these 4 case studies have different types of scenarios, therefore different parameters are used for those 4 case studies.

4.2 Case 1: 3D Model of UNHCR Family Tent with closed openings except for a door

In this case study, 3D Model 1 is a 3D model of UNHCR Family Tent that has single sided ventilation with only door opening as the pressure inlet. For this case study, the simulations parameters are stated on Table 3.1. After setting up the boundary conditions, the initialization of this case study is using standard initilisation that compute from all zones relative to cell zone. The initial value of the gauge pressure, X velocity, Y velocity, Z velocity, turbulent kinetic energy, turbulent kinetic energy, turbulent dissipation rate and temperature are set as by default inside the software. After finishing with the initialization, the calculation is run in 5000 iterations as this case study has only one pressure inlet. Therefore, the number of iterations can be larger comparing to other case studies that have more pressure inlets.

4.2.1 Air Movement of 3D Model 1

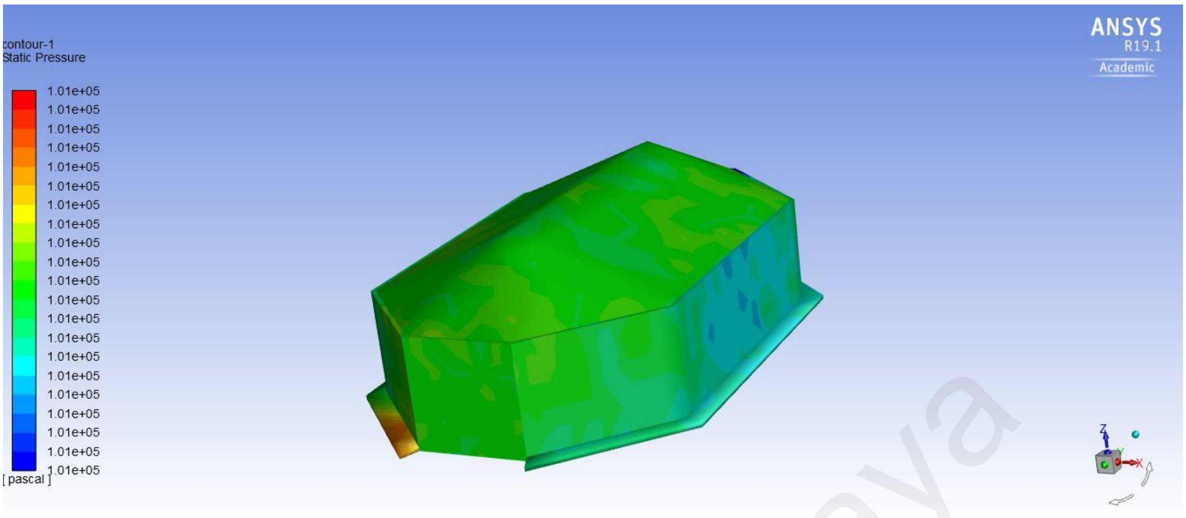

Figure 4.1: View 1 of 3D Model 1 (Static Pressure)

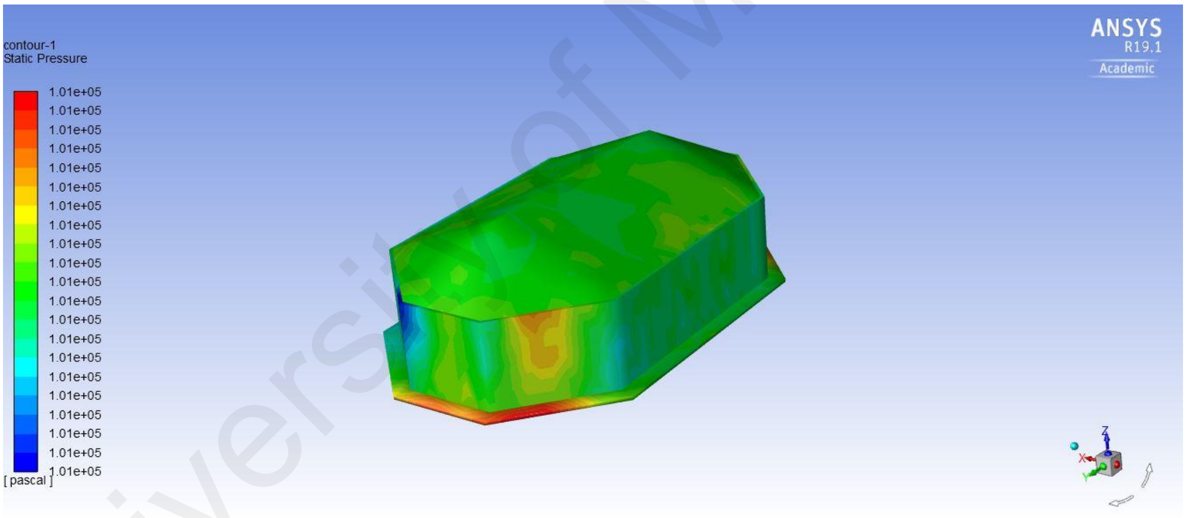

Figure 4.2: View 2 of 3D Model 1 (Static Pressure)

Optimum	Pressure (Pascal)
Minimum	101324.9
Maximum	101325.1

Table 4.1: Optimum Pressure of Case 1 for 3D Model 1

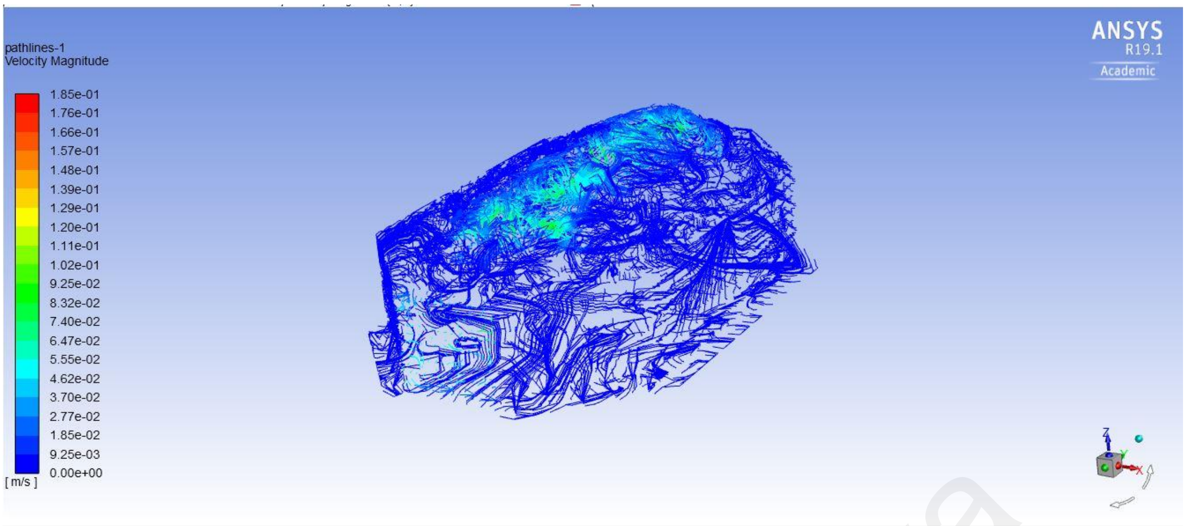

Figure 4.3: View of 3D Model 1 (Velocity Pathline)

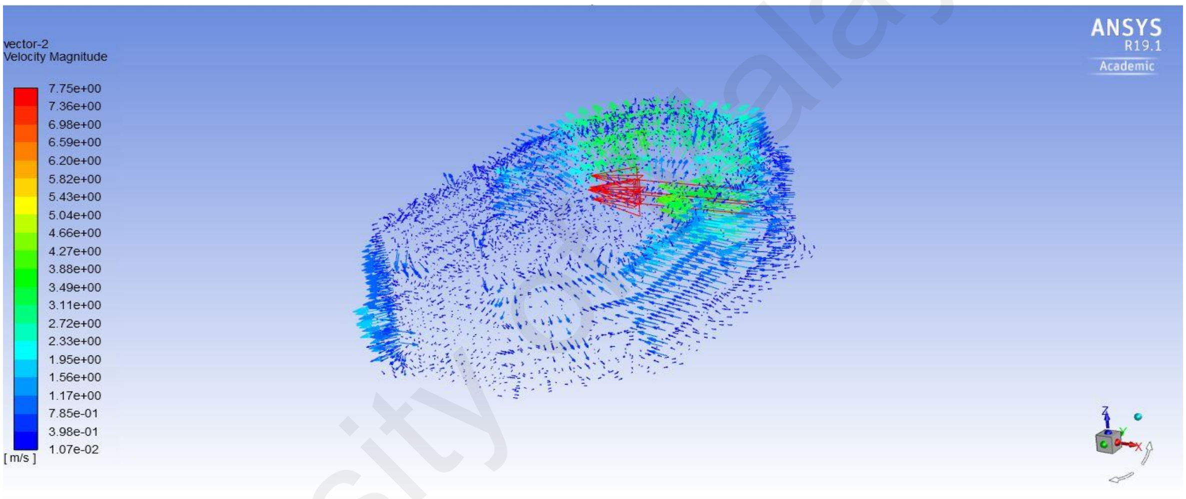

Figure 4.4: View of 3D Model 1 (Velocity Magnitude)

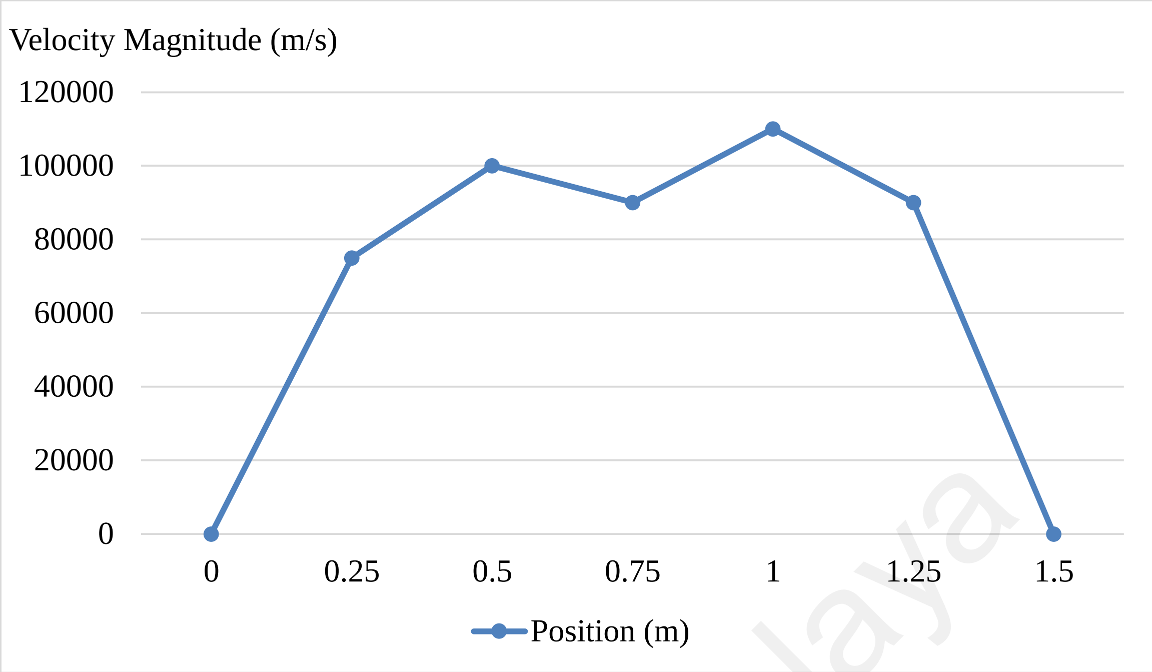

Figure 4.5: Simulated velocity magnitude against position of the 3D Model 1

Position (m)	Velocity Magnitude (m/s)
0.00	0
0.25	75,000
0.50	100,000
0.75	90,000
1.00	110,000
1.25	90,000
1.50	0

Table 4.2: Table of Simulated velocity magnitude against position of the 3D Model 1

Based on Table 4.1, the range of the pressure is between 101324.9 Pascal to 101325.1 Pascal, showing there is a stability in the pressure of the 3D Model 1.This is due to the single sided ventilation where only one opening is used for this design. In the original UNHCR Family Tent, openings are being enclosed with Velcro tape surrounding them. Therefore, it is difficult for occupants to open the openings except for the door openings.

