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A Study on Automatic Platform Gate (APG) and Platform Screen Door (PSD) Alternative Design for Kuching Urban Transportation System (KUTS) Line using Software AutoCAD

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Abstract: Automatic Platform Gate (APG) and Platform Screen Door (PSD) at platform station build a barrier to separate passenger from falling onto the rail track to ensure passenger safety. However, the high initial cost and complex installation of APG system made KUTS only implement to 2 platform station (Hikmah Exhange main station, Simpang Tiga interchange station) for KUTS line phase 1. SWOT analysis was carried out to identify the alternative design solution for platform stations without APG in KUTS line phase 1. Future expansion work, precise stopping point at platform station, and high initial cost identified as major problem issues of APG preliminary design KUTS phase 1. A 3D model of alternative design of APG and PSD called wire screen door was developed using software AutoCAD. Then, software Inventor used to perform Finite Element Analysis (FEA), stress analysis on the wire screen door supporting pillars to examine its safety factor. Wire screen door system developed has low initial cost and fast installation, operation mechanism enhance passenger safety, materials used are suitable to be used outdoor, greater error of stopping distance allowance at platform station.

Keywords: Automatic Platform Gate (APG) and Platform Screen Door (PSD), Wire Screen Door, AutoCAD, Finite Element Analysis (FEA)

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1. Introduction

Platform screen doors (PSD) varies in 2 types which are full-height and half-height barrier. Full-height platform screen doors are barrier from station floor to ceiling that totally separate passengers to the railway tracks. Half-height platform screen doors also called automatic platform gates (APG) usually with a chest-height around 1,600 mm [1]. The significant functions of implementing APG is to prevent people from falling onto the track. APG prevent people to commit suicide by jumping onto the track while a moving train pass by or prevent people to homicide by pushing other onto the track while a moving train pass by.

Automatic platform gate (APG) and platform screen door (PSD) need to be well-designed to meet the station need with the aim to ensure passenger safety and cost effectiveness. During peak hour, the station is crowded of people do make passengers worry about accidentally fell onto the track or even push by inconsiderate passenger. One of the Malaysia rail operator company Prasarana monorail, found out that the passengers just rush in the monorail without queue up or wait by the side of the doors. In this case, Prasarana then decide to implement the APG systems in stages at all monorail stations to ensure passenger safety. [2]

KUTS line operate with Autonomous Rapid Transit (ART) runs on rubber tyres within the virtual track on road that guided by Virtual Guiding System (VGS). KUTS line phase 1 preliminary design for APG and PSD system is half-height platform door or called Automatic Platform Gate (APG). In the preliminary design, 3-cars ART put in operation with the provision of 3 sets APG at each side of platform station. The ART's door is one car one door, 3-cars ART with 3 ART's door each car. The APG system design at platform station for KUTS phase 1 required to undergo future expansion work from 3 sets APG to 4 sets APG once the 3-cars ART expand into 4-cars ART and into operation.

1.1 APG and PSD Implementation for KUTS Phase 1

Table 1: Platform station preliminary design KUTS phase 1 with APG and PSD implementation

Station ID	Name of Station	Type
IS1	Simpang Tiga	Elevated
SM14	Hikmah Exchange	Elevated

The APG and PSD preliminary design KUTS phase 1 implement to 2 out of 27 platform stations with high passenger demand which are the Simpang Tiga interchange station and Hikmah Exchange main station. Both interchange station and main station are elevated platform station. The other 25 platform stations will provisional to cater the design, space and weight requirement of APG and PSD for future installation or expansion.

1.2 Problem issues APG and PSD preliminary design KUTS phase 1

Table 2: List of issues and its problems

Issues	Problems
High initial cost and complex installation.	Costly and time consuming to design, install, testing, and commissioning the APG.
Platform station precise stopping point	Much more sensor at platform side to detect exact ART stopping location.

Future expansion work	Undergo expansion work to fit APG and PSD for 4-cars ART.
25 out of 27 platform stations without APG and PSD	Platform station without barrier to separate passenger and ART.

The KUTS project encountered those problem issues in Table 2 during APG and PSD preliminary design stage. The problem issues of APG and PSD preliminary design KUTS phase 1 inspire a study on alternative design of APG and PSD system. The alternative design of APG and PSD that is more cost effective and customise the needs of KUTS project was studied.

