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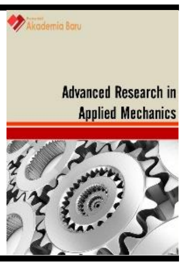

Stress Analysis of Urban Solid Waste Trap by Using Finite Element Analysis (FEA)

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ABSTRACT

Trash trap is a tool used for the purposes of garbage collection in drainage areas such as rivers or drains. However, ineffective trash designs cause the waste to be difficult to clean. Waste that cannot be properly cleaned will cause problematic drainage problems. The main objective of this study is to construct trash traps for public drainage using a wheel and axle mechanisms as a tool to function. Therefore, the ADDIE model is used as the main guideline in the whole process of designing and building a waste trap model. The ADDIE model consists of five main components, namely the analysis phase, the design phase, the development phase, the implementation phase and the phase of the selection. This study involves qualitative data collection methods with data analysis procedures basically done and reported descriptively. The main data sources for this study are Finite Element Analysis (FEA), calculation methods. The Finite Element software, it aims to see the strength of the model capable of bearing the burden imposed, while for analysis the calculation method is to see the difference in energy consumption between ordinary traps and waste traps using the mechanism. Research findings have shown that waste traps are built to help clean up work.

1. Introduction

Solid waste is the most abundant and easily found and most produced waste [1,2]. The increase of population one of the factors that contribute to the generation of solid waste. The problem of unprocessed solid waste management by industry and population causes severe water pollution problems [3,4]. Removal of solid waste will be deposed in the drains and rivers can give the effect that negative to environmental. Due to this, it can cause the problems such as smelly rotten that can disturb the people around it and can cause drain clogged and experience water reservoir due to the garbage disposal and solid waste that contribute to the occurrence of Aedes mosquito breeding in the water [5,6].

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In addition, the main problem that has been detected is that existing waste trap didn't fulfill the design criteria. According to Rahman [7], the traps are only able to trap the waste and do not have the means to help clean it. The gap between each bar waste to large more than 50mm. On the other hand, the structure of the waste trap also can't support the loaded produced by the waste in the river. Waste typically consists of manufactured materials such as bottles, cans, plastic and paper wrappings, newspapers, shopping bags, cigarette packets and hypodermic needles, but it can also include items such as used car parts, rubble from construction sites and even old mattresses [8].

This research focuses on the design prototype development, how the mechanism of the product works and the way in which the worker faces. Other than that, the importance of this study is to preserve the drainage area from waste dumps and clogging drainage problems. The previous researcher [9] state construction of waste traps is the best alternative to reduce water pollution in drains or rivers. The waste trap is one of the best measures to increase water quality from pollution [9]. Besides that, they are two types of the waste trap which are grouped according to storing a dry or wet load, the collected items are either stored above (dry) or below (wet) standing water level [10].

2. Literature Review

2.1 Finite Element Analysis (FEA)

In designing the product, one of the purpose and criteria that need to take considered is the weight of waste loading on the product. The method which had been used to analyse the loading weight of waste of the product is by using Finite Element Analysis (FEA) software. Each of these examples uses the finite element method to solve optimization problems [11]. This study will use finite element analysis (FEA) software for the waste trap model to analyse how much load the material can be covered by the model. Besides that, in this project, the use of finite element analysis (FEA) helps in analysing data more accurately and faster than manually operated testing.

2.2 The Component of Power

The analysis was done using two methods, they are the calculation method and the method of waste trap model development. In the analysis calculation, the data were analysed and the results displayed in the graph. From the graph, note the difference of force (N) used to lift waste with mechanical systems and without the mechanism system. In physical, power is the rate at which energy is transferred, used, or transformed. Power unit joule per second (J/s), which is known as the watt. To get the value of power, firstly must define the value of force in Newton (N) and work in Joule (J).

$$\textbf{Force, F (N)} = \textbf{Mass (kg) x Gravity (m/s}^2\textbf{)}$$

$$\textbf{Work, W (J)} = \textbf{Force (N) x Distance (m)}$$

$$\textbf{Power, P (J/s)} = \frac{\boldsymbol{Work\ (J)}}{\boldsymbol{Time\ (s)}}$$

Fig. 1. Formula Component of Power

3. Results and Discussion

3.1 Pilot Study

Table 1 shows a pilot study was conducted at the Darul Aman Stadium for a month. The waste quantity is measured in kilogram (kg). The heaviest weight of waste is 22 kg at week 3, while the light is 8 kg which is in week 1. Waste weight at week 3 will be used as the weight to be applied in this study.

