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Study on Automatic Platform Gate (APG) Door Rubber Alternative Design of MRT SSP Line Project

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Abstract: Automatic Platform Gate (APG), also known as Platform Screen Door (PSD), is a screen door that was installed at the border platform of modern urban, mainline or metro railway stations. An issue of Automatic Sliding Gate (ASG) having close obstacle detection always raised during 1000 cyclic test caused by sliding effect of rubber door. This study presents the works in designing an alternative ASG and rubber door structure based on the identification factors of ASG to get obstacle detection through deep observation and discussion with technician. Solidworks were used as a platform for the development of 3D model of APG that focused on the ASG frame and rubber doors. Gravity simulation test was selected to examine the performance of current and new rubber door design by comparing their results of stress, displacement and strain. The displacement of the rubber door can be measured as a result of stress and strain, even if the numbers of displacement are too small. As a result, the stress received by both rubber door designs is directly proportional to their displacement. The new design of ASG frame and rubber door were successfully designed, thus able to eliminate the sliding effect of obstacle detection.

Keywords: Automatic Platform Gate, APG, Door Rubber, Rubber Door, New Design, Alternative Design

1. Introduction

Automatic Platform Door (APG) is a screen door that is half the height of the train. APG structures typically do not reach the station's ceiling or structural beam, and hence do not constitute a complete screen door barrier. PSD, on the other hand, has the same construction as APG, but the distinction is that PSD is a full-height screen door that reaches the station's ceiling or structural beam. This will result

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in a whole door barrier that is best suited for installation at the subterranean station [1]. They placed the APG on elevated stations as part of the MRT SSP Line project. They want the station to be designed with an open concept so that there is always natural ventilation. Another reason is that they wish to avoid using the air- conditioning system on the station and instead utilise the large ceiling fan, which is a wonderful technique to reduce the station's operating costs and power consumption.

In terms of underground station design, they installed PSD to create a completely closed- concept to assure passenger safety. PSD can prevent any dust or unknown-flying substance from accessing the platform, which is damaging to the passengers' health. It also meant that air conditioning was used efficiently, since it could circulate freely over the platform area to produce ventilation and provide a pleasant element to the passenger.

The primary reason APG and PSD were installed for the MRT SSP Line project is that they form a barrier that separates the public area from the track area, limiting access to the track area and preventing passengers, particularly children, from entering the track area because this MRT used third-rail as their power supply system that received from TPSS to the rolling stock. The third-rail was supplied with 740 V DC electricity, posing an electrical threat to passengers. It is also possible to avoid suicides and accidents by restricting access to the track area. When they investigated the effects of installing PSDs on the suicide rate in Hong Kong, they discovered that during an 11-year period, PSDs were responsible for a 60.00 % drop in railway suicides [2]. Even if the train suicide was an uncommon occurrence in Malaysia, it is best to be safe than sorry.

1.1 Structure of APG

Table 1: The items and number of pieces for both North and Southbound per station

Item	Items	Pieces per Station
1	Fixed Driving Panel (FDP)	64 (left and right)
2	Automatic Sliding Gate (ASG)	64 (left and right)
3	Emergency Exit Gate (EEG)	16
4	Platform End Manual Gate (PMG)	4
5	Fixed Screen (FS)	48
6	Support Column	34
7	Threshold	100
8	Emergency Stop Plunger (ESP)	4

The mechanical structure of APG includes the gate panels and gate mechanical system. The structure consists of supporting structure, Fixed Driving Panel (FDP), Automatic Sliding Gate (ASG), Platform End Manual Gate (PMG), Emergency Exit Gate (EEG), Fixed Screen (FS) and their framework.

1.2 Factor of ASG to get Obstacle Detection

Table 2: List of issues and its problems

Issues	Problems
Misalignment	ELD, ERM Box, ASG Roller
Intermittent	Limit Switch
ELD Fault	Solenoid
Obstacle Detection	Misalignment issue, motor belt tension, heavy ASG movement, rubber door

Theoretically, 1000 times cyclic test is run in only four hours, meaning that the test can be done in a day because the timer is set in seven seconds per cycle. 250 cycles took one hour to run, 500 cycles

took two hours to run and 1000 cycles took four hours to complete. However, in reality, it will take three to seven days to run this test. Table 2 shows all the common issues that usually happened during cyclic test. The problems can be solved by adjusting the alignment, change the intermittent or fault components with the new one or adjust back the belting tension. Upon all of these problems, there is one issue that should not happened during cyclic test, which is obstacle detection caused by rubber door.

