THREE-WHEELED ELECTRIC VEHICLE DESIGN FOR MOBILITY OF STUDENTS WITH DISABILITIES IN INCLUSION SCHOOLS

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ABSTRACT
Inclusion schools are one of the efforts to fulfil the needs of students who have physical and non-physical limitations. Students with disabilities have the same rights in obtaining education at school up to university level. However, not all schools can meet the needs of students with disabilities. the problem that often occurs is that students with physical disabilities have obstacles when learning activities in college due to lack of transportation facilities and the vast campus area. therefore, it is necessary to design a means of transportation that is easy to use by students with disabilities. This paper discusses the design of a three-wheeled Electric vehicle with a simulation method. Design using Computer Aided Engineering (CAE) software and ANSYS software analysis. The design results of a three-wheeled electric vehicle for students with disabilities using St52-3 frame material show an equivalent stress value of 17.162 MPa which is still below the Yield Strength of the frame material. The stability of the vehicle at a speed of 40 km/hour shows centralized pressure on the center body of the vehicle. It can be seen that the air turbulence flow on the rear body meets the safe level for use by students with disabilities when doing mobility.

Keywords: transportation, electric vehicle, disabilities, inclusion school

INTRODUCTION

The international education system has seen an increase in the number of new students in public schools, especially in developing countries such as Indonesia. These students may experience disadvantages in terms of school connectedness that limit inclusion participation [1]. However, in line with the Indonesian government's regulation through the minister of national education and culture to implement an inclusion school programme to support students' enthusiasm for learning, especially for students with various limitations. The diversity of impairments experienced by students in public schools requires more specialised treatment. Although great strides have been made to integrate and provide the

necessary support for students with diverse impairments, scientific investigations still highlight the existence of various barriers that hinder the social inclusion and connectedness of these students in public schools [2]. The three main types of disabilities affecting student travel behaviour during school learning activities are cognitive, mobility and sensory [3]. Students with disabilities are less likely to be independent and require more assistance from others due to transport difficulties that hinder their access to school and school activities. Travel difficulties related to school learning activities pose challenges in travelling to and from school [4].

The use of electric vehicles is very broad, one of which is for transportation of people with disabilities. One of the problems when people with disabilities pursue higher education, where the large campus area becomes a problem when they move. Optimal services for people with disabilities who do not have perfect bodies can help them with mobility from one lecture hall to another. The adaptation process is not an easy process for persons with disabilities [5]. The vast campus area and the distance between lecture buildings are obstacles for students with disabilities. Meanwhile, to help the mobility of people with disabilities, a means of transportation that is comfortable, safe and easy to operate is needed. Therefore, it is necessary to design a means of transport that is comfortable, safe and easy to operate for students with disabilities [6].

The type of electric vehicle for students with disabilities that is easy to operate, safe and comfortable cannot be separated from the design of electric vehicles. besides that, electric vehicles are environmentally friendly and cost-effective for transportation. The problem of electric vehicles so far is the strength and shape of the frame and chassis design so that it can support all components of electric vehicles, such as batteries, control systems and others. Lightweight and strong frame construction can certainly increase the stability and efficiency of electric vehicles, especially for students with disabilities [7-10]. The electric vehicle frame is the foundation to hold and support the entire weight of the vehicle. Therefore, the electric vehicle frame must be lightweight, sturdy, safe, and cost-effective compared to conventional vehicle frames Artificial Intelligence (AI)-based electric vehicle frame design for Mobility of Students with Disabilities is analysed. The material selection analysis used is the AISI standard. To know the strong impact of all the components in the frame, torque analysis and static simulation are used while doing the analysis. Therefore, it can be concluded that, the frame and chassis of an electric vehicle must be designed in such a way that it can withstand all kinds of impacts, so that it is safe and comfortable to use as a means of transport [11-15].

In addition to a lightweight vehicle frame, electric vehicle design also requires a structure that has enough space to accommodate multiple batteries. Battery built-in-frame (BBF). A hollow shell structure assembled with thin aluminium plates, is considered one of the most promising candidates. The BBF can be made with extrusion moulds suitable for mass production. The BBF for the basic structure of an electric vehicle is designed on the premise that it plays a major role in the total rigidity. Therefore, the dimension of the structure together with the reinforcement of the BBF is important for the total stiffness [16].