Table 1
Weight of Waste Trap in a Month

Week	Type of Waste	Weight (Kg)
Week 1	Plastic bag, paper, fabric, slipper, plastic bottle, leaves.	8kg
Week 2	Plastic bag, paper, plastic bottle, leaves, animal carcasses.	10kg
Week 3	Plastic bag, tree branches, paper, fabric, slipper, plastic bottle, polystyrene, animal carcass, scrap metal, leaves	22kg
Week 4	Plastic bottle, leaves, paper, polystyrene, tree branches.	15kg

3.2 Finite Element Analysis (FEA)

3.2.1 Von Mises Stress (Nodal Value)

The result of meshing and Von Mises stress is shown in Figure 2(a). The number of nodes is 31905 nodes and the number of elements is 15240 elements, then the result of the statistic for the element type is 100%. In addition to Figure 2(b), the result for nodes is 3038 nodes and the element is 1486 elements. For the Figure 2(c) the number of nodes is 337456 nodes and for a number of the element is 33745 nodes and number of the element is 18875 elements. While Figure 2(d) the number of nodes is 3579 nodes and number for the element is 1468. The statistic for the element type is 100 %. That means all of the figures show is Nodes Jacobian criteria and good element.

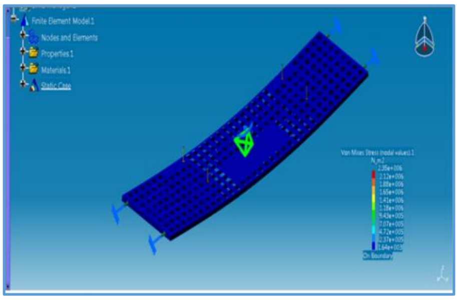

Fig. 2(a): Waste Trap Base

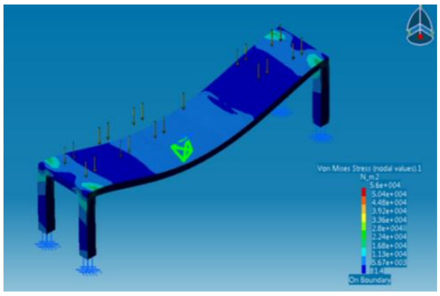

Fig. 2(b): Base

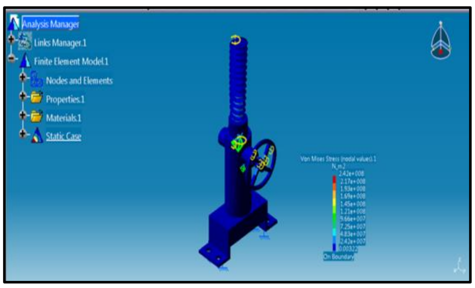

Fig. 2(c): Wheel and Axle

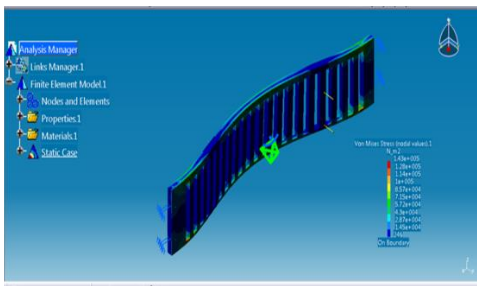

Fig. 2(d): Existing Trap

Based on Figure 2(a) – 2(d), the green colour indicates that the force or load imposed on the structure of the waste trap model to determine if a given material will yield or fracture. It is mostly used for ductile materials, such as metals. The von Mises yield criterion states that if the von Mises stress of a material under load is equal to or greater than the yield limit then the material will yield. Therefore, based on the figure, the components of the built-in waste trap can accommodate the pressure applied to it.