2. Methodology

The validity of research or study is anchored on its methodology [3]. In order to let other people to recognize and convince the reader the research is useful and with potential of contribution, an effective research methodology is grounded. The figure 1 below shows the block diagram of alternative design APG and PSD development.

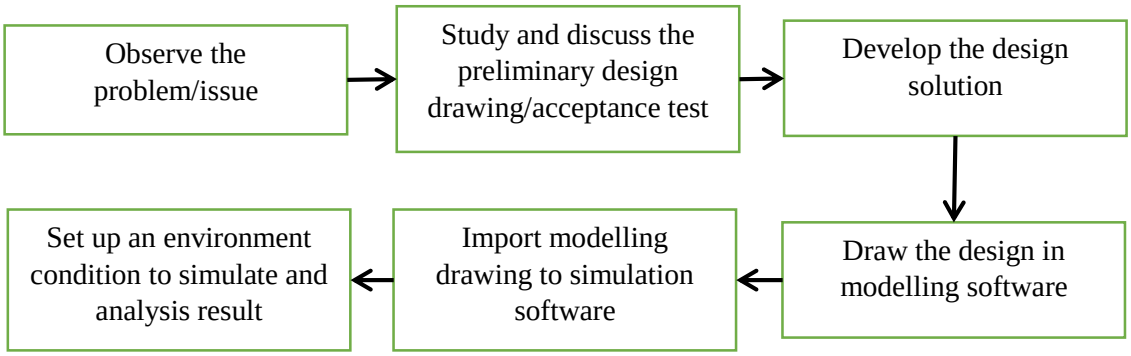


Figure 1: Block diagram of alternative design APG and PSD development

Figure 1 shows the 6 steps development process flow of alternative design called wire screen door system. The problem or issue APG evolve during its preliminary design stage were observed and discussed. The preliminary design drawing and the previous project acceptance test of APG and PSD were studied and discuss with senior project manager of APG from Sarawak Metro Sdn. Bhd.(SMSB). After discussion, the solution idea of alternative design APG were developed. In order to solve the problem, the issues of APG preliminary design should be clarify before proceed to alternative design. SWOT analysis also performed to recognise the strength, weaknesses, opportunities, and threats. In the alternative design, weaknesses and threats intend to reduced or eliminated whereas the strength and opportunities intend to maintain or improved.

2.1 Sources problem issues of APG preliminary design

The problem issues of APG preliminary design were observed through study the preliminary design review document of SMSB. Discussion was made between senior project manager of APG from SMSB. The senior project manager is experienced in railway industry that before ART KUTS project, he involved in project Light Rail Transit (LRT) 2 Ampang Line extension, LRT 3 Bandar Utama - Klang Line and etc.

2.2 Alternative design method

The alternative design of APG and PSD based on 2 major paper finding which are “Inventing new type of platform gate” and “next generation of screen doors are vertical”. The alternative design of APG

and PSD called wire screen door system developed and produced in 3D model using CAD software. AutoCAD software was choose to use to draw the 3D model wire screen door system. The alternative design is focused to make the system more cost effective and with features to customise the KUTS project need. The materials used for the wire screen door are mostly weather resistance that suitable to be operated in outdoor condition. The materials of wire screen door system was listed in the Table 3 below.

Table 3: Material lists wire screen door

No.	Materials	Function Part
I	Steel Alloy 304	Supporting Pillars
II	PVC coated soft steel wire	Wire screen barriers
III	Timing Belt 4M-18	Transmit motor force to open and close the wire screen barriers

After the 3D model wires screen door system produced, it was imported to the Finite Element Analysis (FEA) simulation software, Inventor. FEA use calculations, models, and simulations to predict and understand the object performance and behaviour under different physical conditions[4]. There are 2 features of Inventor were used which are assembly design, and simulation analysis. For assembly design, Inventor enables user with tools to create complex assemblies with defined relationships. For simulation analysis, Inventor allows user to simulate capabilities of 3D model to test its performance and behaviour under real-world conditions. FEA stress analysis was performed to simulate the performance of wire screen door supporting pillars.