The Battery built-in-frame (BBF) model has enough space to accommodate multiple batteries. Frame with battery built-in-frame (BBF). The structural integrity of the frame was verified by comparing the analysis results with the material standard values. The analysis is performed using a finite programme with the results of the heavy frame when the deformation of the vehicle is compared because the lighter weight shows less deformation [17-19]. In addition, Design the electric vehicle frame by Numerical simulation using finite element analysis (FEA)

software to investigate the stress and deformation patterns in the vehicle frame under different loading conditions [20-22]. The boundary conditions for analysis include fixed supports at the bottom bracket and rear dropout, and a concentrated load applied at the top of the seat mount, this can simulate the rider's body weight. The loads were applied in two different directions, both vertically and horizontally. However, the bending and torsional stiffness analyses for the X and V frame models of hollow pipe material have not been analysed, and static loading has not been carried out when testing the frame, which is necessary because the frame is subjected to dynamic loading, so in this study, dynamic loading is carried out to determine the stability of the electric vehicle.

This study focuses on the development of electric vehicles for people with disabilities, where the construction and features of the frame and chassis of electric vehicles require construction and features of the frame and chassis that are different from other electric vehicles. This is a special need that has not been produced by the electric vehicle industry and is not on the market, so that people with disabilities use modified electric vehicles which of course comfort and safety when using these electric vehicles cannot be fulfilled. In addition, non-existent transportation facilities for students who are studying at universities greatly hamper their mobility. The condition makes it an urgent problem to be resolved as soon as possible.

This paper designs a model of a transport device for people with disabilities that can facilitate the journey to school and during activities at school. The three-wheeled electric vehicle model with the placement of the rear door that can be opened automatically makes it easier for people with disabilities to enter the vehicle together with a wheelchair. The automatic system to open and electric vehicle doors can make it easier for people with disabilities to operate electric vehicles on their own without the help of others. The design of this electric vehicle model can be used to complement the supporting infrastructure of inclusion schools as a means of transporting people with disabilities to move from one lecture building to another during learning activities on campus.

METHOD

Finite element analysis method is used for the mechanical structure of electric vehicle frame to estimate stress, deformation and strain energy under critical load conditions. The work available in the literature related to the design and analysis of the vehicle frame is discussed here. Space type electric vehicle frame to be analysed in Computer Aided Engineering (CAE) software [23]. The electric vehicle structure with loading is analysed in ANSYS software, in addition, the strength of chassis joints is analysed using ANSYS tools [24-26]. The frame of the three-wheeled electric vehicle is an unconstrained structure. Therefore, static analysis cannot be applied directly to analyse the structure as the stiffness matrix becomes singular due to the inflexible motion of the frame structure. 3D models of three-wheeled electric vehicles are analysed through the Inertia Relief analysis technique in ANSYS Workbench tool to calculate the translational and rotational inertia relief of acceleration.

Technical Analysis

Analysis techniques to determine the bending and torsional strength of the frame, as well as the aerodynamics of the three-wheeled electric vehicle body so that the strength and load balance can improve the stability and comfort of using electric vehicles. Analysis of flexural and torsional stiffness using simulation methods. The vehicle frame specifications are 1500 mm long, 800 mm wide, 1650

mm high, 150 kg weight, 1,230 cm wheelbase and 150 mm ground clearance. The seat is placed on a battery built-in-frame (BBF) and the suspension is also directly connected. The seat is placed on the battery built-in-frame (BBF) and the suspension is also directly connected. Since most of the external load to the truss beam is applied from the suspension, the behaviour of the truss beam can be substituted for the Saint Venant problem. The frame beam dimensions a = 30 mm, b = 30 mm, t = 2 mm. The materials used for the electric vehicle frame with the properties presented in Table 1.

Table 1. Material properties of St52-3

Mechanical Properties	Parameters value	Unit
Yield Strength	355	MPa
Ultimate tensile strength	350	MPa
Poisson Ratio	0.3	
Elastic Modulus	206	GPa
Shear Modulus	76	GPa

Structural analysis of an unconstrained three-wheeled electric vehicle the 3D solid model prepared in the Weldments module of the Solid Works tool was imported into the ANSYS Workbench module. next, meshing of the frame was performed with the ANSYS using a global mesh control strategy. The domain of all bodies was divided into small discrete cells for solving mathematical equations at nodal/cell positions. The meshed 3D model of the three-wheeled vehicle frame was discretised into 110,442 nodes and 53,577 elements.

The results of this research analysis are presented in descriptive statistics. The research data obtained will be included in the table and displayed in graphical form. Furthermore, it will be described in the form of simple sentences so that it is easy to understand to be able to know the vilocity on the vehicle body when travelling at 40 km/hour, and the stress on the frame when given loading with the loading value presented in table 2.

Table 2. Point of application of loading

S.N. Loading position	Loading (2G) for electric vehicle frames (N)
Front wheel point	3.650
Right rear wheel point	5.000
Left rear wheel point	5.000
Total	13.650

RESULTS AND DISCUSSION

This analysis was carried out to examine the deformation and stresses that occur due to frame loads and loading scenarios with a total weight capacity that the electric vehicle frame can withstand with a load of two people. The stresses developed are checked against the material strength of the electric vehicle frame.