The window openings are being surrounding with mosquito netting when open. The window openings are enable to penetrate proper amount of air flow. Even though based on the numeric data given through the simulation software, there are some pressures that are acting on the rear side of the wall and around the wall based on Figure 4.1 and Figure 4.2. As this research is focusing on the natural ventilation of the UNHCR Family Tent, therefore velocity magnitude and velocity pathline are being analysed for this research. In Figure 4.3, the velocity pathline is dynamic around the horizontal pathway from the front door to the backside of the wall. The surrounding pathline of the 3D Model 1 in Figure 4.3 shows there is no wind around the wall area except for the horizontal pathway where there are more changes in terms of the velocity magnitude from the range from 1.20e-01m/s to 3.70e-02 m/s. This is due to the front door that is located exactly in the middle of the 3D Model 1. There are no ventilation flow around the side walls of the 3D Model 1 as ventilation flow only exists at the horizontal pathway. In Figure 4.4, the velocity magnitude for the air is ranging from 4.66e+00 m/s to 1.07e-02 where there are some air movements that are happening at the rear side of the 3D Model 1. This is due to the horizontal pathway air movement that is moving towards the rear side of the wall. Figure 4.5 shows the graph of the simulated velocity magnitude against position of the 3D Model 1. Based on the Figure 4.5, it is shown that the velocity magnitude at the position 1.0 m has the highest velocity magnitude which is 110,000 m/s whereas the position 0m and 1.5m which are the position of the wall has the lowest velocity magnitude as those two positions are the wall. The graph shows most of the air movement is mostly happening from the position of 0.5m to 1.25m where the door opening is located. There are active air movements from 0.5m to 1.25m due to the air that are flowing in and out from the front door opening. Based on the Figure 4.5 and Table 4.2, the velocity magnitude at 0.50m to 1.25m are similar, therefore it can be proven that air movement is mostly reacting at that location which is the middle of the tent. Based on data given above, it can be concluded that the velocity magnitude is the highest at 1.0m where the air blows directly from the door which is the source of the air entering into the tent.

4.2.2 Temperature of UNHCR Family Tent

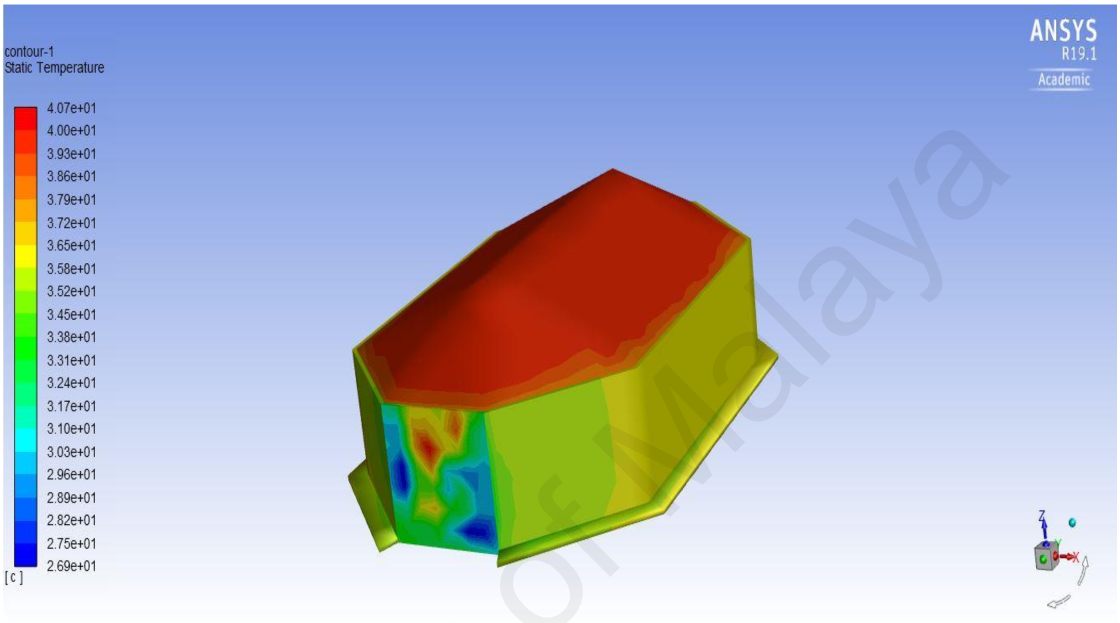

Figure 4.6: View 1 of 3D Model 1 (Temperature)

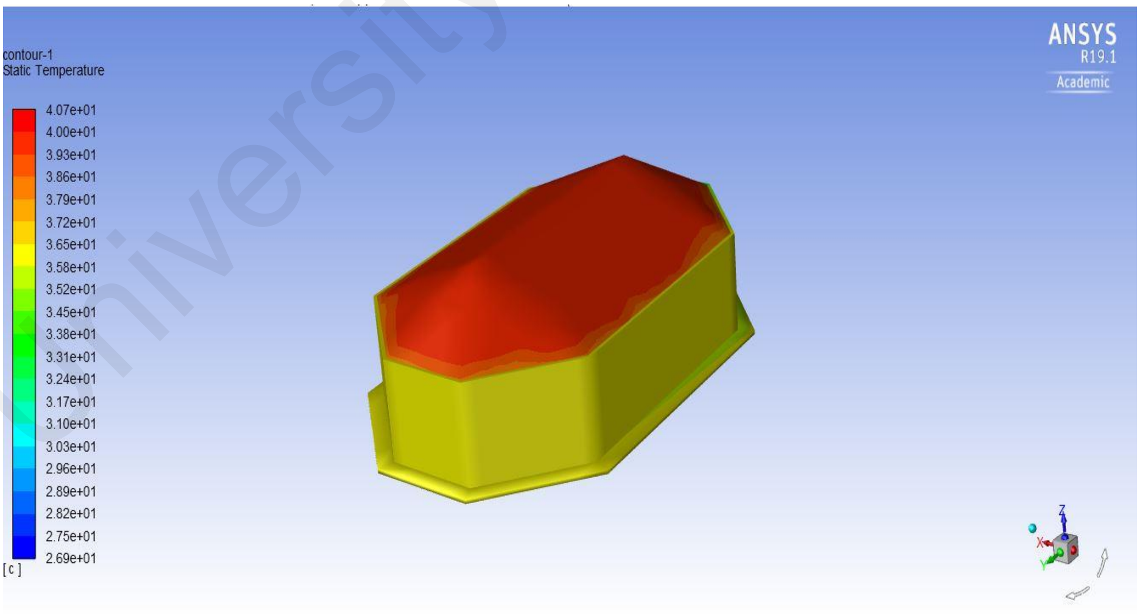

Figure 4.7: View 2 of 3D Model 1 (Temperature)

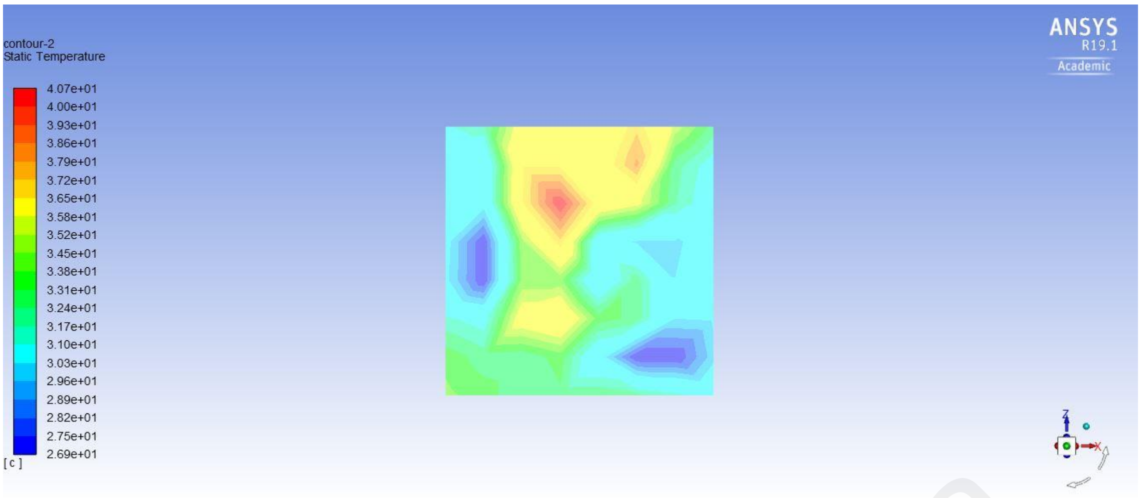

Figure 4.8: View 1 of 3D Model 1 (Temperature for Pressure Inlet)

Optimum	Temperature (°C)
Minimum	26.85
Maximum	40.6903

Table 4.3: Optimum Temperature of Case 1 for 3D Model 1

Based on Figure 4.5 and Figure 4.6, the temperature of the roof for 3D Model 1 is 4.07e+01 °C whereas the temperature for the wall of 3D Model 1 is 3.72e+01 °C. In Figure 4.5, the temperature changes mainly on the pressure inlet which is the door of 3D Model 1. In Figure 4.8, the temperature of pressure inlet for 3D Model 1 is ranging from 3.93e+01 °C to 2.59e+01 °C. In Table 4.3, it is shown that the minimum temperature of the 3D Model 1 is 26.85 °C and 40.6903. Based on data collected, we can conclude that in Case 1, the temperature changes mainly on the pressure inlet which is the door of 3D Model 1. The roof and the wall of 3D Model 1 has very static temperature changes. As can be seen in the Figure 4.6 and 4.7, the temperature changes mainly on the door of the 3D Model 1 as that is where the wind blows into the 3D Model 1. Since the temperature behavior is related with the ventilation flow where the ventilation flow is mainly acting on horizontal path way, only the door of the 3D Model 1 experience dynamic changes on temperature.

4.3 Case 2: Addition of Window Openings to Case 1

In this case study, the 3D Model 2 is a 3D model of UNHCR Family Tent that add in window openings to the 3D Model 1. The window openings will acts as the second pressure inlet to the 3D Model 2. Inside the 3D Model 2, boundary conditions are set up as Table 3.2. After setting up the 3D Model 2, the standard initialization that compute from all zone in relative to cell zone with all initial values of gauge pressure, X velocity, Y velocity, Z Velocity, Turbulent Kinetic Energy, Turbulent Dissipation Rate and Temperature which set as default are proceeded. The calculation is run with 100 ilterations as this is the maximum amount of ilterations that can be run before floating point exception occur.