3. Results and Discussion

The preliminary design review documents SMSB for APG were studied before performing SWOT analysis. SWOT analysis was carry out to identify the alternative design solution for platform stations without APG in KUTS line phase 1. Through discussion with senior project manager APG, the SWOT analysis results was shown in the Table 4. Alternative design APG and PSD, wire screen door system design to reduce weaknesses and threats. At the same time, its strength and opportunities were keep maintain or improved when develop the design of wire screen door system. 3D model of wire screen door system are shown in Figure 2 and Figure 3. FEA stress analysis show in Table 5. From the result of stress analysis, the wire screen door system can be tested whether it is safe to be used with the given environment condition.

3.1 SWOT analysis

SWOT analysis is a compilation of company's strengths, weaknesses, opportunities and threats[5]. SWOT analysis was performed in this study to analyse SMSB's product which is the preliminary design of APG of KUTS line phase 1. Perform a SWOT analysis was effective in exploring new initiatives which help to solving the existing problem or issues of APG preliminary design of KUTS line phase 1. SWOT analysis results come out through discussions between senior project manager signalling, train control and APG unit, system department Sarawak Metro sdn bhd. Table 4 below shows the result of SWOT analysis on APG preliminary design KUTS phase 1.

Table 4: Results table for SWOT analysis on APG KUTS preliminary design phase 1

Weaknesses	Threats
● Complex installation. APG has to integrated with interface, signalling system, and platform station infrastructures. ● High initial cost. ● Small error allowance for ART to stop at precise stopping point at platform station (much more sensor required).	● Do not totally separate passenger from entering track. ● Closing doors pinch passenger and get hurt (sensor failure or dead zone). ● Future expansion 3-cars ART to 4-cars ART. ● Market competition (high initial cost).
Strengths	**Opportunities**
● Neat and nice appearance. ● Effective in separate passengers from falling into the track. ● Reduce manpower cost. ● Reduce litter on the track.	● Rising need of public safety. ● Large market size.

3.2 Wire screen door system

The platform stations of KUTS line are 45 m in length. Each platform station implement 4 set of 10 m wire screen barriers which means a total of 40 m length of wire screen doors. There are 5 supporting pillars with a average gap of 10 m between each other. 2 stages of wire screen which each wire screen consist of 14 wire strings gapped with 50 mm. When the wire screen door in closing condition, the 2 stage wire screen door reach a height of 1300 mm. When the wire screen door in open condition, it rise up until a height of 2,000 mm which is 36 mm above the 1964 mm of ART's door. (dimension of 3D model wire screen door system refer to **APPENDIX D1-D2**) Figure 2 and Figure 3 below show the front view and isometric view of 3D wire screen door system.

