INFLATABLE TENT FOR COVID-19 ISOLATION AND DISASTER RESPONSE WITH INDEPENDENT SOLAR ENERGY

Hery Budiyanto[1*], Nurhamdoko Bonifacius[2], Aries Boedi Setiawan[3]
[12]University of Merdeka Malang, Architecture Department
62-64,Jl. Terusan Raya Dieng, Malang, Indonesia
[3]University of Merdeka Malang, Electrical Engineering Department
62-64,Jl. Terusan Raya Dieng, Malang, Indonesia
*Corresponding author: Hery Budiyanto. E-mail: *hery.budiyanto@unmer.ac.id*

ABSTRACT

This research departs from the problem of the lack of Covid-19 isolation rooms and disaster preparedness which currently uses a lot of tents with conventional structural systems and technology so inflatable tents are one of the right solutions. Electrical energy inflates inflatable tents and medical emergency equipment using solar power generation. The purpose of this study was to create and test an Inflatable Tent Prototype for the Covid-19 Isolation Post and Puskesmas. The research method used is experimental on an inflatable tent prototype with a solar power plantation; trials are carried out on variables: the strength of the tarpaulin, the speed of construction and dismantling, thermal comfort, and the effectiveness of the solar power plant. The results of the research are: the design and implementation of an inflatable tent prototype measuring 6x9 m2 for a capacity of 10 patients, a solar power plant with a power of 3,600 WP, and a 24 Volt 200 Ah VRLA battery capable of storing 4,800 watts of power, so that it is sufficient for electricity needs in an inflatable tent.

Keywords: Covid-19, inflatable tent, isolation, disaster

1. INTRODUCTION

This research departs from the problem of lack of space for COVID-19 isolation patients that occurred during the pandemic as well as problems handling residents who are sick and medical emergency facilities that always appear in disaster areas. The COVID-19 pandemic and disaster events that often occur in all regions of Indonesia require rapid and effective preparedness and handling. The Ministry of Education, Culture, Research, and Technology encourages science and technology activists, students, industry experts, and the general public to innovate to work together to protect the nation from COVID-19 through proposing ideas/thoughts, not limited, to virus prevention, virus control, management service, and patient care. The National Agency in charge of Disaster Management has made a Technical Guideline in the form of Ways of Handling Health Crises caused by disasters" (Roswati et al., 2007) and is supported by regulations issued by the Head of the National Disaster Management Agency Number 17 of 2009 concerning Guidelines for Standardization of Disaster Management Equipment Disaster, providing direction that disaster preparedness will minimize the consequences adverse outcomes through effective prevention, rehabilitation, and recovery and timely delivery of assistance and assistance. Aid and assistance are intended, among other things, so that a large number of disaster victims can immediately be accommodated in livable and comfortable buildings, one of the disaster management facilities is the Disaster Emergency Health Post.

Several major disasters in Indonesia were assisted by health post facilities that used emergency tents or buildings with conventional structures and technology, including tents with steel frames which took a long time and cost a lot of money. Several alternative structures for emergency tent buildings were presented by Bakowski in the form of a "mobile hospital" (Bakowski, 2016) namely an emergency hospital using a container truck that was converted into a hospital. Durumunda stated that field hospitals are at least in the form of places and tents that can accommodate a minimum of 10 patient beds, one operating room, and one clinical laboratory (Durumunda et al., 2017). The Covid-19 isolation health post and disaster emergency require structures that are quickly built, including using an inflatable structure whose frame is inflated by air (air-inflated structure). This structure is a building structure that uses materials in the form of cloth, rubber, or specially made to be able to withstand the weather so that it can be used for more than 10 years. In addition, the Air Inflated Structure material must be reliable and strong against tensile test forces up to 200 kg/cm2, the material resistance to temperatures of more than 70 degrees Celsius, and fast installation and disassembly. The inflatable tent structure can be used in a limited area, the structure material is light, easy to move, fold or transport to other locations (Budiyanto et al., 2018).

