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Inflatable Tent for Covid-19 Isolation and Disaster Response with Independent Solar Energy

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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 that inflatable tents are one of the right solutions. Electrical energy to inflate inflatable tents and medical emergency equipment using a solar power plant. The purpose of the study was to develop an Inflatable Tent Prototype for Covid-19 Isolation and Health Clinic Posts. This study uses experimental methods and action research in the form of making prototype designs of inflatable tents with a solar power plant, field trials on variables: strength of tarpaulin fabric, speed of construction and disassembly, thermal comfort, and effectiveness of PV mini-grid systems. The results of the research are: the design and application of an inflatable tent prototype for the isolation of COVID-19 patients and disaster response with a size of 6x9 m2 for a capacity of 10 patients, a solar power plant in the form of a solar panel with a power of 3,600 WP and a 200 Ah 24 Volt VRLA batteries that can store 4,800 watts of power, sufficient for patient needs.
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 in 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, for virus prevention, virus control, management service and patient care. The National Disaster Management Agency publishes “Technical Guidelines for Managing Health Crisis Due to Disasters” [1] and Regulation of the Head of the National Disaster Management Agency Number 17 of 2009 concerning Guidelines for Standardization of Disaster Management Equipment, 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 disaster events in Indonesia were facilitated by health posts using tents or emergency buildings built using 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" [2] 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 [3]. 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's resistance to temperatures of more than 70 degrees Celsius, fast installation and disassembly. Inflatable structures can be used in limited areas, lightweight structural materials, easy to move, fold or transport to other locations [4].

Regarding the Covid-19 isolation room and the post-disaster emergency health clinic, there are several research articles that serve as references for this research. First, the Decree of the Ministry of Health of the Republic of Indonesia Kepmenkes 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. (confirmed cases) with mildmoderate 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, 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 [5]. Third, Pillay wrote in the Guidelines for Quarantine and Isolation in Relation to Covid-19 Exposure and Infection, that the isolation room is intended as a space to separate Covid-19 patients in preventing 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 [6].

Regarding the health clinic post, First, Bakowski[2] in his article A Mobile Hospital - Its Advantages and Functional Limitations 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 infrastructure is 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 [7] in Portable Health Care Facilities in Disaster and Rescue Zones: Characteristics and Portable Health Care Facilities in Disaster and Rescue Zones: Characteristics and Future Suggestions write about portable health care facilities in classified disaster zones. into two categories: permanent portable health care facilities and temporary portable structures. Permanent portable health care facilities are independent functioning medical units that are moved or transported as a whole, or per unit to a disaster zone. The facility has its own power source and has a built-in mobility aid. Portable structures are temporarily transported as separate elements.

Related inflatable pneumatic structure. First, Muhammad Iqbal in his article Disaster Emergency Hospital with Inflatable Pneumatic Structure, explained that the pneumatic membrane structure is one of the soft shell structural systems, where the structure can stand due to the difference in air pressure inside the pneumatic structure with 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, the tensile force occurs due to the difference in air pressure inside the pneumatic structure with air pressure outside this structure [8]. Second, HeryBudiyanto 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 difference in pressure will cause a pull on the membrane. The membrane can only be stable when it is in tension. Air-inflated fabric structures belong to the category of tensioned structures and have unique advantages in their use over traditional structures. These advantages include lightweight design, quick and easy installation, fast transport and small packing volume. Most of the research and development of inflated structures was carried out on aerospace, military, commercial, marine and recreational functions [4].

Related to Solar Power Generation. First, Widayana, G. [9]. In the article on 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 [10].

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 the process of isolating Covid-19 patients and handling health for 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

This study uses experimental methods and action research [11] 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 were 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 plantunit 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 inverter. 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 solar power plantin the parking lot of the Merdeka University, Malang.

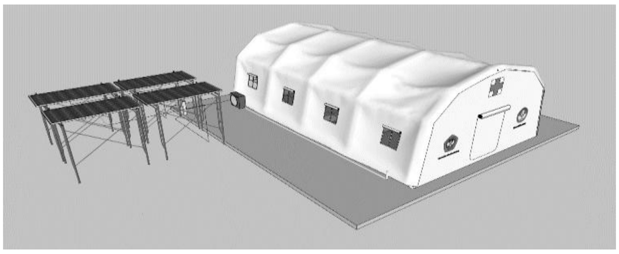

Figure 1. Inflatable Tent Design for Covid-19 Isolation or Disaster Emergency

Figure 2. Installation of Inflatable Tents and SOLAR POWER PLANT

2.2 Data analysis

Data analysis was carried out qualitatively and quantitatively. Qualitative data analysis method was used to reveal the observation of the design process of the prototype of the inflatable tent and solar power plantas well as the process of installing and dismantling the inflatable tent 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 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 4 photovoltaic panels placed on 4 portable brackets takes 20 minutes (figure 3).