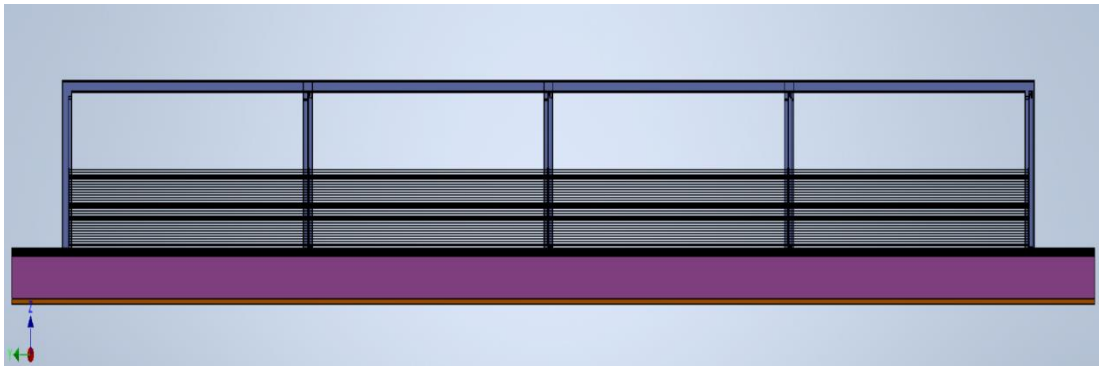


Figure 2: Front view of 3D model wire screen door

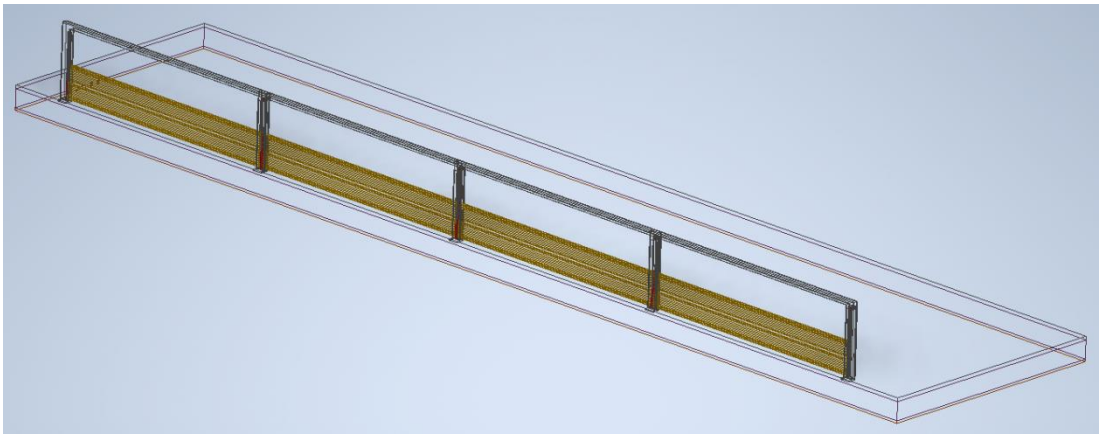


Figure 3: Isometric view of 3D model wire screen door

Since the wire screen door open and close vertically, the 2 stage of wire screen door has their own vertical sliding track in the supporting pillars. One of the stage of wire screen door in front of the another one. Since they do not share the sliding track, the 2 stages wire screen door will not collide each other. The conventional bi-parting APG door will collide each other during door closing and this may lead to APG system salvage even malfunction. The collision made by the APG doors will cause much more equipments salvage compare to wire screen door.

3.3 FEA stress analysis wire screen door supporting pillars

Stress analysis simulation works on the 3D model wire screen door to assess the internal stresses and deformations. The steps to simulate stress analysis include preprocessing, solver set-up, solution, and post-processing. For the preprocessing, import the 3D model wire screen door from AutoCAD DWG file into Inventor software. Create a study on stress analysis and assign the material properties. Then solver set-up, set the constraints on the fixed point regions to the supporting pillars. Set the magnitude and direction of force or load acting on the supporting pillars. For solution, software Inventor will discrete the 3D model into large number of finite elements. Numerical equations derived from mesh added together and used to calculate stresses and deformations. For post-processing, the software will visualise the stress distributions, generating contour plots.

Table 5: Results of stress analysis on wire screen door supporting pillars

Category	Minimum	Maximum	Unit or Dimension
1st Principal Stress (Tensile stress)	-33.59 x10^5	290.9 x10^5	Pa, Nm^{-2}
3rd Principal Stress (Compressive stress)	-314.2 x10^5	26.88 x10^5	Pa, Nm^{-2}
Displacement	0.000	1.866	mm
Safety Factor	6.267	15.00	ul

The simulation of stress analysis using software Inventor on the supporting pillars. The force acting on the supporting pillars with a magnitude of 2000 lbs or 8,896.44 N from the direction of passenger platform station to the track. The simulation of stress analysis display its results in the form of stress distribution visualise in contour plots. The figures below shows the contour plots results in minimum and maximum value for each categories respectively. Figure 4 shows 1st Principal Stress. Figure 5 shows 3rd Principal Stress. Figure 6 shows displacement. Figure 7 shows safety factor.

