SCHOOL OF ENGINEERING
TAYLOR'S UNIVERSITY

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Numerical Analysis

Assignment 2 report (Submission 1)

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1.0 Introduction

Air conditioner is a very common cooling unit, that almost 80% of the properties in Malaysia, including houses, offices, shopping malls and more consist of at least one air condition in their respective places. This is mostly due to the hot and humid climate in Malaysia. However, there are many types of air conditioner in this market, which the most common ones for household units would be the split wall mounted air conditioner, which comes along with an aircon outdoor unit, or be it compressor where we normally call it.

The aircon outdoor unit(compressor) is placed outside the house and has a bracket below to hold it in place. For space saving purposes, it is usually mounted on a high position. The aim this assignment is to analyse the bracket that supports the 1horsepower aircon outdoor unit, in terms of reducing material usage and optimizing the safety factor according to equivalent stress. The bracket is analysed using the Ansys software to break the bracket into smaller elements. By breaking down the bracket into smaller elements, we would be able to improve the accuracy in determining the stress that the object may withstand and experience. Besides, the smaller the size of element chosen, the longer the time taken to analyse the bracket to obtain optimal results. Therefore, choosing the suitable element sizing to analyse the bracket is important to run an efficient and effective result.

In order to choose the most suitable element sizing, we could obtain the maximum equivalent stress against the number of elements. The number of elements indicate the element sizing where the smaller the element sizing, the higher the number of elements. We could also visualize through graphs. For instance, the stagnant point from the maximum equivalent stress against the number of elements will be chosen as the suitable elements sizing for the bracket. The maximum equivalent stress against the number of elements will increase at the beginning and after a certain point, the graph will smooth out with saturated behaviour or rather low fluctuations with any further decrease in elements sizing. The starting point of the saturated line will be used to determine a suitable sizing to further improve at the position where the maximum equivalent stress that accumulated at the bracket.

2.0 Solid Modelling

Figure 1: Existing aircon bracket

A	B	C
Property	Value	Unit
Material Field Variables	Table	
Isotropic Elasticity		
Derive from	Young's Modulus and Poisson...	
Young's Modulus	68900	MPa
Poisson's Ratio	0.33	
Bulk Modulus	6.7549E+10	Pa
Shear Modulus	2.5902E+10	Pa
Tensile Yield Strength	276	MPa
Tensile Ultimate Strength	310	MPa

Figure 2: Engineering data

The figure 1 above shows that the aircon bracket that exist in the market. The bracket shows in the figure 1 is to hold a 1 horsepower outdoor aircon unit. The outdoor 1 horsepower aircon unit will be placing on top of the bracket with the maximum weight of 36kg. Therefore, this bracket will be constructed in the solidworks and used for analysis. The material of the bracket is 6061 Aluminium which having the Young’s Modulus of 68.9GPa, Tensile Yield Strength of 276MPa, Tensile Ultimate Strength of 310MPa and the Poisson’s Ratio of 0.33 as shown in figure 2.

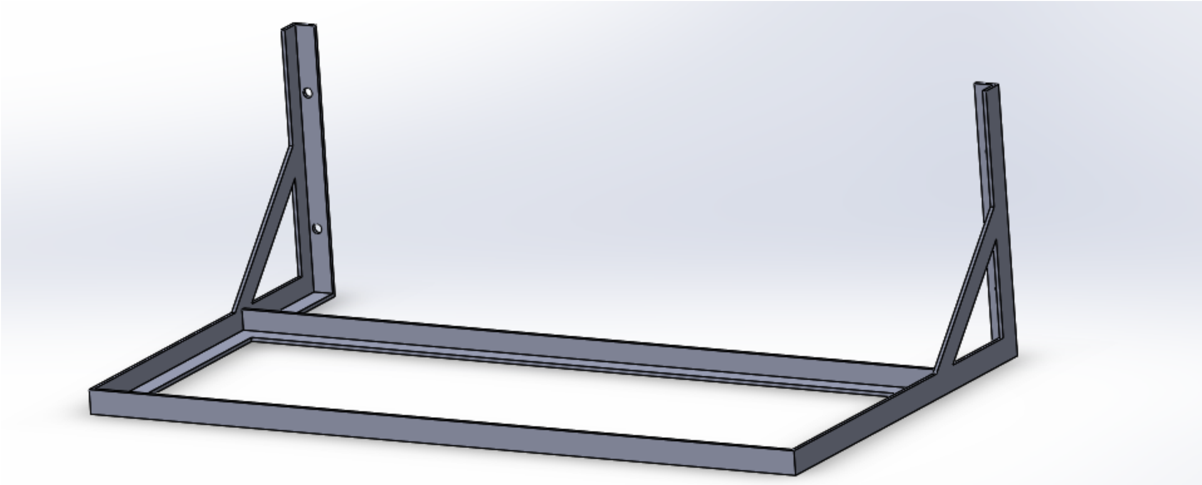

Figure 3: Construction of the aircon in Solidworks

The solid model shown in figure above is simulated by using the Solidworks software. The solid model is constructed to the scale of 1:1 to the existing product. Referring to the figure above, the thickness of the model is 4mm and the entire material of the body is built of 6061 Aluminium.