3.3 Displacement

The figures below show the maximum reading value for the four-model structure waste trap. The maximum displacement for Figure 3(a) and Figure 3(b) is in the middle of it (0.021mm) and (0.00061mm). Whereas, the maximum displacement reading a value of Figure 3(c) and Figure 3(d) is (0.0021mm) and (0.231mm). The value of this reading, taken at the highest value shown in the analysis result that has been made. Notice that the displacement values in the scale are very small. This illustrates the amount of exaggeration present in the visualization. The displacement option allows viewing the translational displacement of the model based on the loads that were applied upon it. The option is important for visualizing which part will react under the given load conditions.

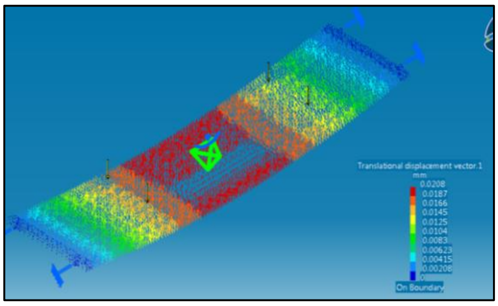

Fig. 3(a): Waste Trap Displacement

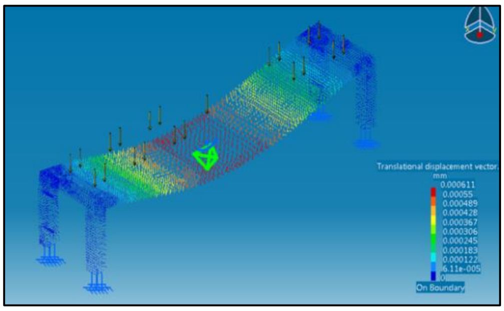

Fig. 3(b): Base Displacement

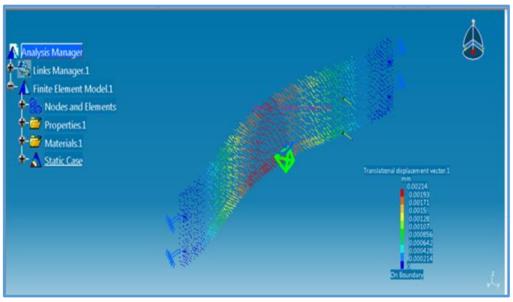

Fig. 3(c): Existing Trap Displacement

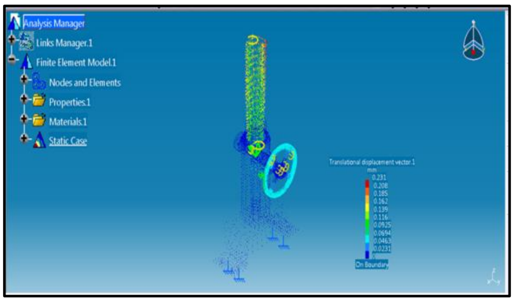

Fig. 3(d): Wheel and Axle Displacement

The red colour shown in the diagram shows that the area has been received high pressure compared to other areas. From the diagram, you can see the displacement field is displayed and in the plot with arrow symbols. The displacement field can now be used to compute other results such as strains, stresses, reaction forces and so forth. Additionally, the colour palette shown in the figure helps in focusing on a specific portion and the value of the auxiliary value.

3.4 Principle Stress

The principal stress option allows viewing the principal stress tensor that is created based on the loading or stress imposed. Inwards/outwards indicates the sign of the principal stress applied to each part of the element waste trap. This allows visualising the directions in which the loads are acting throughout the model. The principal stress is indicated by the colour palette shown in the diagram. Colour palette other than red, states that there is less static pressure on the area. While Blue is the safest area based on the specified figures as below.