Regarding the Covid-19 isolation room and the post-disaster emergency health clinic, several research articles serve as references for this research. First, a Decree issued by the Minister of Health of the Republic of Indonesia, namely Kepmenkes Number HK.01.07-Menkes-230-2021 concerning Guidelines for the Implementation of Field Hospitals/Emergency Hospitals during the Corona Pandemic Period, that the establishment of field hospitals / COVID-19 emergency hospitals is intended for COVID-19 patients. (a confirmed cases) with mild-moderate symptoms and asymptomatic confirmed COVID-19 patients who do not have adequate self-isolation facilities (Ministry of Health, 2021). Second, research by Putra and Roosandriantini in the Journal of Architecture and Planning (JUARA), 4(1), 49–61 writes about the need for negative air pressure compared to the surrounding room. In a Covid-19 isolation room, the arrangement of the composition of the room is very important to prevent the transfer of infection sources to other areas. The risk of this infection being transmitted through the air is no exception, to the Covid-19 virus. Patients who have this disease can transmit the virus through droplets that can float in the air and are inhaled by the human respiratory system and touch virus particles that are not visible because they are <5 m in size (Putra & Roosandriantini, 2021). Third, Pillay stated in a Guideline for Quarantine and Isolation Facilities Related to Covid-19 Exposure and Infection, that isolation rooms are intended as a space to separate Covid-19 patients in prevent the spread of infection that may occur to medical staff, other patients, and their family members. either in the hospital environment or in the patient's residence (Pillay, 2020).

Regarding the health clinic post, First, Bakowski (Bakowski, 2016) in his article Mobile Hospital - Discusses the advantages and limitations of its function wrote about an emergency post in the form of a health post that moves in the form of a disaster response health clinic idea. All infrastructures were ensured to function properly, but the essence remains the same as an emergency i.e. direct action against a state of health or life threat. The criteria for establishing an emergency health post lie in technical solutions related not only to the construction problem of emergency hospital units but to mobile architecture in general, including the aspects of modularity (the ability to pack functions into cubic containers) and mobility (understood as ease of construction for transported from one place to another). Second, Bitterman and Zimmer (Bitterman & Zimmer, 2018) in Portable Health Facilities in Disaster and Rescue Areas: Discussing Characteristics and Future Suggestions write about Portable healthcare facilities located in disaster areas are categorized into two, namely: a) permanent portable healthcare facilities are medical units that function independently that can be moved or transported as a whole, or per unit to the disaster area, and b) temporary portable structures. The facility has its power source and built-in mobility aid. Portable structures are temporarily transported as separate elements.

Related to inflatable pneumatic structure, Muhammad Iqbal in his article Disaster Emergency Hospital with Inflatable Pneumatic Structure explained that a pneumatic membrane structure can stand due to the difference in air pressure inside the structure with the air pressure outside the structure. The pneumatic structure is characterized by all the forces that occur on the membrane in the form of tensile forces. In pneumatics, tensile stress will arise due to the difference in air pressure inside the pneumatic membrane structure with the air pressure outside the pneumatic membrane structure. (Iqbal et al., 2020). Second, Henry Budiyanto in various articles on the use of inflatable structures stated that the principle of pneumatic structures lies in a relatively thin membrane supported by a pressure difference. In other words, the pressure of the enclosed space is higher than the atmospheric pressure. The pressure difference will cause a pull on the membrane. The membrane can only be stable when it is in tension. Compared with the traditional structure, the air-inflated fabric structure has advantages including lightweight design, fast and easy installation, fast transportation, and relatively small packing volume. Past studies have mostly been in the following functions: aerospace, military, marine, recreational and commercial (Budiyanto et al., 2018)

Related to Solar Power Generation, Widayana, G. (Widayana, 2012). In the article on the Utilization of Solar Energy, it is stated that solar energy can be used to produce electricity efficiently. Second, Purwanto in Solar Cell (Photovoltaic/PV) Solutions Towards an Electric Independent Island stated that the main component of a Photovoltaic Solar Energy System is a photovoltaic cell that converts solar radiation/radiation into electricity directly (direct conversion) captured by the Solar Array, a Balance is required. of System (BOS) includes charge controllers and inverters, energy storage units (battery) and other supporting equipment (Purwanto, 2020).

The problem raised in this study is how to design and make prototypes of emergency health posts based on the needs of health facilities for COVID-19 isolation and health posts in disaster areas. Meanwhile, the purpose of the research is to assist in the process of isolating Covid-19 patients and handling the health of disaster victims. A health post must meet the needs of health facilities that are fast, portable, safe, and comfortable for patients and medical personnel.

2. METHOD

The method used is experimental and action research (Siyoto & Sodik, 2015) with a mix-method approach of qualitative and quantitative in the form of making prototypes and field trials, namely: 1). testing the speed of construction and dismantling of PVC-coated tarpaulin membrane inflatable tents. 2). testing of materials and effectiveness of solar photovoltaic power supply systems. The implementation of this research was carried out at the Unmer Malang Parking Lot. The process of developing the design, improving the prototype design, training, and preparing guidelines for the use of inflated water health post tents was carried out at the Design Lab of Architecture Study Program, Faculty of Engineering, Merdeka University, Malang.