3.0 Boundary Condition

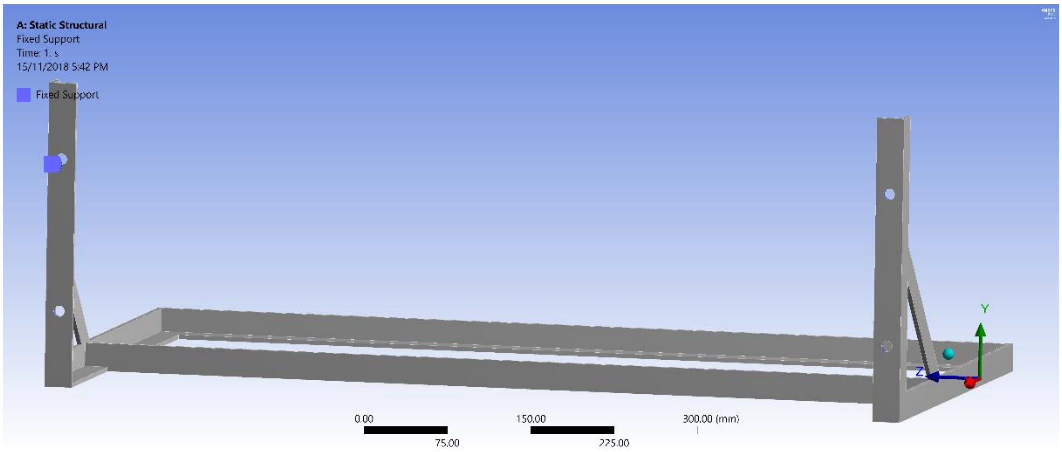

Figure 4: The fixed support of the bracket

Fixed support will be selected from the support features during the simulation. The reason of choosing fixed support is because the entire body is to be mounted on the wall to hold the outdoor unit. Therefore, the body must be fixed in a suitable position. The faces of the four screws hole as shown in the figure above will be selected to be fixed support.

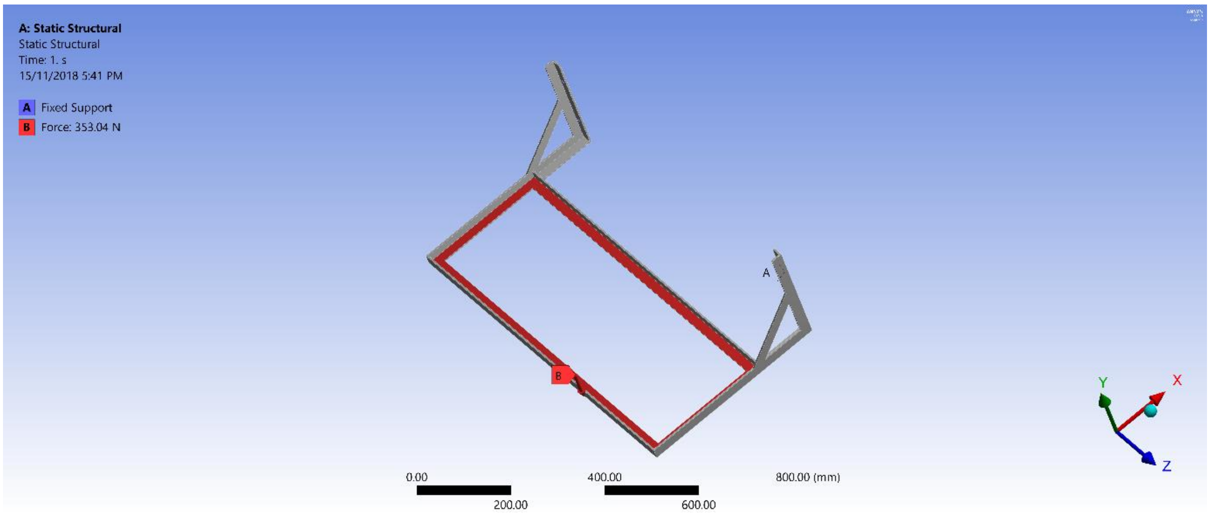

Figure 5: The Force Applied

Force will be selected from the load feature where the force is to act as the weight of the actual outdoor aircon unit. The red surface that is highlighted is the surface where the outdoor aircon unit will be usually place at and the force will be acting on the highlighted red surface. A 1 horsepower outdoor aircon unit have a maximum of 36kg approximately. 353.04N is converted from 36kg which it will be used as the force load during analysing. In the Ansys software, the force will be analysing in component form, therefore the force which stands for the outdoor aircon unit would be -353.04N in the y axis.