3.2 Pressure Test in Inflatable Tent Tube

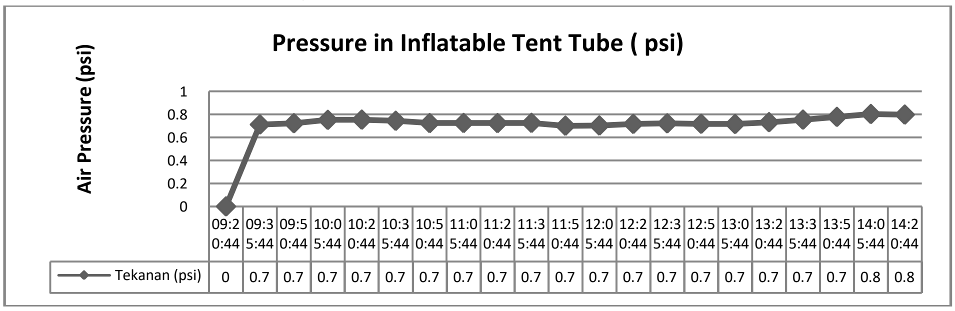

Figure 2. Graph of Pressure In Inflatable Tent Tube

The minimum air pressure required for the installation of the inflatable membrane tube is 0.7 psi, this pressure is achieved within 25 minutes of the start of the bubble. The air pressure in the inflatable tube can decrease and increase according to the increase with the outside temperature.

3.3 Thermal conditions inside and outside the Inflatable Tent

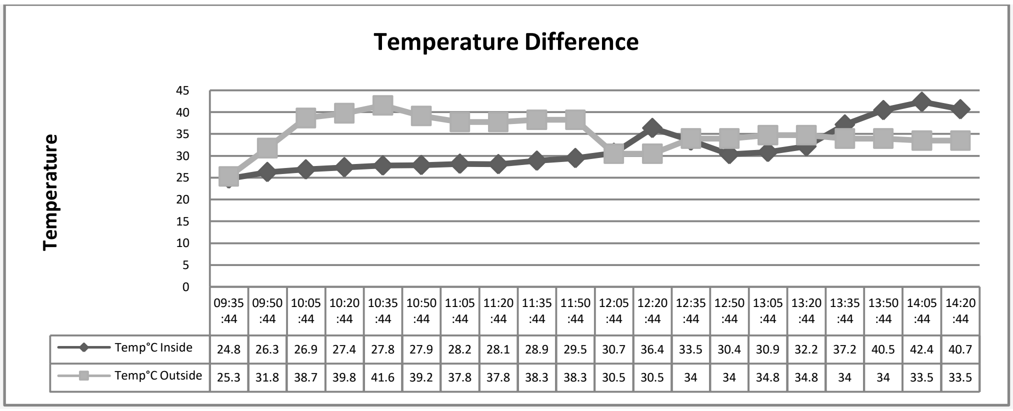

Figure 3. Graph of Thermal Conditions inside and outside the Inflatable Tent

In the morning between 09.05 to 12.05 the air temperature inside the inflatable tent is lower than outside. There is a difference in temperature inside and outside between -4.9°C to 3.8°C.

3.4 Test the strength of the inflatable tent tube terpaulin fabric

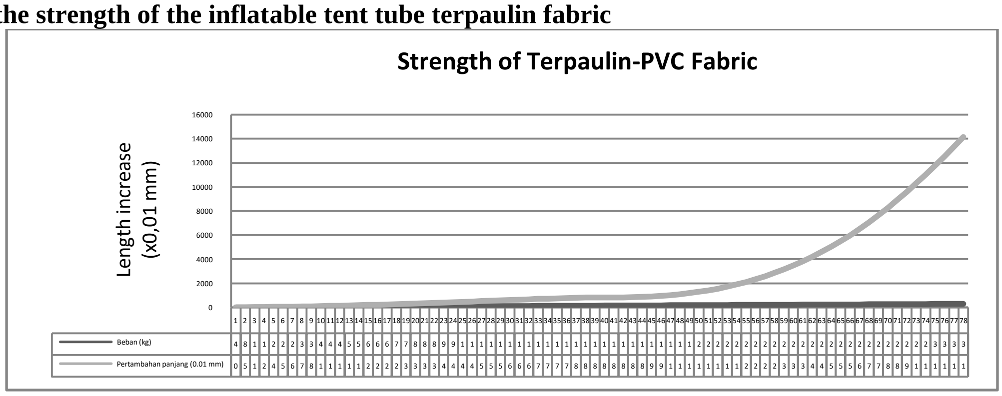

Figure 4. Graph of the Strength Test of PVC Terpaulin Fabrics

The maximum strength of the PVC coated tarpaulin membrane with a thickness of 0.5 mm was achieved at a load of 312 kg for a surface area of 1 cm2.

3.5 Photovoltaic Energy Test

The test results of 4 monocrystallin solar panels, each 540 wp 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

When the weather is sunny, 4 solar panels with a power of 540 WP each can produce a minimum of 11.6 Ampere 31.8 Volt, while when the weather is cloudy the current drops to 6.8 Ampere 25.2 Volt. The electrical energy stored in 2 batteries of 200 Ah 12 V each on 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 -4.9oC to 3.8oC.

The maximum strength of the PVC coated tarpaulin membrane with a thickness of 0.5 mm was achieved at a load of 312 kg for a surface area of 1 cm2. SOLAR POWER PLANT with solar panels with a power of 3,600 WP and a 200 Ah battery can store 4,800 watts of power for the electrical needs of patients in an inflatable tent. In the conclusion section, the research findings are briefly written, without additional new interpretations. The disadvantages of this study include: 1) The absence of an air pump that also controls air pressure, 2) The capacity of an inflatable tent of 10 patients requires development to increase the capacity of a minimum of 20 patients, 3) There is no air conditioning in the room. Inflatable tents 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) Increasing the capacity of the inflatable tent, 2) Monitoring the air pressure in the inflatable tent tube with a pump that automatically works at pressures that are less than the minimum standard and stops at the maximum pressure, 3) Researching the temperature in the inflatable tent with additional regulators temperature (air conditioning).

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