4.3.1 Air Movement of UNHCR Family Tent

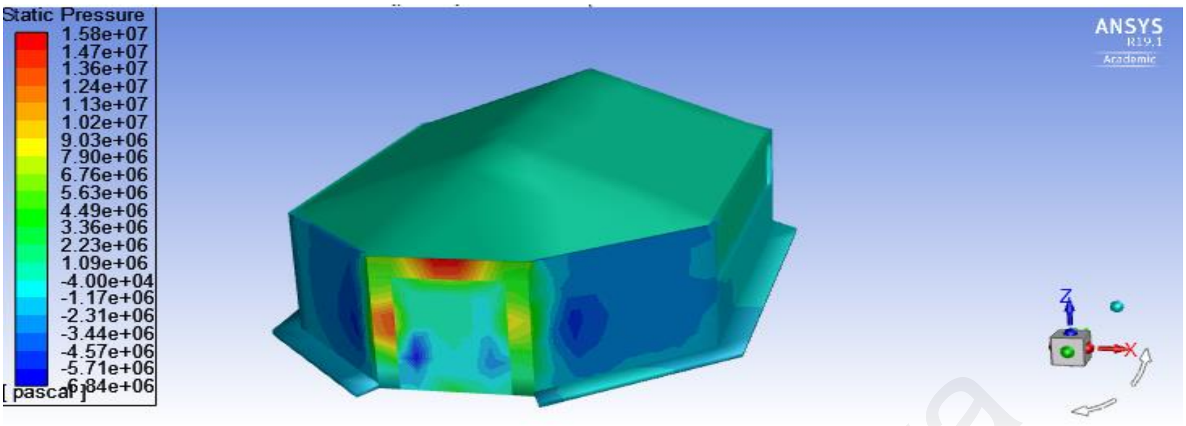

Figure 4.9: View 1 of 3D Model 2 (Static Pressure)

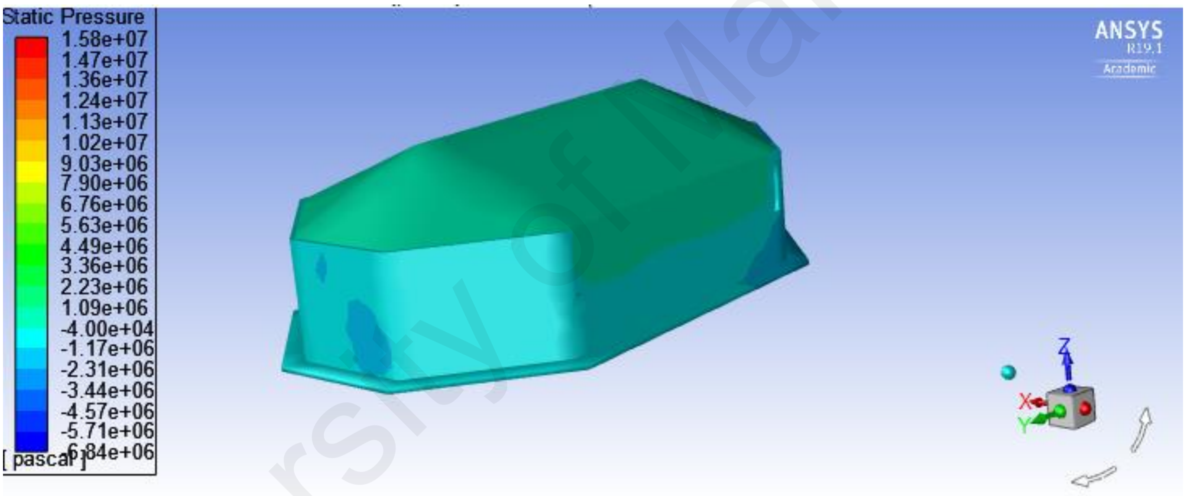

Figure 4.10: View 2 of 3D Model 2 (Static Pressure)

Optimum	Pressure (Pascal)
Minimum	-1.17e+06
Maximum	1.58e+07

Table 4.4: Optimum Pressure of Case 2 for 3D Model 2

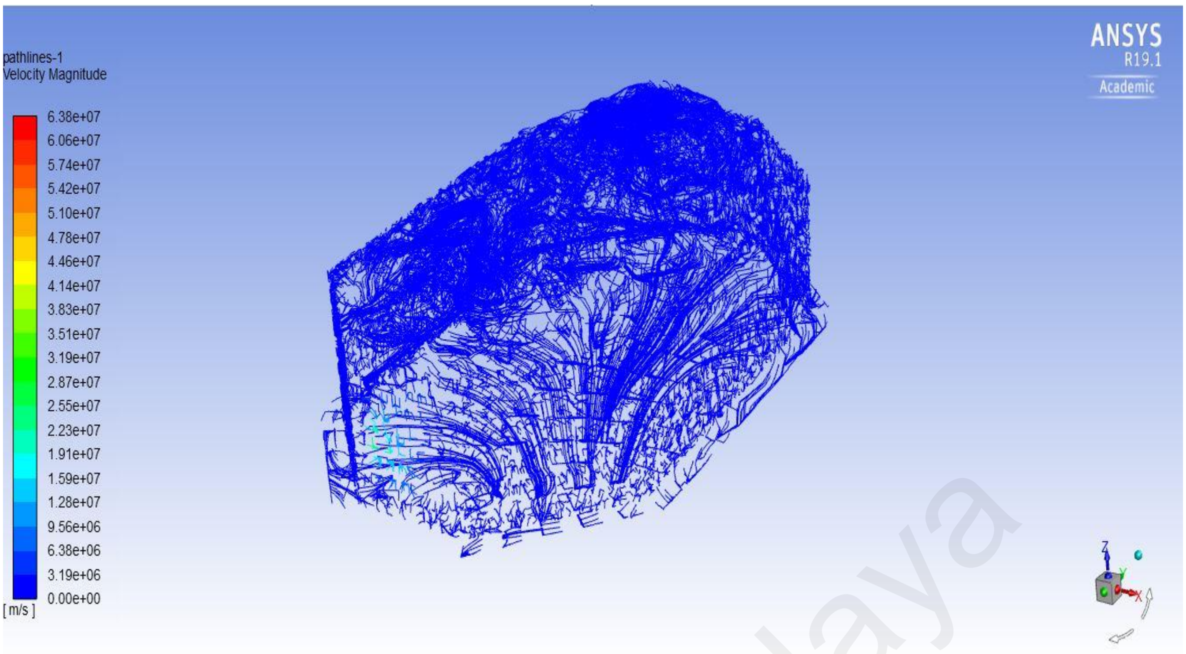

Figure 4.11: View of 3D Model 2 (Velocity Pathline)

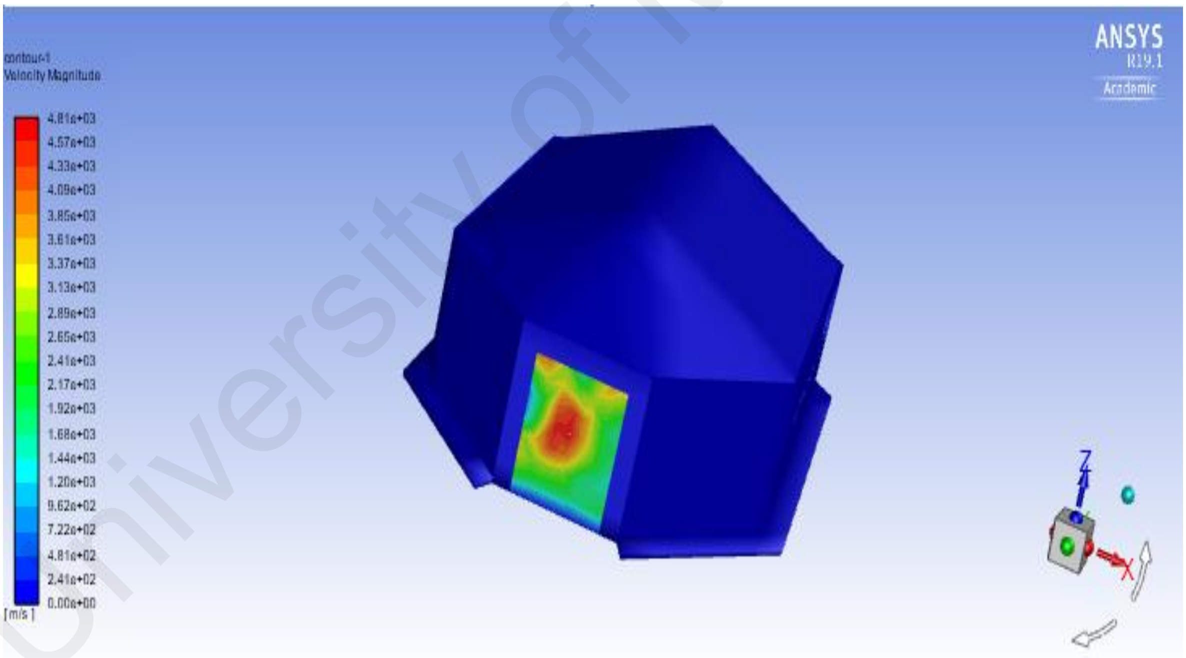

Figure 4.12: View of 3D Model 2 (Velocity Magnitude that is contoured and filled)

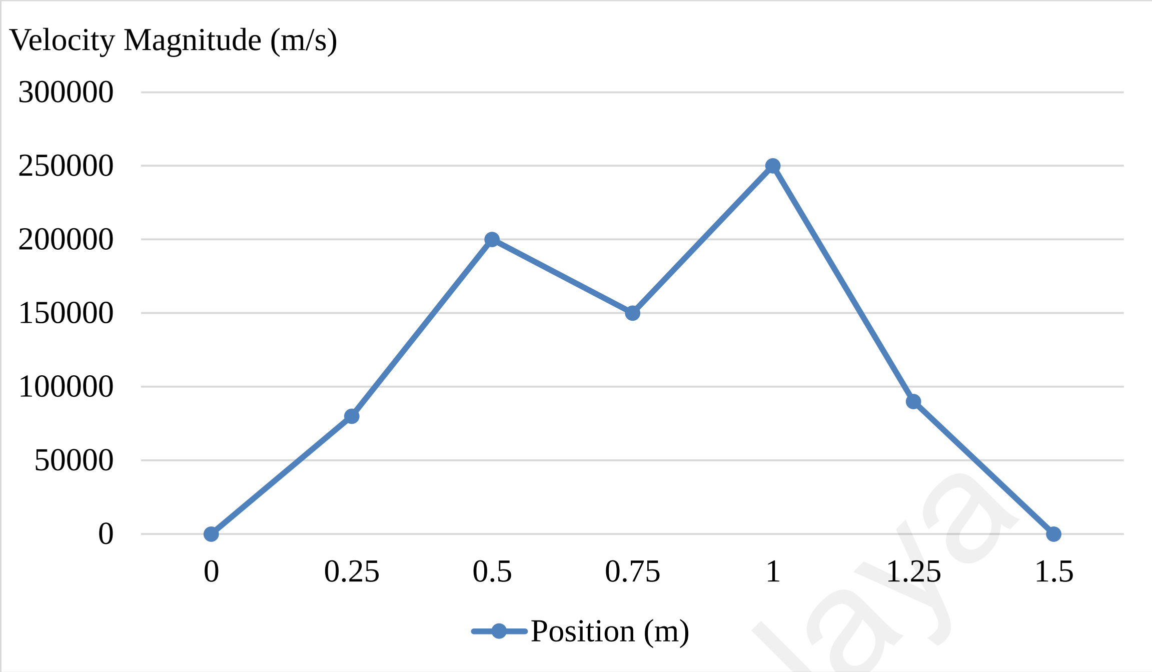

Figure 4.13: Simulated velocity magnitude against position of the 3D Model 2

Position (m)	Velocity Magnitude (m/s)
0.00	0
0.25	80,000
0.50	200,000
0.75	150,000
1.00	250,000
1.25	90,000
1.50	0

Table 4.5: Table of Simulated velocity magnitude against position of the 3D Model **2**

Based on the Figure 4.9 and Figure 4.10, the most dynamic pressure is put on the front door whereas the window openings have the same pressure as the roof. The pressure on the front door is ranging from 1.58e+07 Pascal to -1.17e+06 Pascal. The roof, window openings and the wall have similar pressure ranging from 4.49e+06 Pascal to -4.00e+04 Pascal. This is due to the air movement that is travelling on a straight path from the door opening. Then, based on Figure 4.11, the velocity pathline shows that there are more active reaction on the top of tent as there are air coming in from the windows and the door. In Figure 4.12, the velocity magnitude for all parts of the 3D Model 2 except the door is 4.81e+02m/s. The velocity magnitude for the door is ranging from 4.81e+03 m/s to 1.92e+02 m/s. Since the air is moving only in horizontal pathway, the window openings do not experience any ventilation flow, thus the velocity magnitude of the window openings are similar with other parts of the 3D Model 2. In Figure 4.13 and Table 4.5, the highest velocity magnitude is on the position of 1.00m. The velocity magnitude for this location is 250,000 m/s. This is due to window openings that are allowing more air entering into the 3D Model 2 as more air movement is reacting on the side of the 3D Model 2. The pattern of the graph as shown on Figure 4.13 is similar with the result that is gained from 3D Model 1 except for higher velocity magnitude. This is mainly due to the air movement that is flowing from the door and the window openings are reacting and circulating around the middle part of the 3D Model 2 instead of other parts of the 3D Model 2.