2. Methodology

There is an essential criterion that will be discussed in this part to guarantee that the design method is feasible. The main block diagram as shown in Figure 1, depicts the key components employed in this project. Each of these components has a certain role to perform.

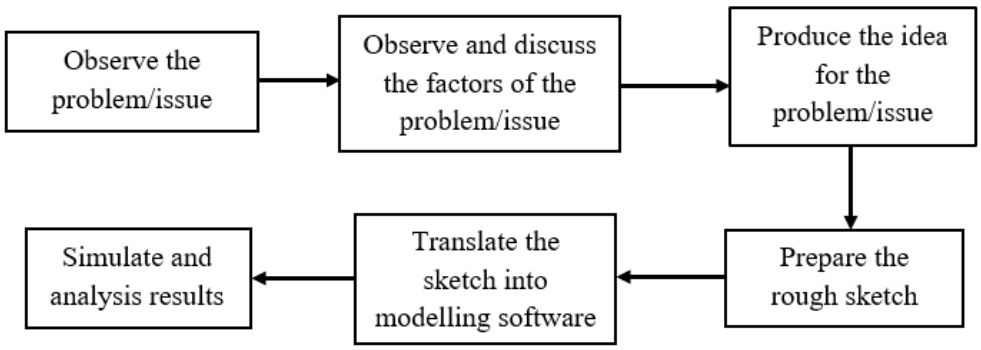

Figure 1: The Block Diagram for the development of a new rubber door design

Figure 1 depicts the block diagram for development of modelling design of APG for the new rubber door design. Before begin the design process, the problem of obstacle detection issue needs to observe for a few times to ensure the issue happen a few times during cyclic test. After that, have some observation and discussion together with technician about the factors that causes the obstacle detection. When rectify the issue, the source of problem is coming from the rubber door which had been slide down. This matter caused the existence of contact between rubber door and insulation mat of threshold. To solve the problem, the cause of the issue needs to be catered first, in order to make the design process much easier.

2.1 Factor that causes ASG to get Obstacle Detection

The procedure for identifying obstacle detection variables can be accomplished by observation and discussion with a technician. The technician is experienced in the installation, testing and maintenance of APG, which have a lot of knowledge about APG structure and systems.

2.2 Design Methods

The design of a new slot for rubber door can be achieve using 3D CAD design software, such as Solidworks or AutoCAD. This new design is focused on how to make the rubber door slot a lot more convenient for a long time, especially during the official operation service without having the same issue from happening again. The other structure will remain the same as the current design.

2.3 Initial Design

Figure 2 shows the rough sketch of the initial design for the door rubber slot. The door frame of ASG will have three vertical-square holes (female part) for the slot of the door rubber. The door rubber also has a new structure male part), which design to attach itself at the door frame for a better grip. This male-female concept will really prevent the rubber from sliding down, as the female part will hold the male part of the rubber.

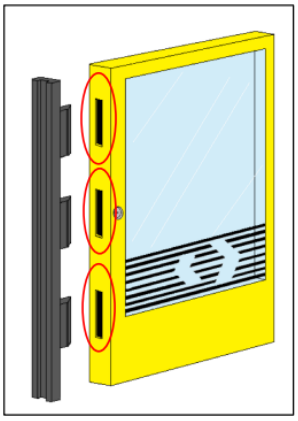

Figure 2: The initial design of new ASG frame with three verticle-square holes shown in the red circle

The design of this concept is based on the factors of obstacle detection by the rubber door. To avoid sliding effect, the sliding factor need to be eliminated first. The factor of sliding is floating effect caused by the air gap, the design of the slot frame and the uses of water soap as a lubricant. With these three factors, it seems that the uses of slot frame need to be removed. This is because slot frame is the reason why the rubber door can slide down after installation even though the reason slot frame was design is to attach and hold the rubber door to the ASG frame. With this reason, the clipping concept that uses male-female design might be uses to replace the slot frame.