The analysis of the skeletal structure is restricted to specific locations in all degrees of freedom with respect to the global coordinate system. The frame is restrained from moving or rotating at these constrained points. Such constraints are known as boundary conditions as shown in Figure 1. Three-wheeled electric vehicles are generally designed to withstand loads of 200-300 kg, so that they can accommodate two people. The design of the three-wheeled vehicle frame for disability strength of the applied load on the frame surface of 500 kg. loading on

the frame surface to check the structural integrity under the maximum loading capacity.

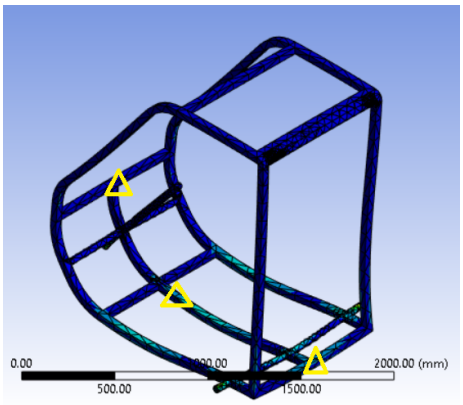

Figure 1: Fixed supports applied to the frame

The results of the stress analysis with full loading capacity carried out to check the stresses that develop with the strength of the frame material show a stress distribution that is centred at several points on the frame, as shown in Figure 2.

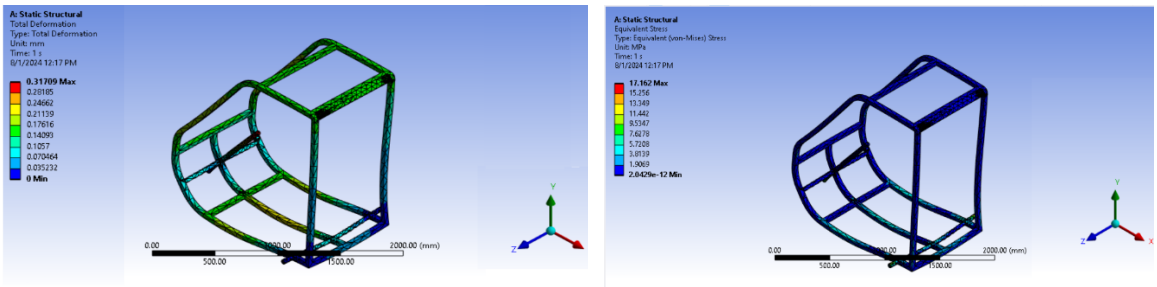

Figure 2. Stress distribution in the frame

The frame stress of the three-wheeled electric vehicle shows an equivalent stress of 17.162 MPa under the maximum loading capacity of 500 kg. The allowable strength of the St 52-3 material used as the high-strength frame is 355 MPa. The allowable strength of the material is greater than the stress occurring in the frame of the three-wheeled electric vehicle, so the frame design made meets the design requirements.

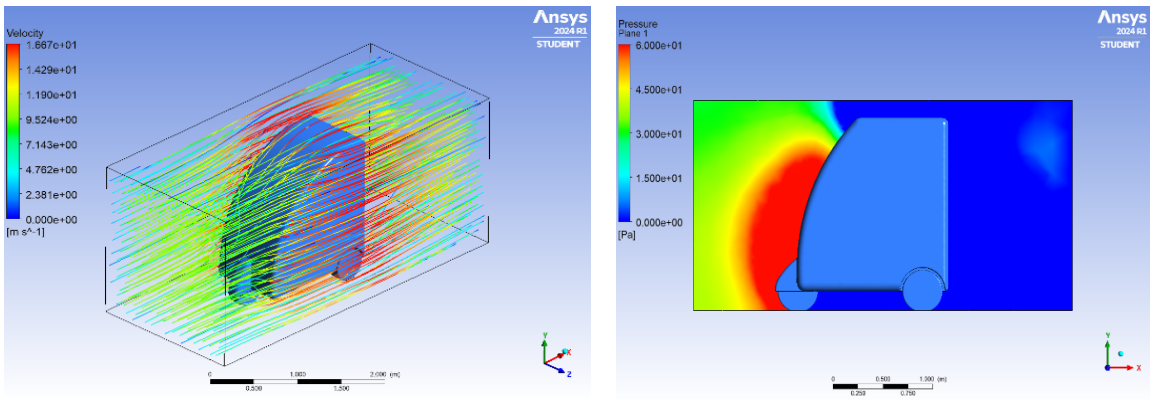

Figure 3. Front side vehicle body airflow pressure

Meanwhile, the results of airflow analysis on the three-wheeled vehicle body on the front, top and side at a speed of 40 km / h show an increase on the front side of the body of 60 KPa. this increase in pressure is due to an increase in vehicle speed. in addition, the increase in vehicle speed also increases the pressure on the side body of the vehicle which can reduce vehicle stability. Therefore, the shape of the vehicle body designed at a speed of 40 km/hour shows a high level of stability so that it is safe to use for a maximum speed of 40 km/hour, as shows figure 3.