4.3.2 Temperature of UNHCR Family Tent

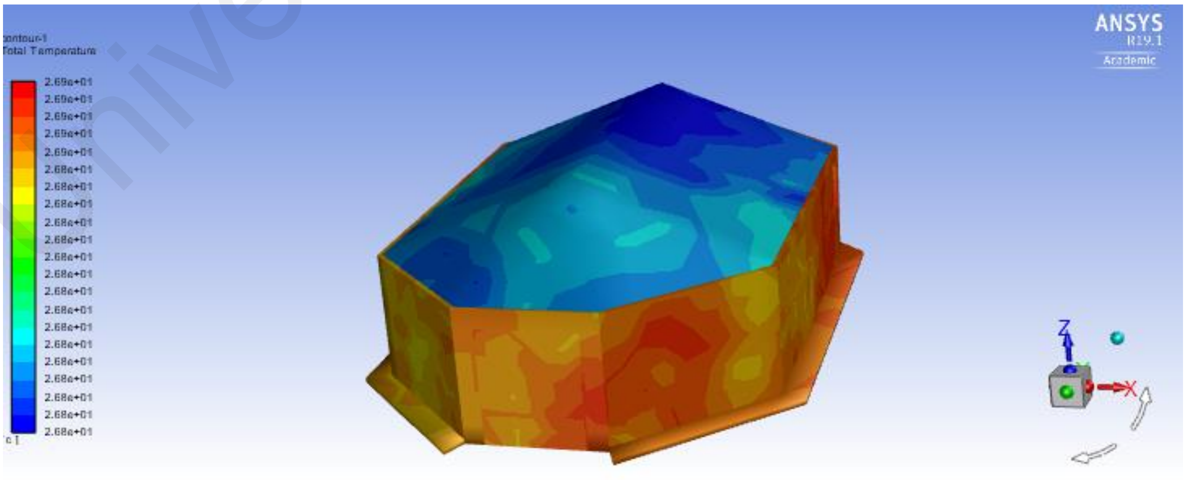

Figure 4.14: View 1 of 3D Model 2 (Temperature)

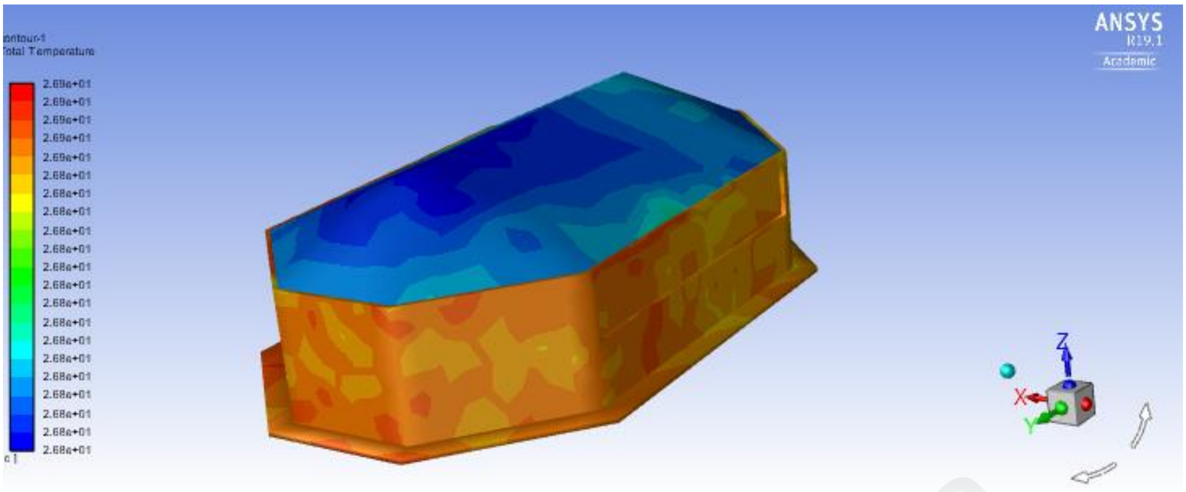

Figure 4.15: View 2 of 3D Model 2 (Temperature)

Optimum	Temperature (^oC)
Minimum	26.85
Maximum	40.6903

Table 4.6: Optimum Temperature of Case 2 for 3D Model 2

Based on Figure 4.14 and Figure 4.15, there are two situations that happening on the 3D Model 2. The first situation is the temperature of the wall, windows and openings are having similar temperature. The second situation is the temperature of the roof is colder than the walls, windows and openings. As the 3D Model 2 is not reaching the desired complete stage of simulation, therefore the difference of the temperature for different parts of the 3D Model 2 only can be seen using the different colour of the temperature inside the simulated 3D Model 2. Since 3D Model 2 is experiencing cross ventilation where there are two or more openings, the air movement is circulating around the middle part of the 3D Model 2 instead of the wall of the 3D Model 2. The air movement then starting to circulate around the upper part of the 3D Model 2, which is why the temperature of the roof for 3D Model 2 decrease as compared with the wall where there is no air circulate around the wall.

4.4 Case 3: Addition of Rear Door to Case 2

In this case study, 3D Model 3 is UNHCR 3D Model that is the same as 3D Model 2 with an additional the rear door at the back side. 3D Model 3 is facing the same issue as 3D Model 2 as there are 4 openings inside the 3D Model 3. . Inside the 3D Model 3, boundary conditions are set up as Table 3.3. After setting up the 3D Model 3, the standard initialization that compute from all zone in relative to cell zone with all initial values of gauge pressure, X velocity, Y velocity, Z Velocity, Turbulent Kinetic Energy, Turbulent Dissipation Rate and Temperature which set as default are proceeded. The calculation is run with 100 ilterations as this is the maximum amount of ilterations that can be run before floating point exception occur.

4.4.1 Air Movement of UNHCR Family Tent

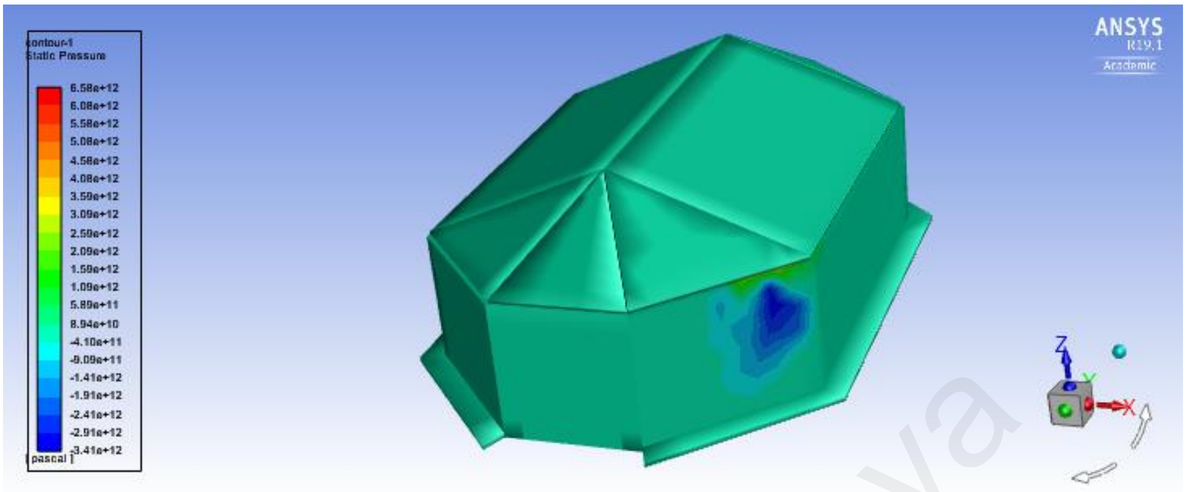

Figure 4.16: View 1 of 3D Model 3 (Static Pressure)

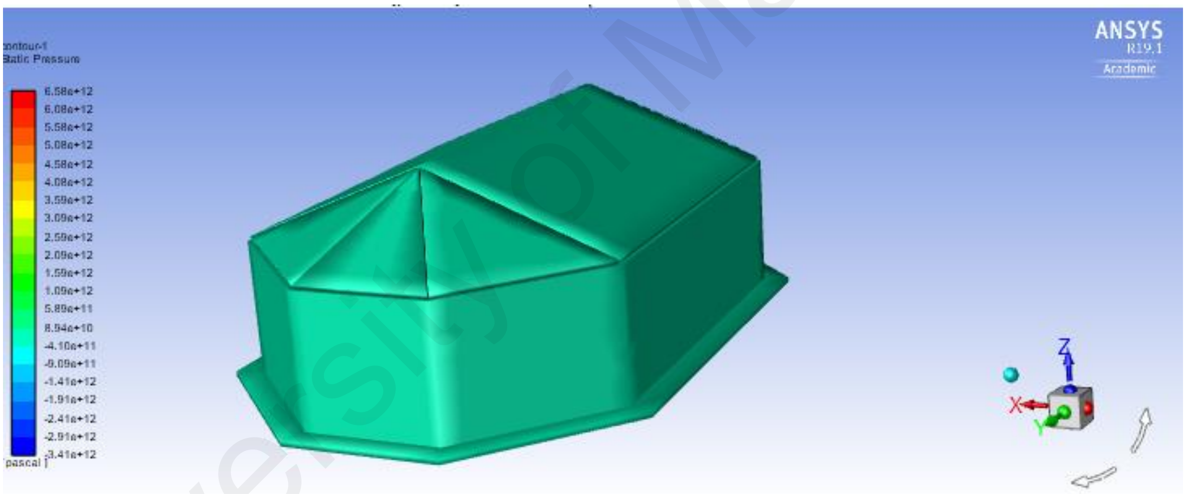

Figure 4.17: View 2 of 3D Model 3 (Static Pressure)