Table 3: The comparisons between current design with new design of rubber door

Current Design	Comparisons	New Design
Has three main components: door rubber, slot frame and ASG frame	**Main components**	Has two main components: door rubber and ASG frame
Insert door rubber into the top of slot frame, spray the water soap and force the rubber door to slide through the slot frame	**Installation process**	Insert the rubber door to the holes and push the rubber door to the frame until there is no ga between them
Cause by the sliding structure of frame slot	**Sliding effect**	No
Cause by the evaporation of water soap	**Floating effect**	No
Water soap	**Lubricant**	No

As state in the initial design earlier, the hole on the ASG frame can be used to attach and hold the rubber door. It has three holes for extra support. with this, the ASG frame will be the female part of this concept. For the male part, the rubber door will get three extended structure that have same dimension and shape as the holes on ASG frame to support itself when attached to the frame. Not only that, the installation process is really easy, just insert the rubber door to the holes and push the rubber door to the frame until there is no gap between them. Table 3 shows the advantages of the new design and the current design of rubber door.

2.4 Gravitational Simulation Test

In Solidworks software, gravity simulation is a simulation features which uses the gravity forces as a load to hit on an object. When a gravity force of 9.81 m/s 2 hit the object, Solidworks can simulate the stress, strain and displacements on the deformation part. This method can be use in this project to test the performance between the current design and the new design of rubber door. Stress can simulate

how much magnitude of forces that cause deformation to the rubber door. Strain can measure the quantity that describe the deformation from stress. Displacement can be simulated to know how far the stress of the object can deform. To get in picture, this simulation will be test on both current and new rubber door design. By comparing both designs with these three aspects, the results on which design have the best performance can be examine through this simulation test.

3. Results and Discussion

Apparently, factors that causes ASG to get obstacle detection has been discussed and provided on Methodology in Chapter 2: 2.1. Among all of those issues, there is one that should not have occurred during the cycle test: obstacle detection induced by the rubber door.

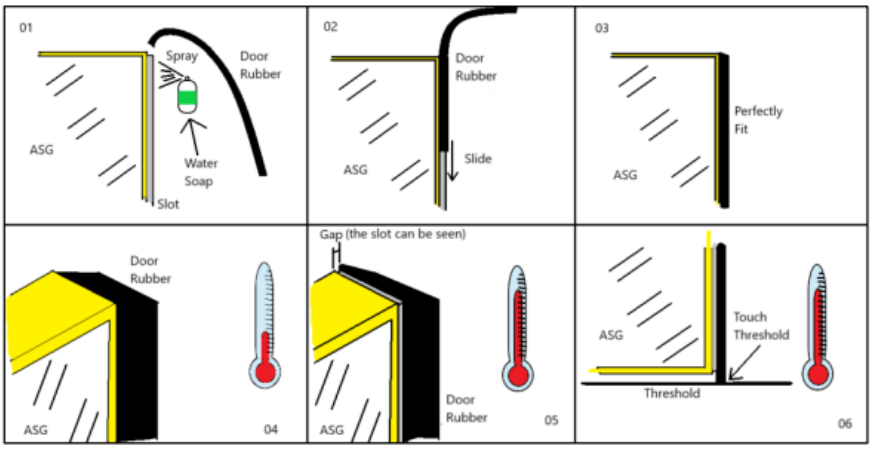

Figure 3: The illustration on how the problems of rubber door occur

Through deep observation and discussion with the technician, obstacle caused by rubber door happened because there is a little gap between the rubber door and the slot. Figure 3 shows that a formed air gap will loosen the friction between the rubber door and the metal surface of slot, creating a floating effect. This was happened because when installing the rubber door, the technician used water soap as a lubricant to insert and slide down the rubber into the slot. When in heat, the water soap evaporates, which a chemical process that transform water molecule into gas molecule, expand the rubber door and loses the grip and create the floating effect.

The other possible factor is that the weight of the rubber door itself making the sliding effect when the APG is operate frequently. With the vibration caused by the operation of ASG, floating effect and the weight itself, making the rubber door to slide easily. When it slides, the bottom end of rubber touches the threshold surface. Thus, making an obstacle detection when the ASG were in operation either for functional testing or actual operation.