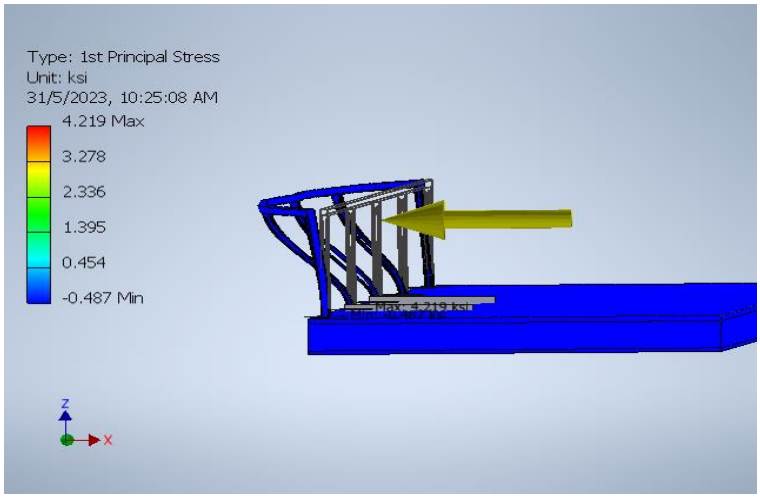


Figure 4: 1st Principal Stress

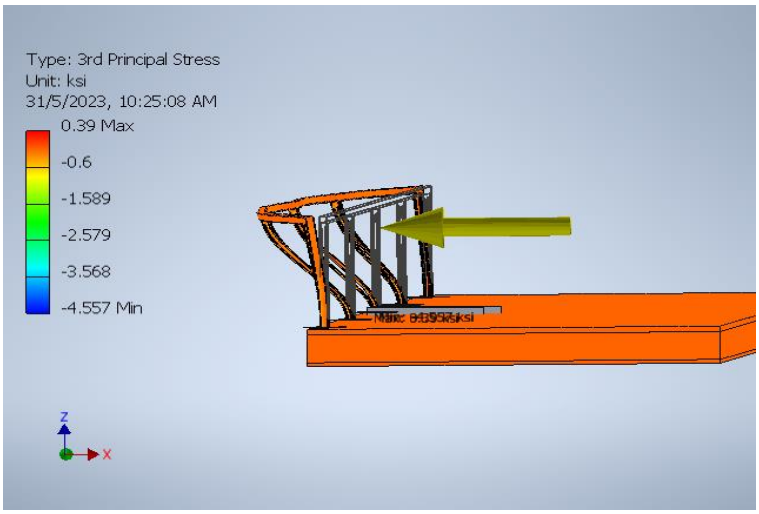


Figure 5: 3rd Principal Stress

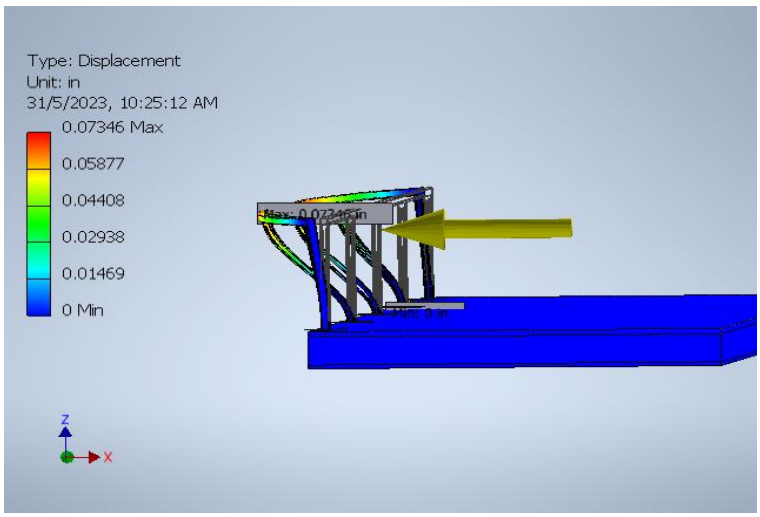


Figure 6: Displacement

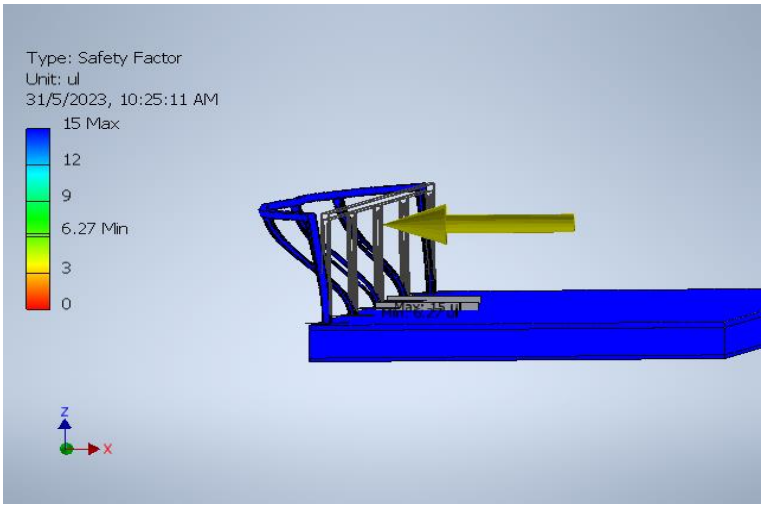


Figure 7: Safety Factor

3.4 Comparison between APG preliminary design KUTS phase 1 and the alternative design wire screen door system

After produce the alternative design APG and PSD called wire screen door system, the discussions was carried out to compare the functionality between each other. Table 6 below shows the comparison between APG preliminary design KUTS phase 1 and the alternative design wire screen door system.