Optimum	Pressure (Pascal)
Minimum	-3.42e+12
Maximum	2.59e+12

Table 4.7: Optimum Pressure of Case 2 for 3D Model 3

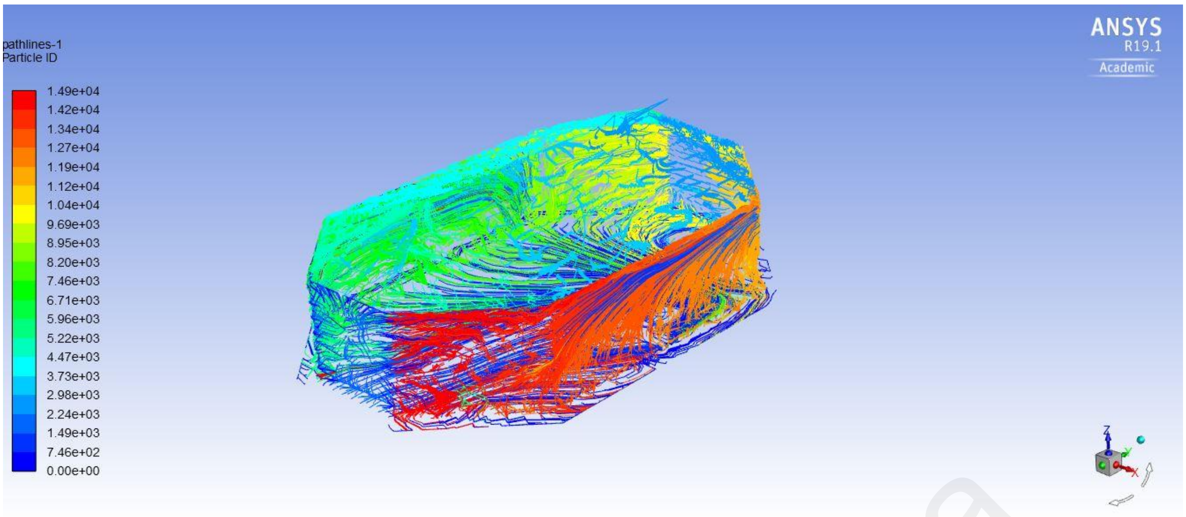

Figure 4.18: View of 3D Model 3 (Velocity Pathline)

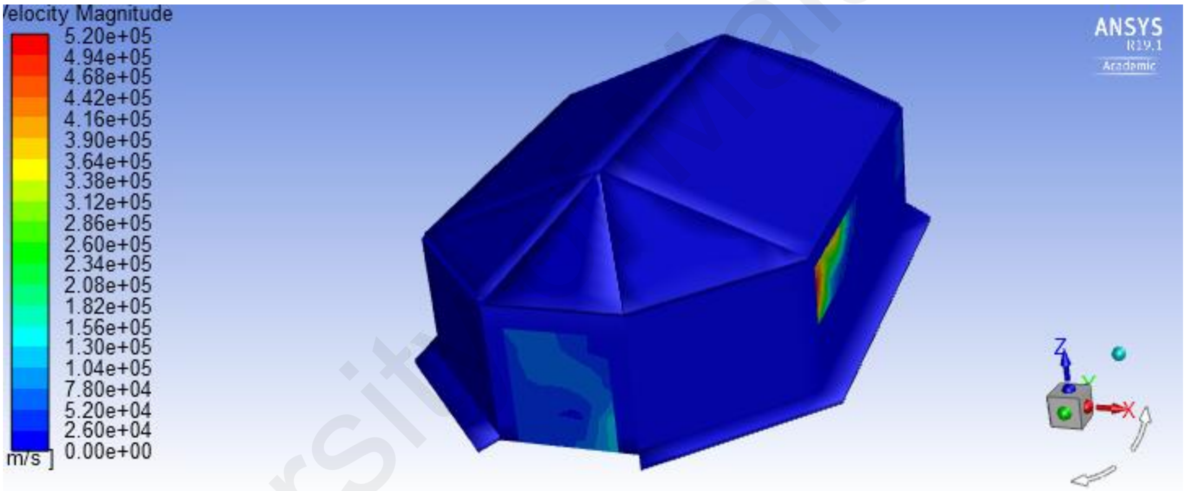

Figure 4.19: View 1 of 3D Model 3 (Velocity Magnitude)

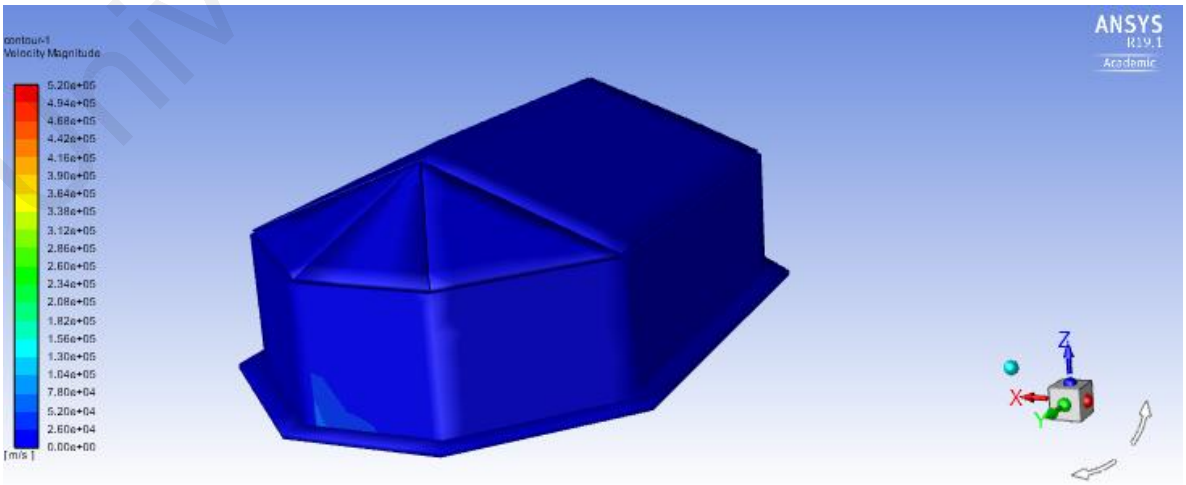

Figure 4.20: View 2 of 3D Model 3 (Velocity Magnitude)

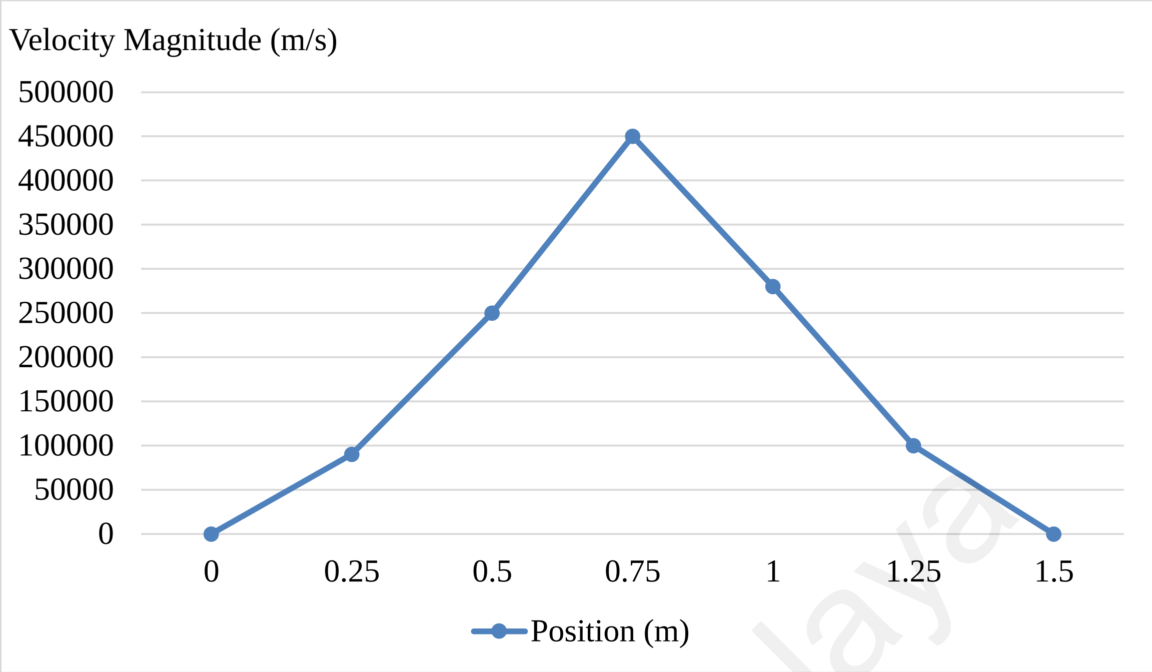

Figure 4.21: Simulated velocity magnitude against position of the 3D Model 3

Position (m)	Velocity Magnitude (m/s)
0.00	0
0.25	90,000
0.50	250,000
0.75	450,000
1.00	280,000
1.25	100,000
1.50	0

Table 4.8: Table of Simulated velocity magnitude against position of the 3D Model 3

Based on Figure 4.16 and Figure 4.17, the pressure on the 3D Model 3 is very uniform, ranging around 5.89e+12 Pascal. The only place that has different pressure is the front part of the wall where the pressure is ranging from 2.59e+12 Pascal to -2.41e+12 Pascal. This is due to the front door acts as the main pressure inlet where the air moves through the front door. Based on Table 4.7, the minimum static pressure is -3.42e+12 Pascal and maximum static pressure is 2.59e+12 Pascal. In Figure 4.18, there are active ventilation flow that is happening in a higher speed at the side of the walls of the 3D Model 3. The increasing of the rear door to the 3D Model 3 has create the pressure outlet for the ventilation flow. The previous simulation of 3D Model 2 often facing the problem of reverse flow due to the air that enters through those openings are unable to be released out from the 3D Model 2. However, in Figure 4.19 and Figure 4.20, the velocity magnitude only has some ventilation that are happening around the doors and the windows, ranging from 4.94e+05 m/s to 2.60 e+4 m/s. This is due to the openings are reacting with the air movement inside and outside the 3D Model 3. In Figure 4.21, the highest velocity magnitude of 3D Model 3 is located at the position 0.75m of 3D Model 3. This is due to the rear door that is added onto the 3D Model 3 is directly in the middle of the 3D Model 3, allowing more air movement inside and outside the 3D Model 3. The rear door of the 3D Model 3 is acting as the pressure and velocity outlet for the air to circulate out from the tent.

4.4.2 Temperature of UNHCR Family Tent

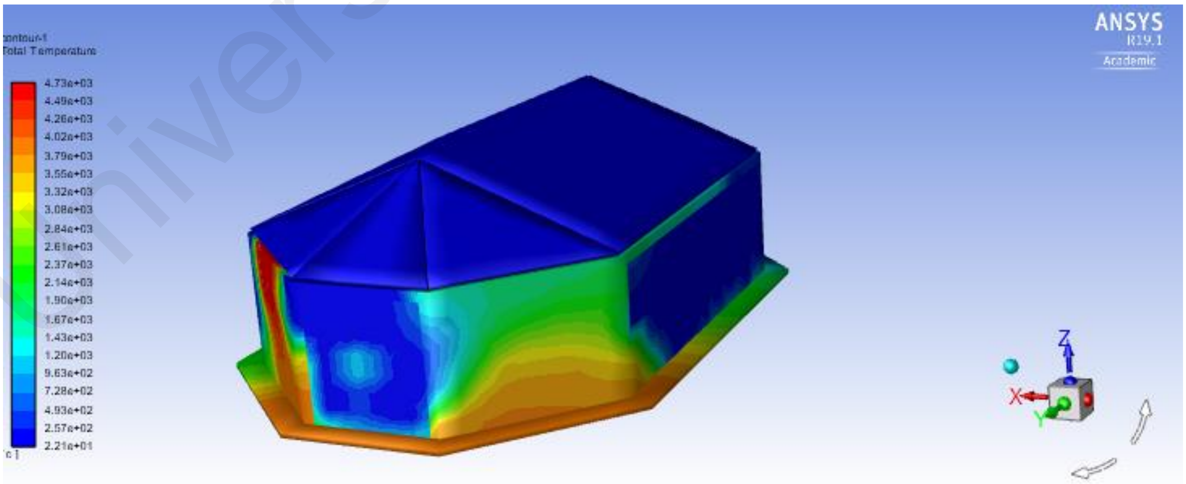

Figure 4.22: View 1 of 3D Model 3 (Temperature)