3.1 3D Model of APG

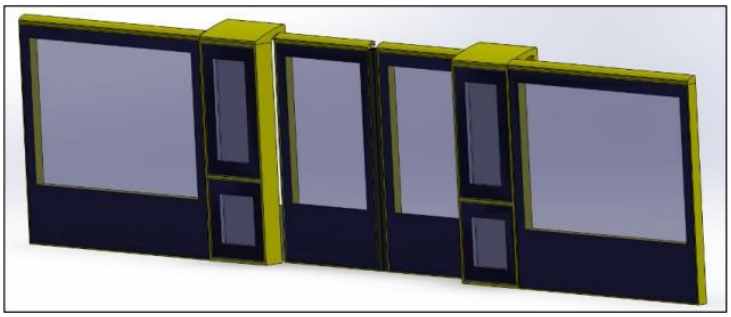

Figure 4: One set of APG that contains FS, FDP and ASG

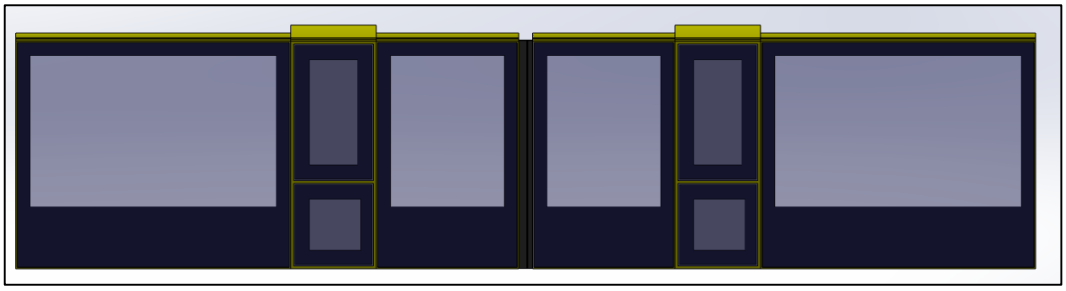

Figure 5: Front-plane view of APG

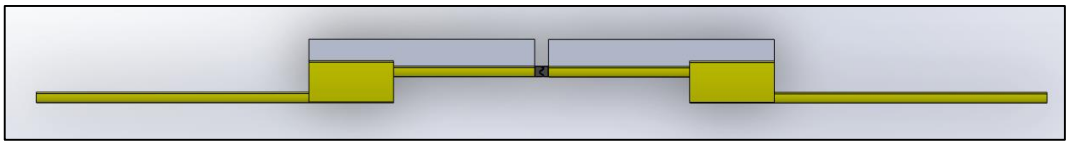

Figure 6: Top-plane view of APG

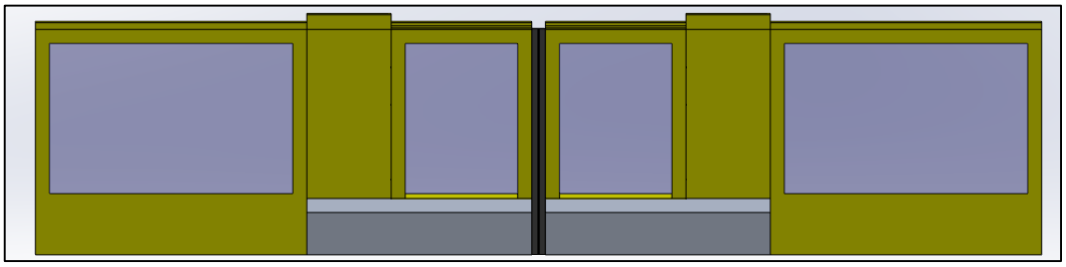

Figure 7: Back-plane view of APG

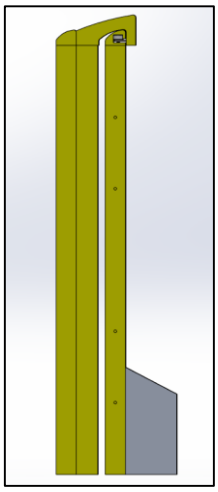

Figure 8: Side-plane view of APG

Figure 4 shows one set of APG that have been modelled using Solidworks software. It consists of ASG, FDP and FS for both left and right side. Figure 5 is a front-plane view of APG, which is a perspective view from platform side. Figure 6 is a top-plane view of APG that shows platform side (bottom side) and track side (upper side). Figure 7 is a back-plane view, which shows the APG structure from track side. Lastly, Figure 8 shows a side-perspective-plane that provide figure of platform side (left side) and track side (right side).