2.1 Data collection

The data collection method was carried out through observation, namely interaction with the object in the form of an inflatable tent measuring 6x9 m2, 1 (one) solar power plant unit consisting of 4 monocrystalline solar panels each 540 WP to the MPPT 60A solar charge controller, 2 (two) 200 VRLA batteries. Ah and 3,000 Watt inverters. The inflatable Tent Model Design for Covid-19 Isolation or Disaster Emergency with Photovoltaic Independent Energy was completed on June 6, 2022, as shown in Figure 1. Based on this design, an inflatable tent was made in Yogyakarta. Data collection was carried out for 3 (three) days, namely September 9-11, 2022 for the prototype of an inflatable tent with the solar power plant in the parking lot of Merdeka University, Malang.

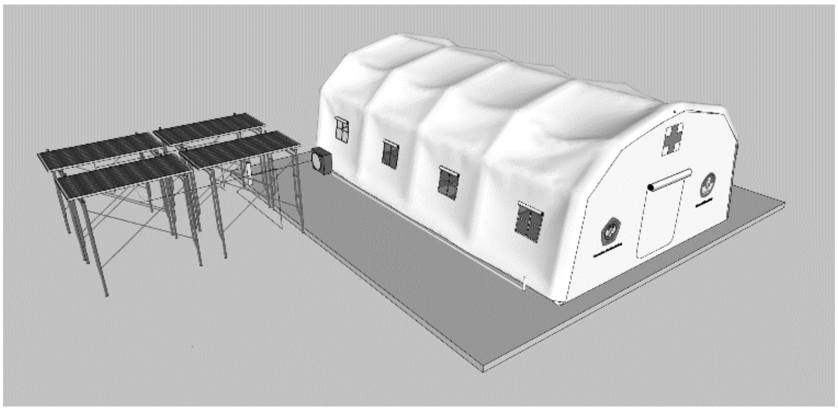

Figure 1. Inflatable Tent Design for Covid-19 Isolation or Disaster Emergency

Figure 2. Installation of Inflatable Tents and Solar Power Plant

2.2 Analysis of Data

In performing data analysis using a combination of qualitative and quantitative. The qualitative data analysis method was used to reveal the observation of the design process of the prototype of the inflatable tent and solar power plant as well as the inflating process until the inflatable tent stands up and the inflatable tent deflation process and solar power plant. While the quantitative data analysis method was used to get the air pressure figures in the inflatable tent tube, the temperature inside and outside the inflatable tent, the strength of tarpaulin fabric as an inflatable tent material, and the current and voltage strength of the solar power plant.

3. RESULTS OF ANALYSIS AND DISCUSSION

3.1 Process Speed

The process of installing the inflatable tent takes 45 minutes (figure 4), while the process of installing a series of electrical energy sources in the form of solar cells in the form of 4 photovoltaic panels each with a power of 540 WH, placed on 4 portable brackets. This process takes 20 minutes (see figure 3).

3.2 Pressure Test in Inflatable Tent Tube

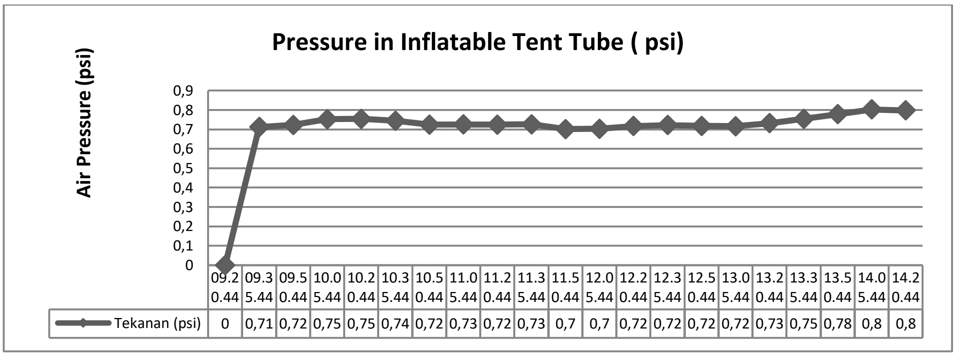

Figure 3. Graph of Pressure In Inflatable Tent Tube

It takes 0.7 Psi of air pressure to inflate the inflatable tube frame so that the inflatable tent can stand up on its own, this air pressure can be achieved after blowing lasts for 25 minutes. The air pressure inside the inflatable tube can increase and decrease as the temperature rises and falls outside the inflatable tent.