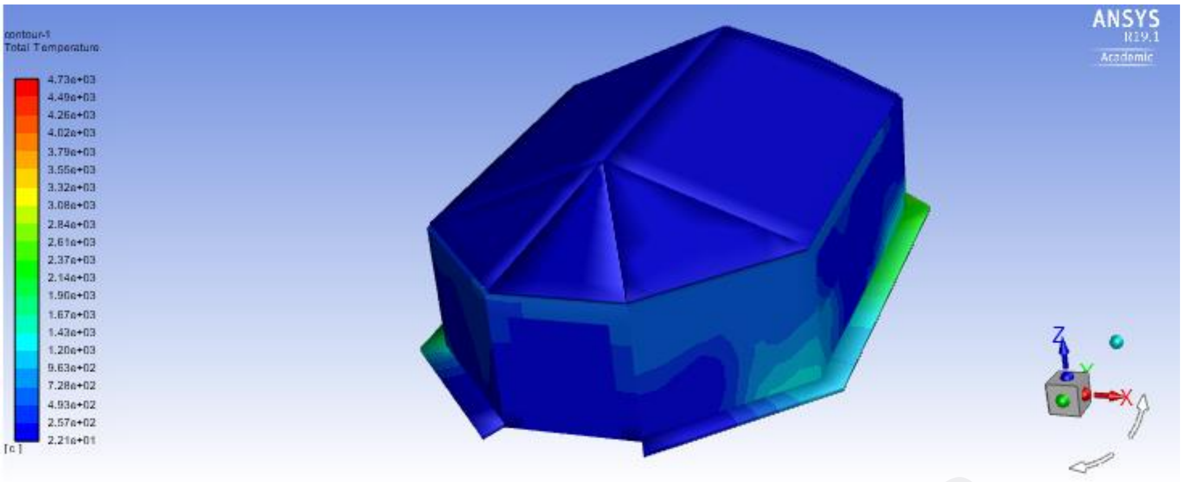

Figure 4.23: View 2 of 3D Model 3 (Temperature)

Optimum	Temperature (^{o}C)
Minimum	2.21e+01
Maximum	4.02e+03

Table 4.9: Optimum Temperature of Case 3 for 3D Model 3

Based on Figure 4.22 and Figure 4.23, the 3D Model 3 has shown more reaction for the rear side of the simulated 3D Model 3. The front part of the 3D Model 3 and surrounding walls have similar range of temperature, ranging from 2.57e+01 ^{o}C to 1,20e+03 ^{o}C. The rear side of the 3D Model 3 shows temperature changes ranging from 4.02e+03 ^{o}C to 2.21e+01 ^{o}C. This is due to more pressure and air movement that are reacting at the rear side of the 3D Model 3. When there is air movement, there will be ventilation that circulates both hot and cold air. When this happens, there will be some drastic changes of temperature at the rear side of the 3D Model 3 comparing to the fron part of the 3D Model 3. Based on those two figures, it can be concluded that the temperature increase at the rear side of the tent after adding in the rear door for the 3D Model 3.

4.5 Case 4: Addition of a Roof Opening to Case 3

In this case study, 3D Model 4 is UNHCR 3D model that is the same as 3D Model 3 with an additional roof opening on the top of the 3D Model 4. In this case study, air will enter through the front door, window openings, roof openings and the rear side of the door. However, same as Case 2 and Case 3, the iterations of the 3D Model 4 is set as 100 as there are 5 openings inside the 3D Model 4, casing even more dynamic ventilation flow. The boundary conditions for 3D Model 4 is set up as stated in Table 3.4. After setting up the 3D Model 4, the standard initialization that compute from all zone in relative to cell zone with all initial values of gauge pressure, X velocity, Y velocity, Z Velocity, Turbulent Kinetic Energy, Turbulent Dissipation Rate and Temperature which set as default are proceeded. The calculation is run with 100 ilterations as this is the maximum amount of ilterations that can be run before floating point exception occur.

4.4.1 Air Movement of UNHCR Family Tent

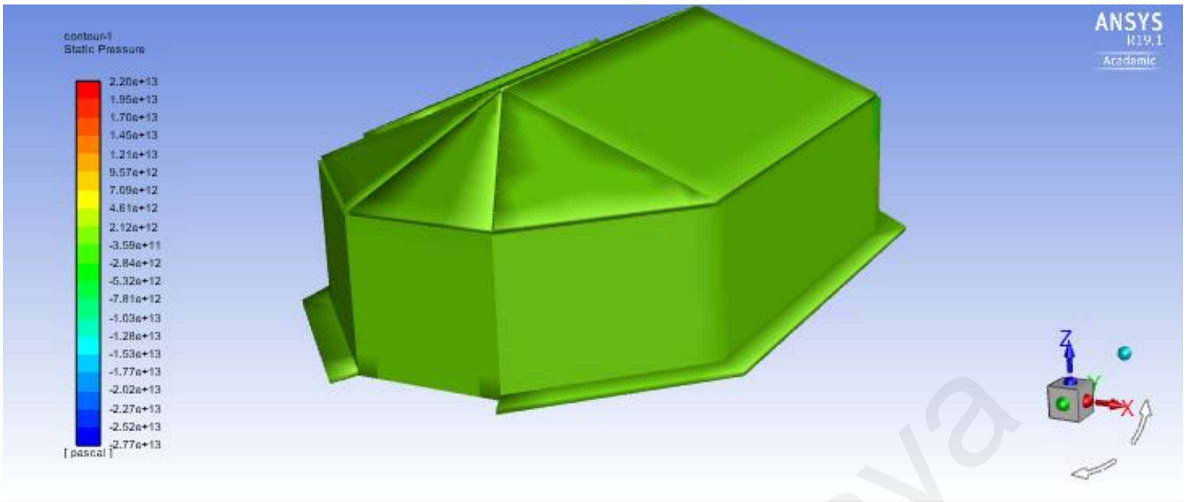

Figure 4.24: View 1 of 3D Model 4 (Static Pressure)

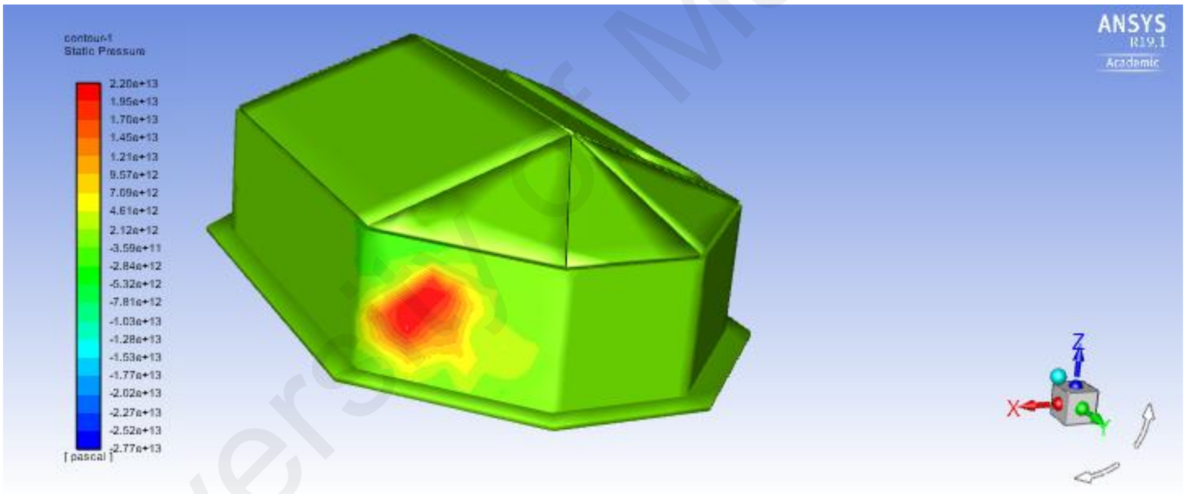

Figure 4.25: View 2 of 3D Model 4 (Static Pressure)

Optimum	Pressure (Pascal)
Minimum	-2.84e+12
Maximum	2.20e+13

Table 4.10: Optimum Pressure of Case 4 for 3D Model 4

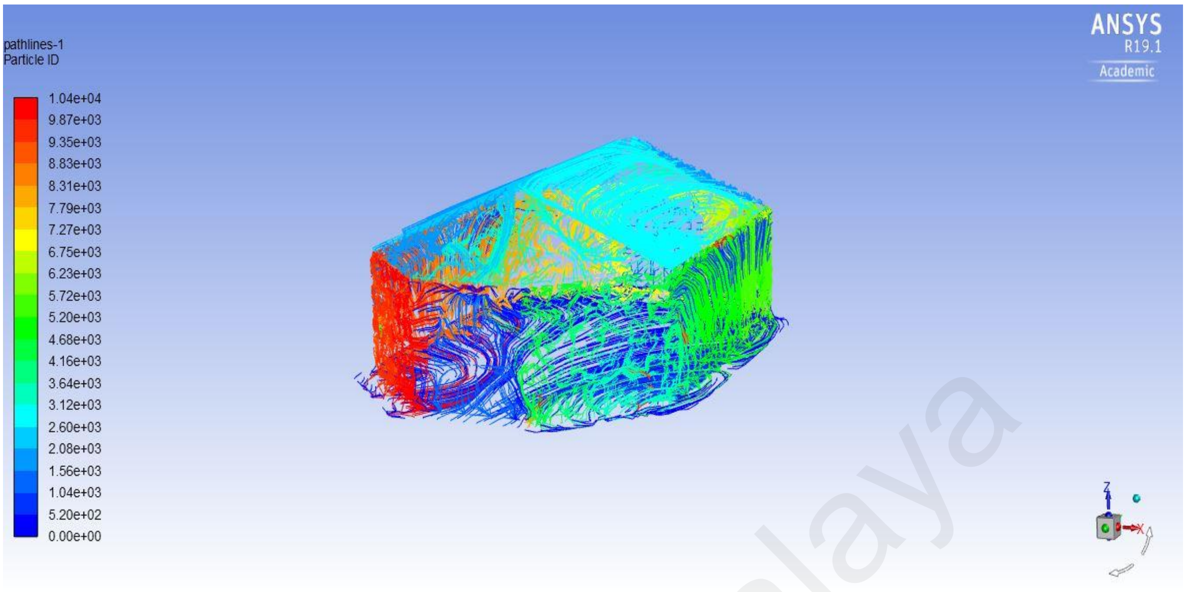

Figure 4.26: View of 3D Model 4 (Velocity Pathline)

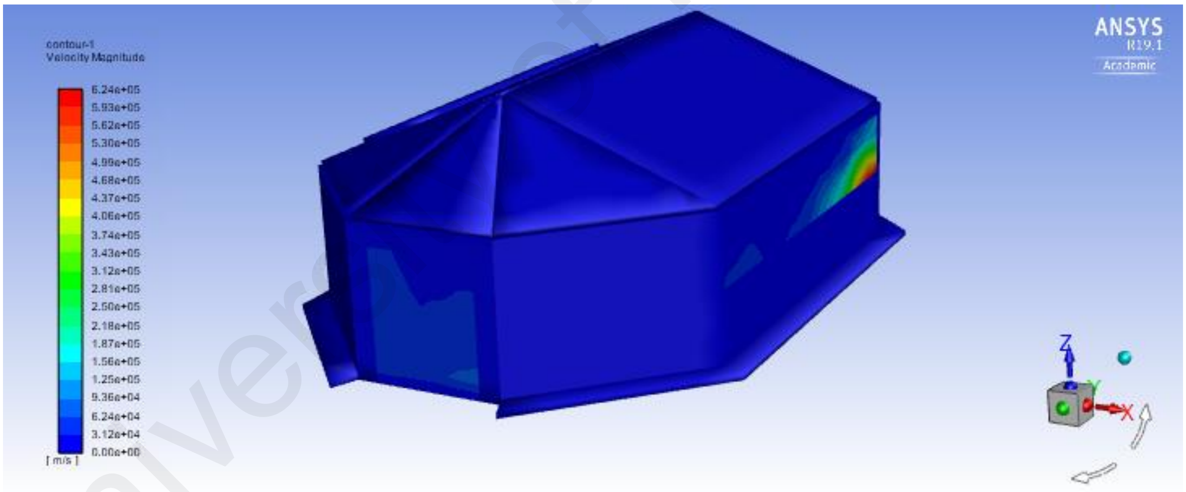

Figure 4.27: View 1 of 3D Model 4 (Velocity Magnitude)