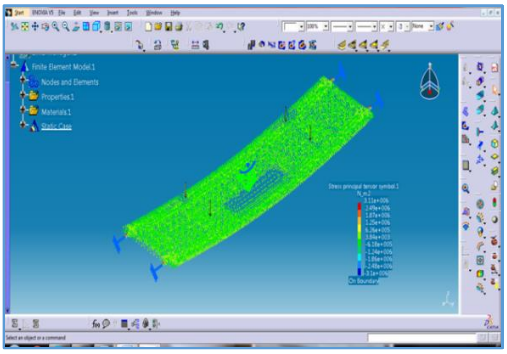

Fig. 4(a): Stress Principal of waste trap base

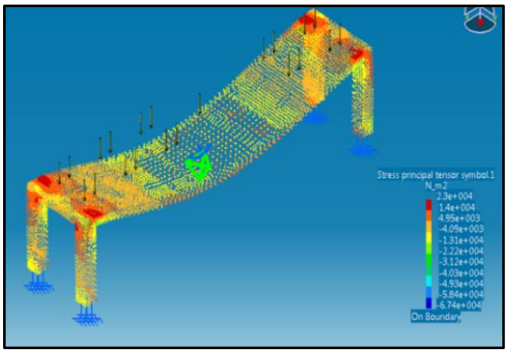

Fig. 4(b): Stress Principal of base

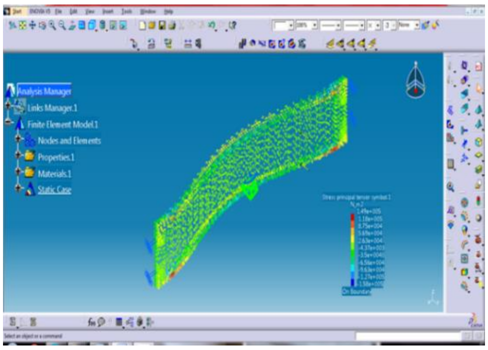

Fig. 4(c): Stress Principle of static screen

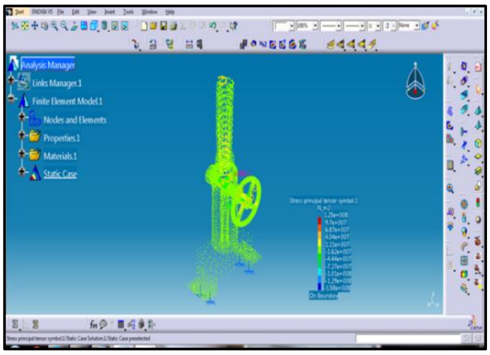

Fig. 4(d): Stress Principle of wheel and axle

3.5 Estimated Local Error

Table 2 shows the list of estimate local errors. The estimated local error images are used to visualize computation error maps of energy performed in the calculation of each component of the waste trap model structure. A good result of the analysis is that the value of the lowest error. This is to obtain more accurate computation results during the analysis. It also shows a map of the predicted norms of energy errors that provide a qualitative overview of the distribution of errors in each component's structure.

Table 2
List of estimated local errors

FIGURE	SENSOR NAME	SENSOR VALUE
Figure 5(a)	Energy	4.234e-006 J
Figure 5(b)	Energy	1.30e-004 J
Figure 5(c)	Energy	6.184e-005 J
Figure 5(d)	Energy	0.303 J