3.2 Data Analysis of Gravity Test

The gravity test is done by using Solidworks Simulation features, which help to simulate the possible result of the load that we put on the assembled model.

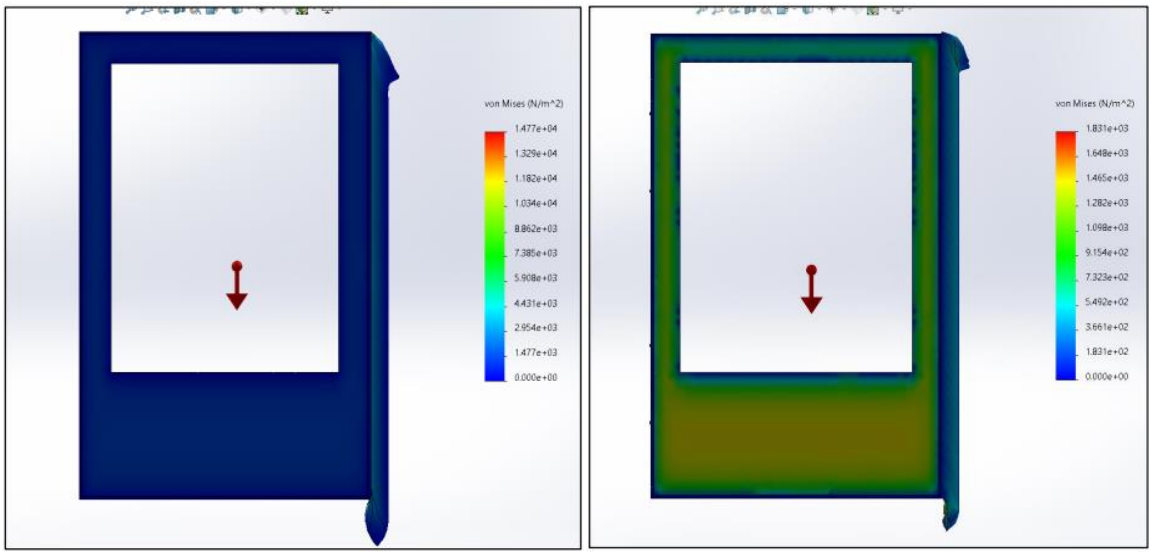

Figure 9: Gravity simulation on current (left) and new (right) rubber door design

Gravity simulation (as in the Basic Motion and Motion Analysis only) is a simulation element that moves components around an assembly by applying a simulated gravitational force [3]. Gravity simulation were chosen for this test because not only it can insert the simulated gravitational force, but also can simulate the stress, displacement and strain for every force the rubber door except. It also shows us the shape of the rubber door when the gravity hit it.

Table 4: The comparison of gravity between the current and the new design of rubber door

New Design	Results	Current Design
$0.000e^{00} < x < 1.831e^{03}$	**Stress, x (N/m^2)**	$0.000e^{00} < x < 1.477e^{04}$
$1.000 < y < 1.726$	**Displacement, y (mm)**	$1.000 < y < 5.342$
$0.000e^{00} < z < 1.475e^{-08}$	**Strain, z**	$0.000e^{00} < z < 5.597e^{-08}$

The data simulation shows that the new design of rubber door results a much better than the current design in terms of stress, displacement and strain, which the rubber received a 9.81 ms2 natural force of gravity. The comparison of those three terms between the current design and the new design of rubber door is already shown in Table 4. The translation of that data has been made into a graph analysis in Figure 10, Figure 11 and Figure 12.