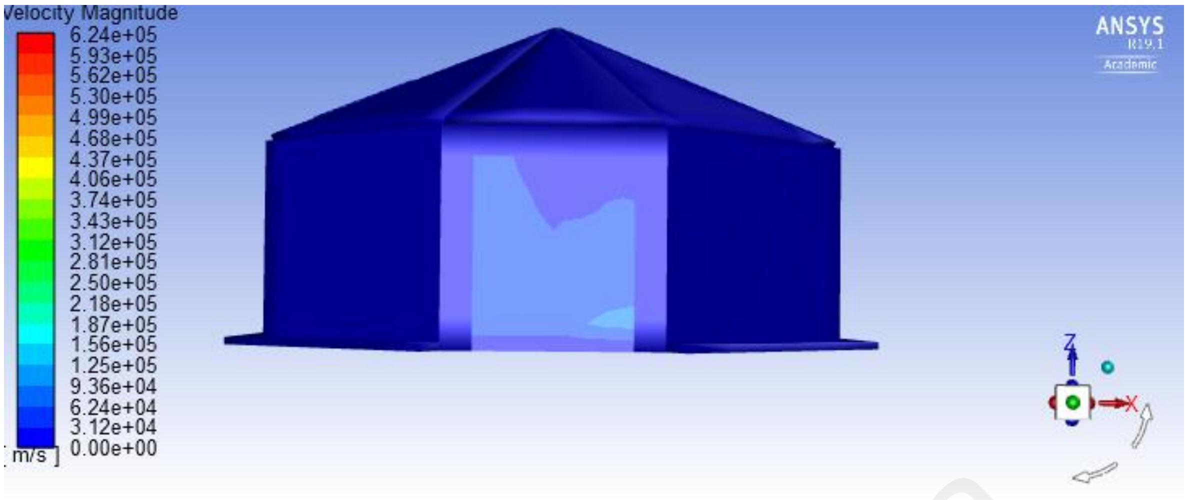

Figure 4.28: View 2 of 3D Model 4 (Velocity Magnitude)

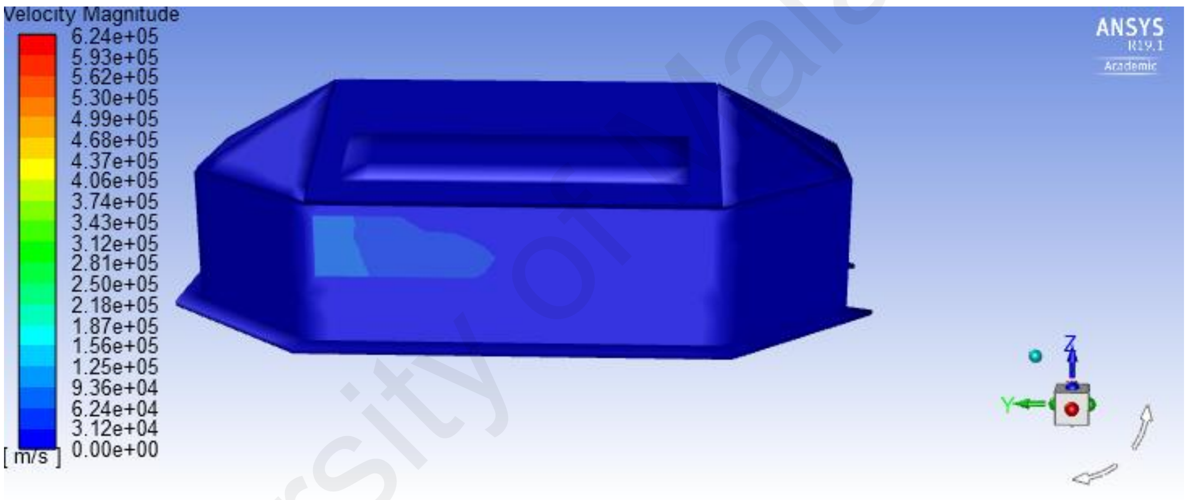

Figure 4.29: View 2 of 3D Model 4 (Velocity Magnitude)

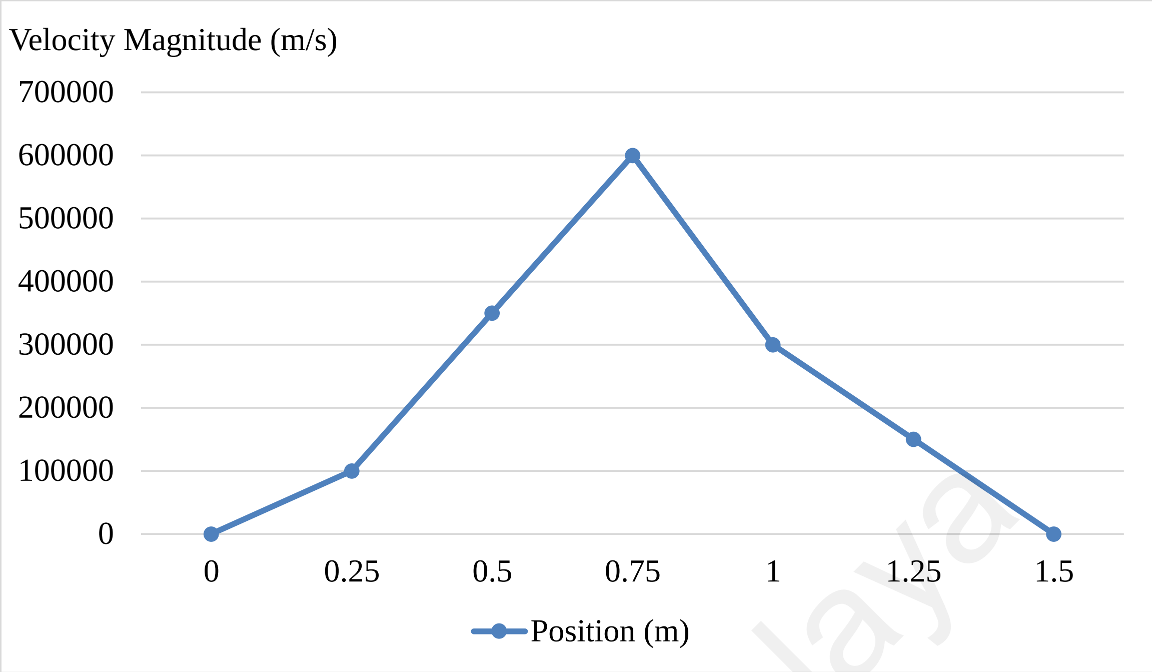

Figure 4.30: Simulated velocity magnitude against position of the 3D Model 4

Position (m)	Velocity Magnitude (m/s)
0.00	0
0.25	100,000
0.50	350,000
0.75	600,000
1.00	300,000
1.25	150,000
1.50	0

Table 4.11: Table of Simulated velocity magnitude against position of the 3D Model 4

Based on Figure 4.24 and Figure 4.25, the static pressure of the 3D Model 4 is -2.84e+12 Pascal for most part of the 3D Model 4. However, there are certain parts of the rear side of the wall that has higher pressure than the other parts, ranging from 2.20e+13 Pascal to -2.84e+12 Pascal. This is due to the pathway of the horizontal air movement that is moving from the side of the windows, the front door and the roof openings. In Figure 4.26, the air movement move actively on the side of the window openings. However, the Figure 4.27 shows little to no changes on the overall velocity magnitude ranging from 1.56e+05m/s to 3.12e+04m/s. In Figure 4.30 and Table 4.11, the simulated velocity magnitude records the higher at the position off 0.75 m and lowest at 0m and 1.50m. This is due to the air entering into the 3D Model 4 through the roof ventilation increase the number of velocity magnitude of the overall air that are moving inside the 3D Model 4.

4.4.2 Temperature of UNHCR Family Tent

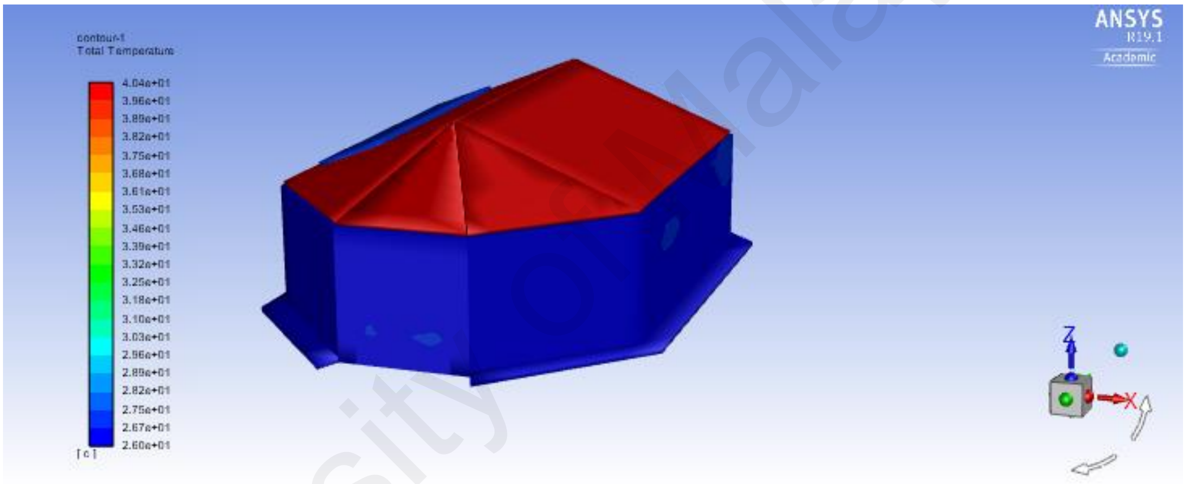

Figure 4.31: View 1 of 3D Model 4 (Temperature)

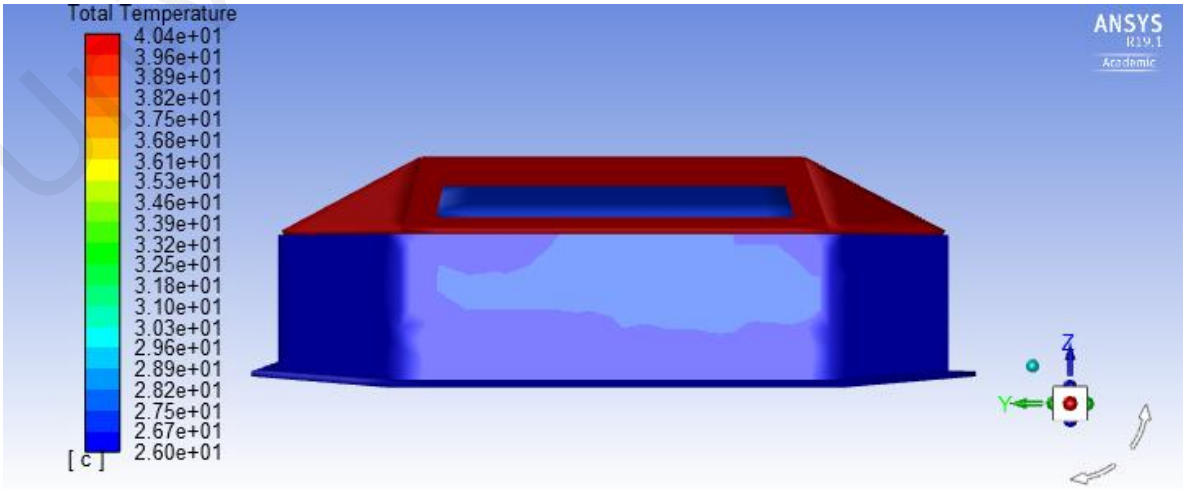

Figure 4.32: View 2 of 3D Model 4 (Temperature)