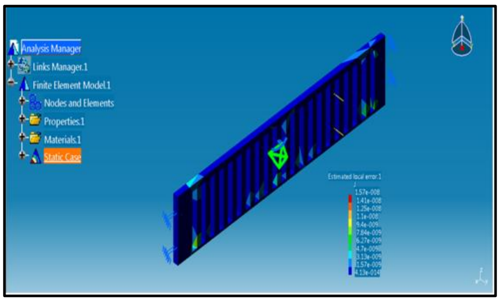

Fig. 5(a): Existing Trap

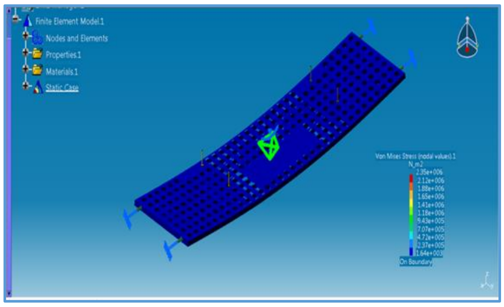

Fig. 5(b): Waste Tap Base

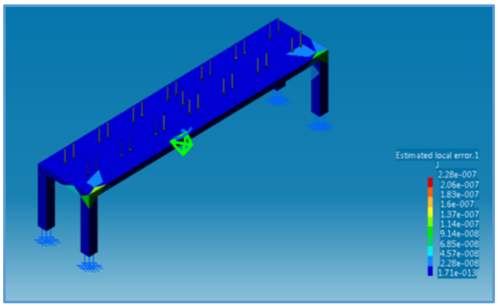

Fig. 5(c): Base

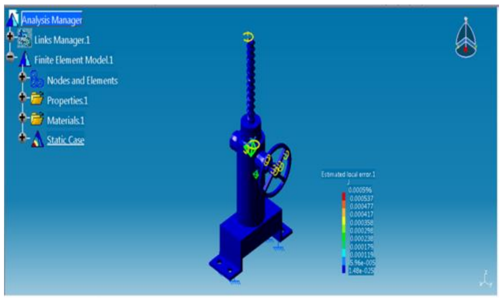

Fig. 5(d): Wheel and Axle

3.6 Comparison of Power Used

Figure 6 shows the comparison power used between using the mechanical system and manual system to lift a load of 22kg. The result shows that the power used to lift the loads with mechanism 0.0001 J/s and the power used without mechanism is 7.19 J/s. It can be concluded that using the mechanical system can reduce the human power, from 7.19 J/s to 0.0001J/s.

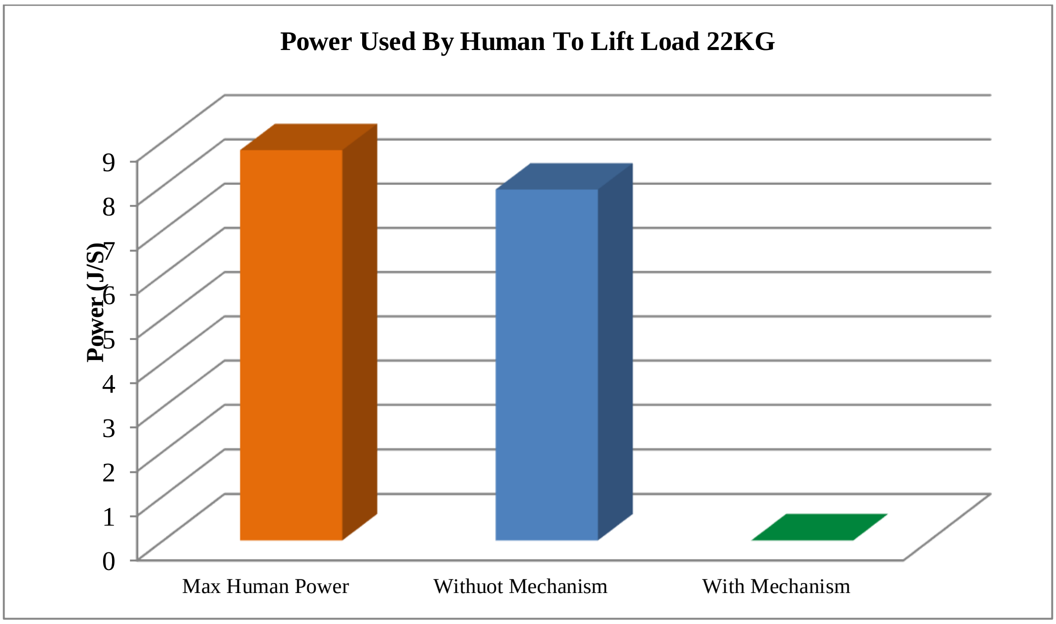

Fig. 6. The Comparison of Power

4. Conclusion

The result of the waste trap model by using the wheel and axle mechanism has sufficient strength to accommodate the load or stress imposed on it. Test results in the stress principal analysis, von Mises stress, displacement, and estimate local errors prove that the model is safe and capable of withstanding the weight of the waste it imposes. The red colour from the FINITE result indicates that the area is experiencing high stress, while for the yellow, green and blue sections it shows that the area is less stressful and safer.

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