Table 6: Comparison between APG preliminary design KUTS phase 1 and the alternative design wire screen door system

APG preliminary design KUTS phase 1	Results	Alternative design wire screen door system
High initial cost and complex installation.	**Initial cost and installation**	Low initial cost and fast installation.
Hikmah Exchange main station and Simpang Tiga interchange station.	**Platform station implementation**	Platform stations except Hikmah Exchange and Simpang Tiga for KUTS phase 1.
3-cars ART.	**Service train type**	Both 3-cars ART and 4-cars ART.
Undergo future expansion work.	**Future expansion work for 4-cars ART**	Eliminate future expansion work.
Not exceeding 0.5m. (much sensors required)	**Precise stopping point error allowance**	Not exceeding 4m. (less sensors required)
Bi-parting closing door may pinch and hurt passenger.	**Closing door operation**	Vertically open and closing wire barrier do not pinch passenger.

From the results Table 6, wire screen door able to serve variety of rolling stock made the wire screen door system eliminate future expansion work once the ART operation system expands from 3-cars to 4-cars. The operation mechanism of wire screen door is vertically can avoid collision between the door panel able to extend its life span and prevent passengers caught by the closing door. Longer durability for wire screen door reduce the malfunction and maintenance cost. The initial cost of wire screen door is low and fast installation compare to APG and PSD system. Material used for wire screen door can withstand outdoor conditions is capable and practical to be installed for the 25 out of 27 platform station without APG system. This can ensure passenger safety and improve ART operation reliability.