Rear side airflow conditions, when vehicle speed increases, can have a significant impact on increasing turbulent air behind the vehicle which can destabilise the vehicle when travelling at speeds above 40 km/hour, as shows figure 4.

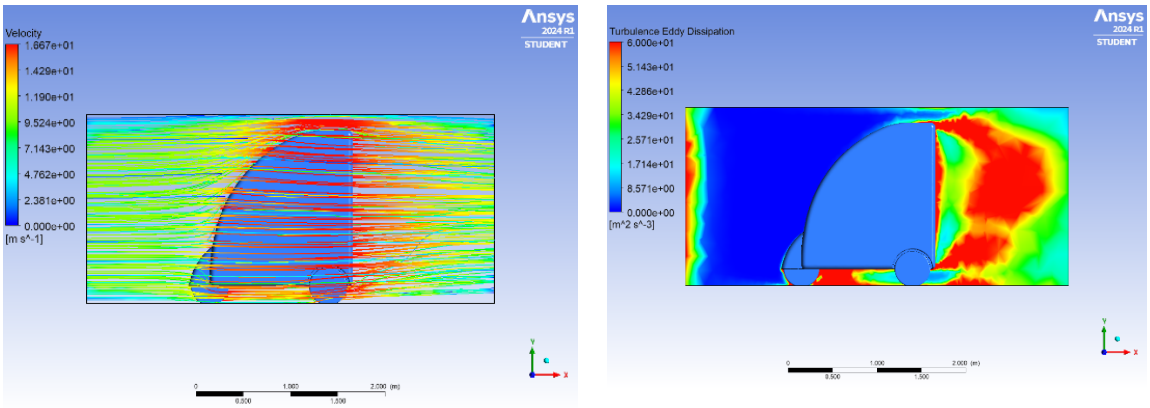

Figure 4. Air turbulence at the rear side of the front side vehicle body

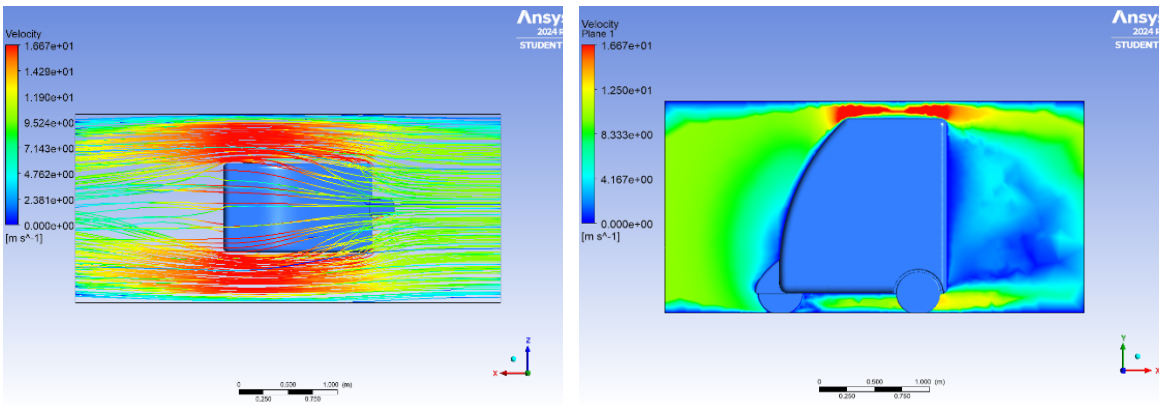

Figure 5. Vehicle roof side air flow shape

The airflow profile on the roof of the vehicle shows a large pressure flow on the right and left edges of the roof which is balanced with an airflow velocity of about 16.67 m/s. This shows that when the vehicle speed increases to the maximum limit of 40 km/h, this condition indicates the stability of the vehicle with no large pressure on the roof body of the vehicle.

CONCLUSION

The three-wheeled electric vehicle design results show safe frame strength under 5000 N loading and high stability under 40 km/h speed. The increase in speed occurs on the larger front side with a value of 60 KPa with a larger area.

While the frame construction model with the strength of the material used shows an equivalent stress value of 17.162 MPa is still below the Yield Strength of the frame material, so the design of the three-wheeled electric vehicle meets the safety level to be used for students with disabilities while getting around campus easily and comfortably.

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