3.3 The difference in air temperature inside and outside the Inflatable Tent

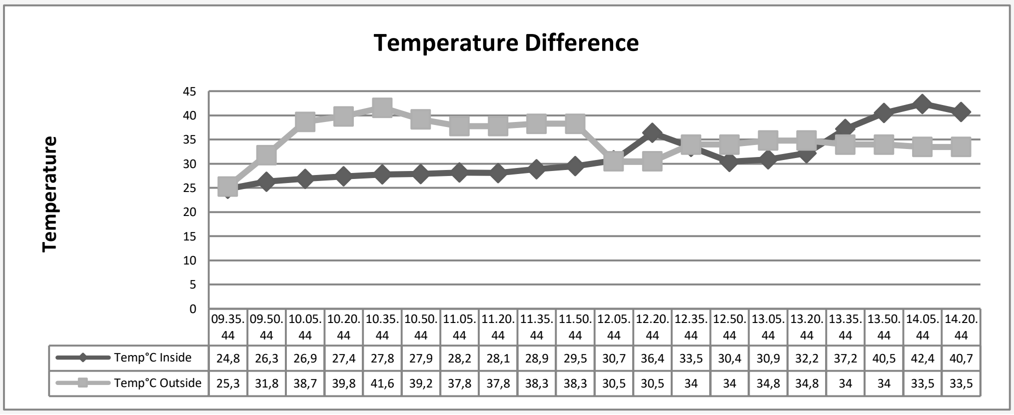

Figure 4. Graph of Thermal Conditions inside and outside the Inflatable Tent

Between 09.05 and 12.05 in the morning, the air temperature inside the inflatable tent is lower than outside, after 13.30 the air temperature inside the inflatable tent is warmer than outside the inflatable tent. The temperature difference inside and outside was recorded between -4.9 degrees Celsius to 3.8 degrees Celsius.

3.4 The strength of tarpaulin fabric as a material for inflatable tent tubes.

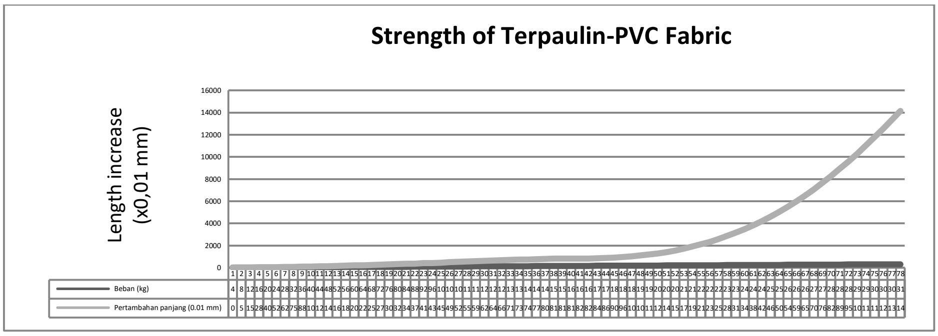

Figure 5. Graph of the Strength Test of PVC Tarpaulin Fabrics

In the Fabric Strength Test, the PVC-coated tarpaulin fabric with a thickness of 0.5 mm has a maximum strength of 312 kg/cm2.

3.5 Photovoltaic Energy Test

Tests were carried out on 4 pieces of monocrystalline solar panels, each with a power of 540 wp. The test results are as follows:

Table 1. Current and Voltage Tests from Photovoltaic Solar Panels

Time	Light (lux)	Weather	Solar Panels Current	Solar Panels Voltage
09.00	73,000	Sunny	13.2 A	34.2 V
11.00	56,800	Sunny	11.6 A	31.8 V
13.00	60,700	Sunny	12.8 A	33,1 V
15.00	37,500	Cloudy	6.8 A	25,2 V

In sunny weather, 4 solar panels with a power of 540 WP each can produce at least 11.6 Ampere current and 31.8 Volt voltage, while during cloudy weather, the current strength drops to 6.8 Amperes and the voltage is 25.2 Volts. In this study, the electrical energy generated by a solar power plant is stored in 2 batteries of 200 Ah 12 V each in sunny weather within 15 minutes is fully charged can store 200 x 24 = 4,800 Watts of power which can already be used to supply electricity needs for patient needs in inflatable tents.