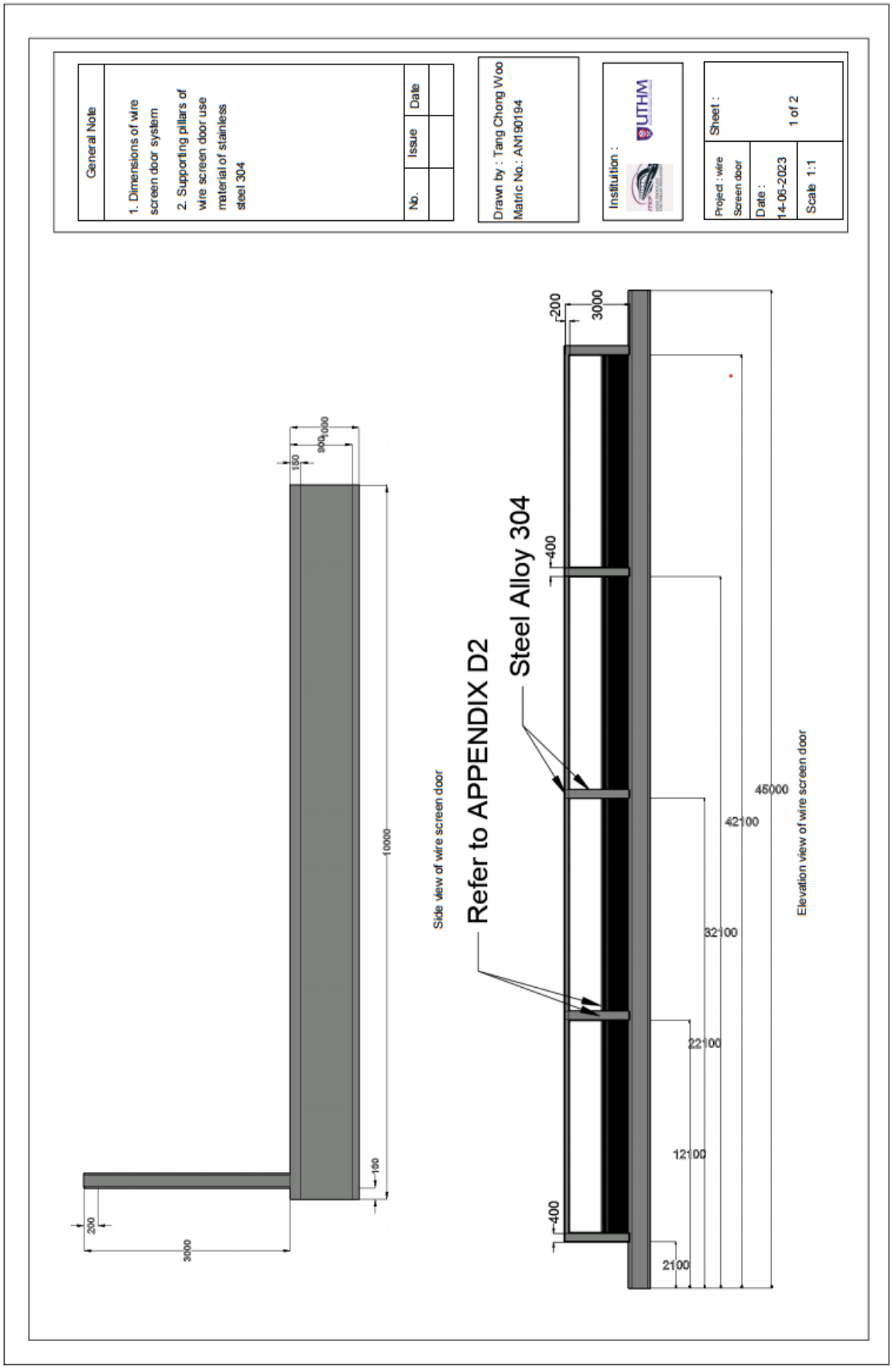
4. Conclusion

In conclusion, SWOT analysis on APG KUTS was successfully performed to identify alternative solution for platform station without APG in KUTS line phase 1. Alternative design of APG and PSD was developed that called wire screen door system. 3D model of wire screen door system was produced using software AutoCAD (APPENDIX D1-D2). Stress analysis was carried out on the alternative design of APG and PSD using software Inventor. The results of wire screen door stress analysis show that wire screen door has good performance which the maximum deformation when subjected to the 2000 lbs of force is 1.8 mm only. This show that the wire screen door supporting pillars are safe to be used. APG and PSD system is very effective in prevent the passenger from get into the track especially during peak hour. However the installation and maintenance cost for APG and PSD is high and not recommend to be implemented at every station platform KUTS phase 1. Then the alternative design which is wire screen door system to take place the APG and PSD system that do not degrade in platform safety level and cater to future ART operation expansion from 3-cars ART to 4-cars ART. Wire screen door system has low initial cost and fast installation, operation mechanism enhance passenger safety, materials are suitable to be used outdoor, greater error of stopping distance allowance at platform station. This study require much more studies to allow the wire screen door system more robust. Sensor detection zone require further studies and the ways to against the situation in minimizing the dwell time at platform station. The conductors on the ART may act as double security through manually checking the ART precise stopping position at station platform and also the CCTV monitor to confirm there is no passenger under the wire screen door during normal operation. Clear and easy understanding signboard can be prepared at the platform station. Last but not least, public education of wire screen door system can play an important role to ensure passenger safety.