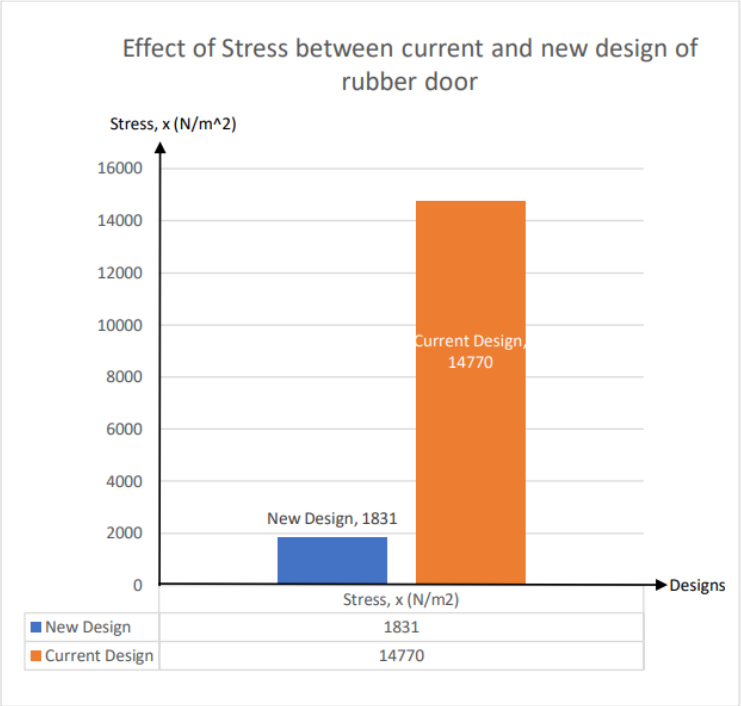

Figure 10: Graph analysis of new design vs current design on the effect of stress for both rubber door

The first data of Figure 10 was about the effect of stress when the rubber door being pull by a gravitational force. From Table 4, the current design of door rubber gets deformed with 14770 N/m^2 of stress, while the new door rubber design gets deformed with 1831 N/m^2.

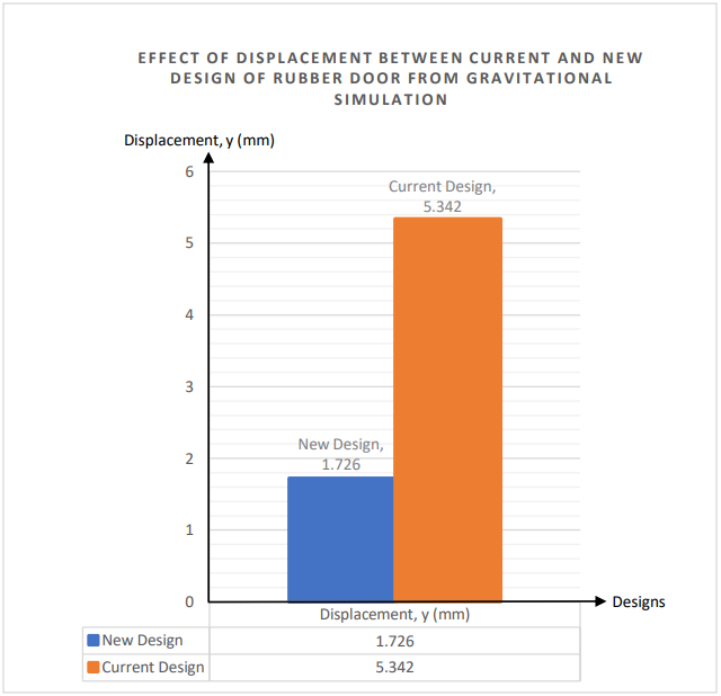

Figure 11: Graph analysis of new design vs current design on the effect of displacement for both rubber door

The second test of Figure 11 simulate on how far the rubber door will displace from the origin shape when the gravity hits them. It seems that the current rubber door design displaced greater than the new rubber door design with 1.726 mm to 5.342 mm. From the results, the current design displaced 3.616

mm more than the new design. The number of 5.342 mm is a lot for as it can reach the threshold because the distance between bottom ASG and top surface of threshold were setting for 2 mm. The new design still got displaces but not exceeding the range of 2 mm. This extra displacement on the current design is the reason why the ASG got obstacle detection.