4. CONCLUSION

In this study, a prototype design of an inflatable tent for the isolation of COVID-19 patients and disaster response has been produced with a size of 6x9 m2 for a capacity of 10 patients. Installation of inflatable tents can be done within 45 minutes after the base of the inflatable tent is prepared, while dismantling takes 30 minutes so it is very fast when compared to using conventional tents. To set up an inflatable tent, a minimum air pressure of 0.7 Psi is required which can be achieved in 25 minutes. There is a temperature difference inside and outside of the inflatable tent, which is between -4.9 degrees Celsius to 3.8 degrees Celsius.

The maximum strength that can be resisted by PVC-coated sheeting with a thickness of 0.5 mm is achieved at a load of 312 kg/cm2. The Solar Power Plant with a power of 3,600 WP and a 200 Ah battery can store 4,800 watts of power so that it is sufficient for the electricity needs of patients in an inflatable tent. The disadvantages of this study include: 1) no air pump also controls the air pressure, 2) The capacity of the 10-patient inflatable tent requires expansion to increase the capacity of at least 20 patients, and 3) There is no air conditioning in the room. The tent is inflatable so that when the tent is placed in a hot climate disaster area, the temperature inside the tent is hot. Recommendations for further research are: 1) Increase the capacity of the inflatable tent, 2) Monitor the air pressure in the inflatable tent tube with a pump that automatically operates at a pressure that is less than the minimum standard and stops at the maximum pressure, 3) Researches the temperature in the inflatable tent with additional temperature control (AC).

ACKNOWLEDGMENT

This paper is the output of Leading Higher Education Applied Research funded by the Ministry of Education, Culture, Research, and Technology

REFERENCES

Bakowski, J. (2016). A Mobile Hospital - Its Advantages and Functional Limitations. *International Journal of Safety and Security Engineering*, *6*(4), 746–754. https://doi.org/10.2495/SAFE-V6-N4-746-754

Bitterman, N., & Zimmer, Y. (2018). Portable Health Care Facilities in Disaster and Rescue Zones : Characteristics and Portable Health Care Facilities in Disaster and Rescue Zones : Characteristics and Future Suggestions. *Journal of the National Association of EMS Physicians and the World Association for Emergency and Disaster Medicine*, *July*. https://doi.org/10.1017/S1049023X18000560

Budiyanto, H., Winansih, E., Setiawan, A. B., & Setiawan, M. I. (2018). Portable Stage and Pneumatic Air Inflated Roof Structure with Independent Energy as a Means of Exhibition of SME Products. *International Journal of Scientific Engineering and Research (IJSER)*, *6*(9), 48–51. http://www.ijser.in/archives/v6i9/IJSER18193.pdf

Durumunda, A., Tahliyesi, H., & Hastanesinin, S. (2017). Evacuation of Hospitals during Disaster, Establishment of a Field Hospital, and Communication. *Eurasian Journal of Medicine*, *49*(2), 137–141. https://doi.org/10.5152/eurasianjmed.2017.16102

Iqbal, M., Budiyanto, H., & Bonifacius, N. (2020). The Parameters of Emergency Disaster Hospital with Inflatable Pneumatic Structure. In B. Ngarawula (Ed.), *5th International Conference of Graduate School on Sustainability* (pp. 151–158).

Pillay, T. (2020). *Guidelines for Quarantine and Isolation in Relation to Covid-19 Exposure and Infection*. Department of Health, Republic of South Africa. https://www.knowledgehub.org.za/elibrary/guidelines-quarantine-and-isolation-relation-covid-19-exposure-and-infection

Purwanto, I. (2020). Solar Cell (Photovoltaic/PV) Solusi Menuju Pulau Mandiri Listrik. *Jurnal Penelitian Dan Karya Ilmiah Lembaga Penelitian Universitas Trisakti*, *5*(2), 117–126.

Putra, H. A., & Roosandriantini, J. (2021). Ruang Perawatan Isolasi Sebagai Bentuk Ruang Pemisah Pasien. *Jurnal Arsitektur Dan Perencanaan (JUARA)*, *4*(1), 49–61.

Roswati, E., Khadijah, S., & Widyastuti, P. (2007). *Pedoman Teknis Penanggulangan Krisis Kesehatan akibat Bencana* (E. Roswati, S. Khadijah, & P. Widyastuti (eds.)). Departemen Kesehatan RI.

Siyoto, S., & Sodik, M. A. (2015). *Buku Metode Penelitian Kualitatif dan Kuantitatif* (Hardani (ed.); 1st ed., Issue April). CV. Pustaka Ilmu Group Yogyakarta.

Widayana, G. (2012). PEMANFAATAN ENERGI SURYA. *Jurnal Pendidikan Teknologi Dan Kejuruan*, *9*(1). https://doi.org/10.23887/jptk.v9i1.2876