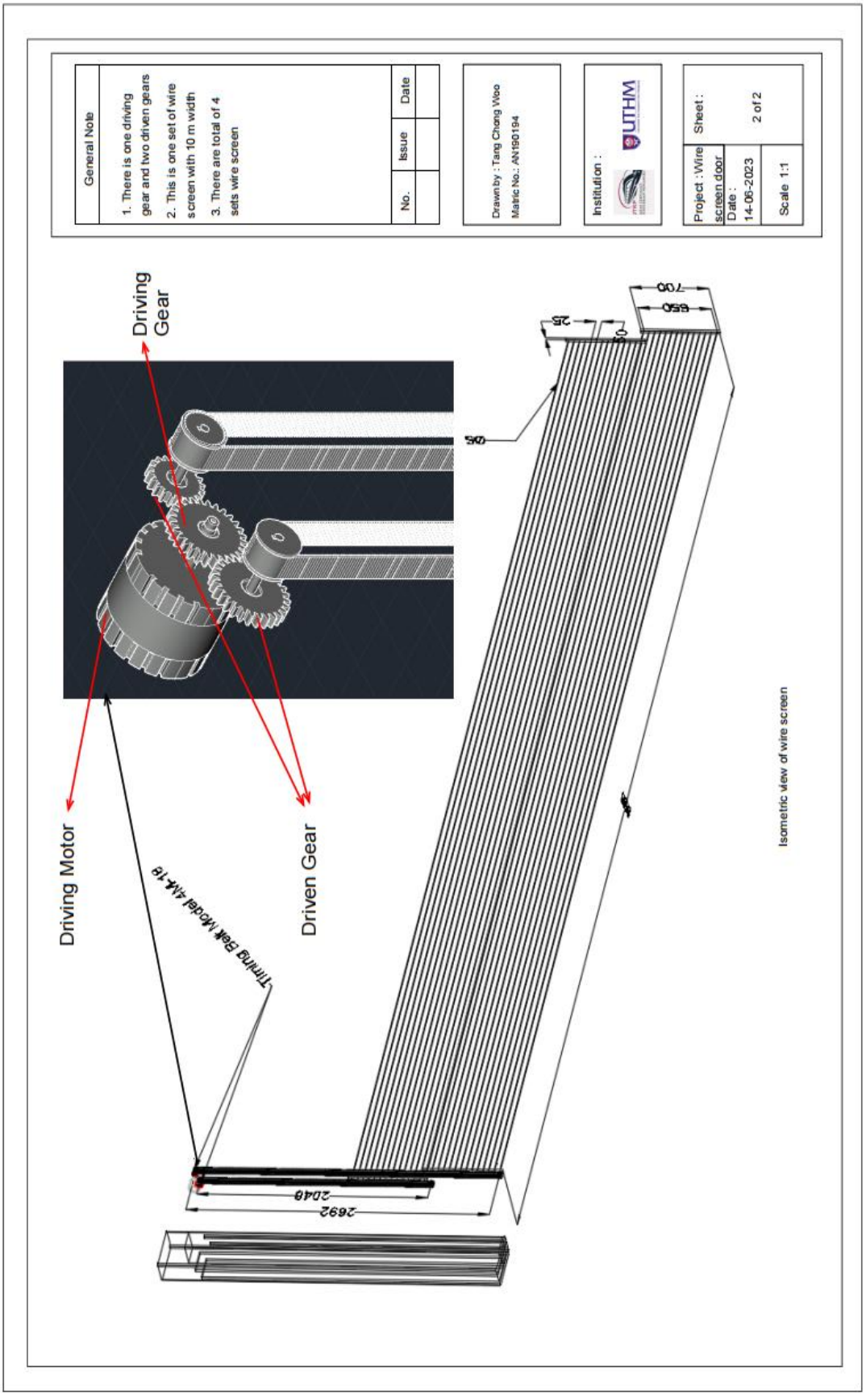
Acknowledgement

The authors appreciate that the Sarawak Metro Sdn. Bhd. for sharing and collaborating on this study. The authors would also like to thank the Faculty of Engineering Technology of the University Tun Hussein Onn Malaysia for all the assistance in completing this study.

APPENDIX D1


General Note
1. Dimensions of wire screen door system
2. Supporting pillars of wire screen door use material of stainless steel 304
No.
Issue
Date
Drawn by : Tang Chong Woo
Matric No.: AN190194
Institution :
UTHM
Sheet :
1 of 2
Project : wire Screen door
Date : 14-06-2023
Scale 1:1
Side view of wire screen door
Refer to APPENDIX D2
Steel Alloy 304
Elevation view of wire screen door
200
3000
400
46000
42100
32100
22100
12100
2100
150
900
1000
10000
100

APPENDIX D2


General Note
1. There is one driving gear and two driven gears
2. This is one set of wire screen with 10 m width
3. There are total of 4 sets wire screen
No.
Issue
Date
Drawn by : Tang Chong Woo
Matric No.: AN190194
Institution :
UTHM
Project : Wire screen door
Date : 14-06-2023
Sheet : 2 of 2
Scale 1:1
Driving Gear
Driving Motor
Timing Belt Model 4Mx-18
Driven Gear
700
650
25
50
95
2692
2048
Isometric view of wire screen

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