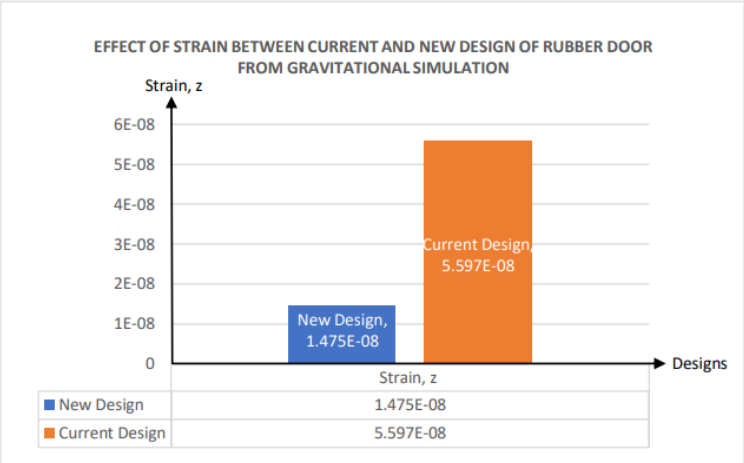

Figure 12: Graph analysis of new design vs current design on the effect of strain for both rubber door

The last test on of gravitational simulation on Figure 12, simulate the amount of strain received by the rubber door. By receiving 0.0000000597 ($5.597e^{-8}$) amount of strain, the bar chart for the current design of rubber door rises higher than the bar graph of the new rubber door design that get 0.00000001475 amount of strain ($1.475e^{-8}$).

3.4 Discussions

The final result for this project is based on the displacement and stress received by both rubber door designs. As in the physics definition, stress generally defined as force per unit area [4]. Meaning that stress was a quantity that define the magnitude of forces that can cause deformation on the object, in this case, the object was rubber door.

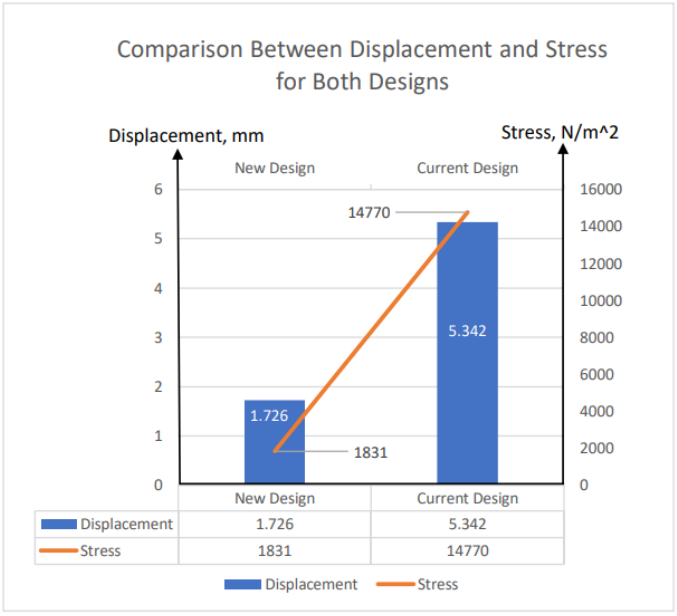

Figure 13: The relationship between stress and displacement for both door rubber design

When gravity forces pull on the object, it will affect elongation, which caused by the stretching of an elastic band (rubber door). This elongation was called tensile stress. If the forces cause a compression effect, it was called as compressive stress, and if the forces squeezed from all sides of surface area, it was called as bulk stress or volume stress. The acting gravity forces were set on tensile and compressive stress. As the effect from stress, the displacement of the rubber door can be measure, even the numbers of displacement are too small. Because of this, the stress received by the both rubber door design is directly proportional to the displacement of both rubber door design.

4. Conclusion

The three objectives of this project are being achieved by identify that the door rubber caused ASG to get obstacle detection. When the factor has been identified, the model of APG that focused on the ASG frame and the rubber door can be developed using Solidworks based on the current design and the proposed new design. Finally, the performance of the model of current and new rubber door design can be examine by simulate the Gravitational Test using the same software, Solidworks. The final result for this project is based on the displacement and stress received by both rubber door designs. The greater the displacement, the easier the rubber door tend to move from its slot. This means that the slot, included in the current door rubber design, cannot hold or withstand the amount of pressure that coming from gravity force alone. Meaning that the current slot did not have much grip to hold the rubber for a long time. This happened because the acting gravity forces were set to tensile and compressive stress. The displacement of the rubber door can be measured as a result of stress, even if the numbers of displacement are too small. As a result, the stress received by both rubber door designs is directly proportional to the displacement for both rubber door designs. With all of this data, the new design of ASG frame and rubber door were successfully designed, thus able to eliminate the sliding factor of obstacle detection.

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