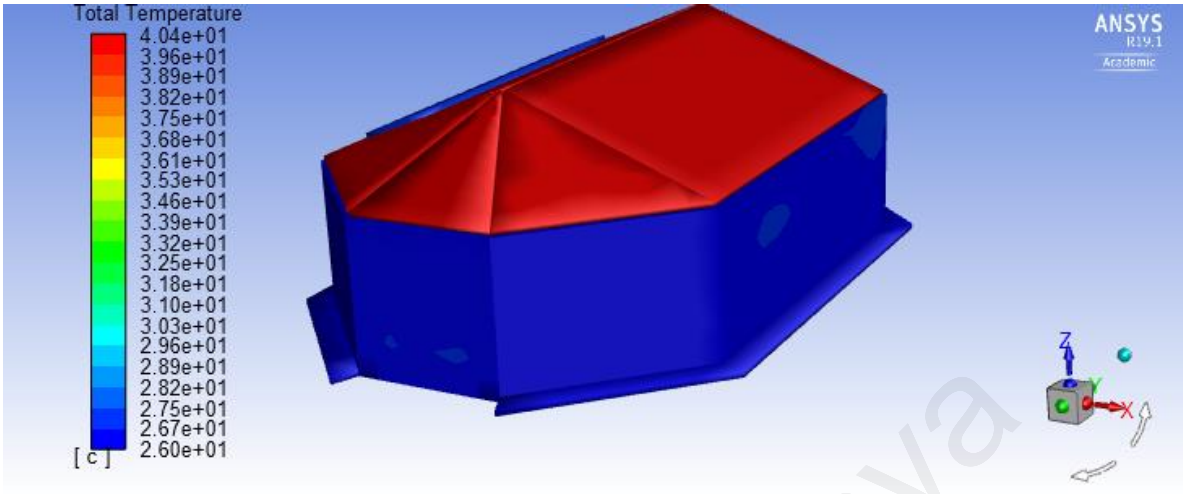

Figure 4.33: View 3 of 3D Model 4 (Temperature)

Optimum	Temperature (°C)
Minimum	2.67e+01
Maximum	44.04e+01

Table 4.12: Optimum Temperature of Case 4 for 3D Model 4

The temperature on the simulated 3D Model 4 shows that the minimum temperature of the 3D Model 4 is 2.67e+01 °C and the maximum temperature of the 3D Model 4 is 44.04e+01 °C. The roof of the 3D Model 4 has temperature ranging from 4.04e+01 °C to 3.89e+01 °C. The wall of the 3D Model 4 has the temperature ranging from 3.89e+01 °C to 2.75e+01 °C. Even though the contour colour show that there is a huge difference between temperature on Figure 4.33, the difference between minimum and maximum value of the temperature is not as drastic as it shown. Moreover, the temperature changes is even less dramatic comparing to other case studies.

4.6 Comparison on Velocity Magnitude for Case Studies

Position (m)	Case 1	Case 2	Case 3	Case 4
0	0	0	0	0
0.25	75,000	80,000	90,000	100,000
0.5	100,000	200,000	250,000	350,000
0.75	90,000	150,000	450,000	600,000
1	110,000	250,000	280,000	300,000
1.25	90,000	90,000	100,000	150,000
0	0	0	0	0

Table 4.13: Velocity Magnitude from Case 1 until Case 4

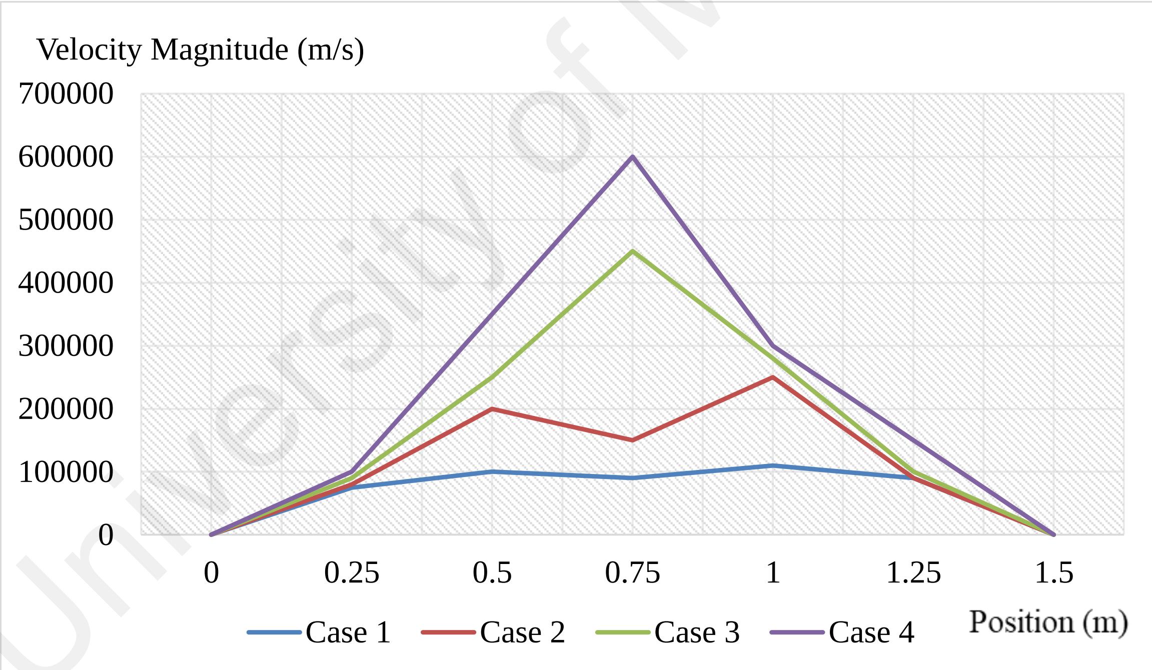

Figure 4.34: Comparison on Velocity Magnitude against Position of 3D Model for Different Case Studies

Case 1 is UNHCR 3D Model that has closed ventilation except for front door. Case 2 is simulated with UNHCR 3D Model that that has window openings and a front door. Case 3 is simulated with UNHCRR 3D Model that has window openings, a front door and a rear door. Case 4 is simulated with UNHCR 3D Model that has window openings, a roof opening, a front door and a rear door.

Based on Table 4.13, the highest point of velocity magnitude for Case 1 is at the position 1.0 meter with the velocity magnitude of 110,000 m/s. Then, for Case 2, the highest point is at the position 1.0 meter with the velocity magnitude of 250,000 m/s. For Case 3, the highest velocity magnitude of 450,000 m/s happens at 0.75m. The highest velocity magnitude of 600,000 m/s happens at 0.75m.

Case 1 and Case 2 have highest velocity magnitude happen at 1.0 m, but Case 3 and Case 4 have highest velocity magnitude happen at 0.75m. For Case 1, the air movement is the most active at the front door. Therefore, the position from 0.5m to 1.25m have similar velocity magnitude, ranging from 90,000 m/s to 110,000 m/s. For Case 2, the air movement are mostly active at the middle of the tent as there are window openings at the side of the UNHCR Family Tent, allowing air to enter at the windows and front door. However, the air movement is more active at the side of the UNHCR Family Tent which located at the position of 0.5m and 1.0 m. Then, the addition of the rear door at Case 3 has increase the air movement at the middle of the UNCR Family Tent at the location of 0.75m. Finally, Case 4 has even higher velocity magnitude comparing to Case 1, Case 2 and Case 3 as there is a roof opening at the top that allows more air enter into the space, increasing the velocity magnitude at the position of 0.75m.

CHAPTER 5: CONCLUSION

5.1 Conclusion

As most of the UNCHR Family Tents are being used in a long period of time, it is siginificant for refugees to experience maximum air flow inside the tent in order for them to feel comfortable and cold. This research study is using the ANSYS Fluent 2018 software to run the simulation on different case studies of the UNHCR Family Tent with different locations of openings.

In this research, Case 1 is using the front door as the main source of the inlet for air to enter the space. Case 2 is using the front door and side window openings as main source of the inlet for air entering into the space. Case 3 is using the rear door, front door and side windows openings to allow air entering into the space. Case 4 is using the roof openings, rear door, front door and side window openings as inlet and outlet for the air entering into the space.

This aim for this research to study and find the problems of the existing UNHCR Family Tent in terms of ventilation flow and temperature inside the tent. This has proven in this research where Case 1 has shown unsatisfied condition on the ventilation flow and temperature on 3D Model 1. As the ventilation flow for Case 1 only focus on the middle part of the 3D Model 1, causing the temperature behavior for 3D Model 1 on the surrounding wall and roof is high. The objectives of this research are investigating the optimum ventilation flow inside the UNHCR Family Tent based on different situations by using CFD simulation program, analyzing the optimum temperature inside the UNHCR Family Tent based on different situations by using CFD simulation program and exploring on the improvements of UNHCR Family Tent in terms of ventilation flow and temperature after the addition of the openings.

Based on the research data that are collected based on chapter 4, the air movement is reacting differently according to the locations of the openings. The velocity magnitude increases when the number of openings for the UNHCR Family Tent increases. Based on the results gained, it can be seen that by adding roof opening and rear door can increase the air movement inside the UNHCR Family Tent gradually. The results show that Case 1 that has only one front door as the source of the air moving into the UNHCR Family Tent, is having the least reactive air movement inside the UNHCR Family Tent. Case 2 that has both window openings and front door shows improvement on the velocity magnitude but less that the velocity magnitude that are shown in Case 4 and Case 3. The optimum ventilation flow is achieved on Case 4 where there is the most dynamic ventilation flow with the highest velocity magnitude among all case studies.

As the air movement is related with the temperature of the UNCHR Family Tent, temperature of the UNHCR Family Tent is also being analysed in this research. Case 4 has the best result of temperature comparing to other cases as there are more uniform and lowest temperature on the UNHCR Family Tent. As the air that enters into the space of the UNHCR Family Tent decreases the temperature of the tent. It can be concluded that the higher the velocity magnitude of the air entering into the UNHCR Family Tent, the lower the temperature of the UNHCR Family Tent. Therefore, the second objective of this research is achieved where the minimum and maximum temperature of 3D Model 4 for Case 4 is lowest

In a conclusion, Case 4 has the best results of the ventilation flow and temperature out of the four case studies. The third objective is archieved when improvements on ventilation flow and thermal performance are shown in Case 4 where roof, window and door openings are added. It can also be concluded that the higher the number of openings at different locations, the higher the number of velocity magnitude of the air entering into the UNHCR Family Tent, the lower the number of the temperature of the UNHCR Family Tent.

5.2 Recommendations

Besides changing the number of openings at different locations of the UNHCR Family Tent, the changing of materials can also decrease the temperature of the UNHCR Family Tent. The suggested material that can decrease the temperature is the retro reflective material that can reflects the sunlight from the surface of UNHCR Family Tent. Retro reflective material has been shown in studies in helping lowering the temperature of tents. Changing material would be a method to improve the overall conditions of the tent.

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APPENDIX A: UNHCR FAMILY TENT FOR HOT CLIMATE

APPENDIX B: UNHCR FAMILY TEN