4.0 Mesh Element & Method

There will be two type of meshing methods using to analyse the bracket such as Tetrahedrons mesh method and the Hex Dominant mesh method. The bracket will be undergoing both methods with the same body sizing. After applying both mesh methods, the average skewness that obtained from both mesh methods will be compared to determine whether which method will be better to analyse for the bracket. The lower the average skewness the better the quality of the analysing. The mesh method with the better skewness will be used to analyse the bracket for the entire simulation analysis.

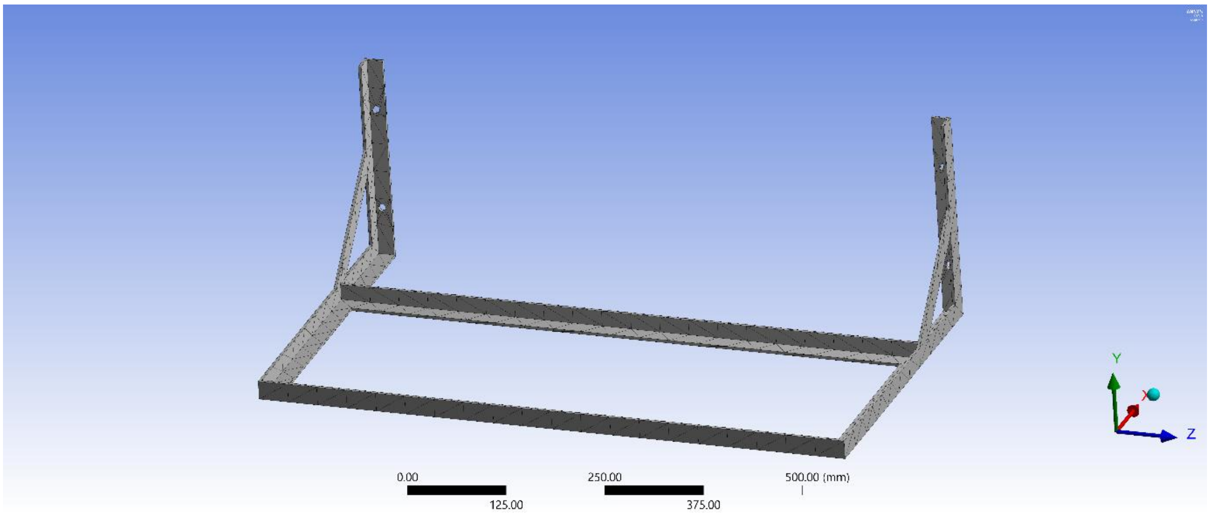

Figure 6: Tetrahedrons Meshing

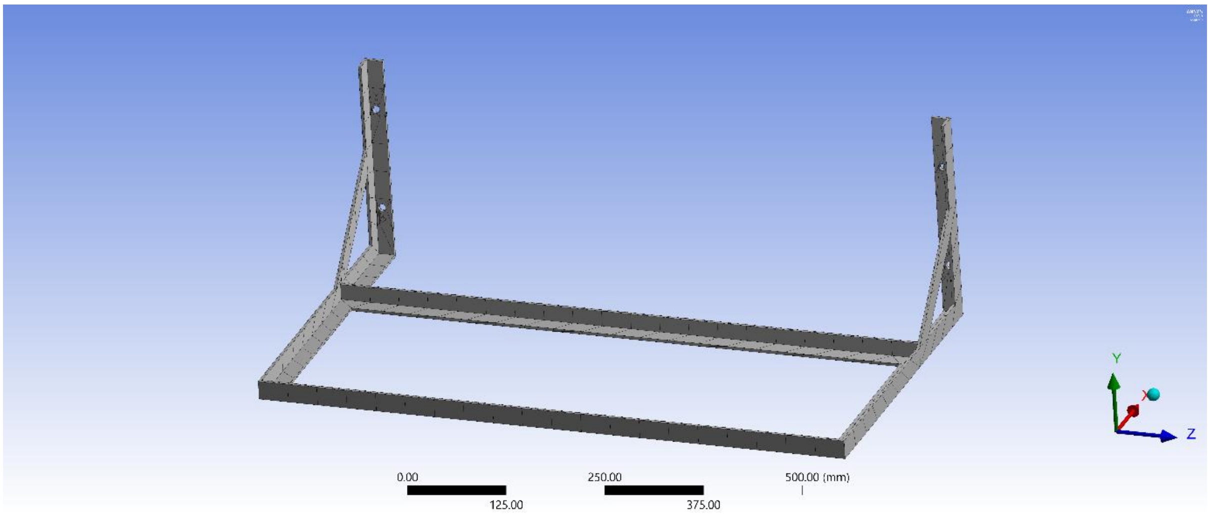

Figure 7: Hex Dominant Meshing

Table 1: Comparison of Tetrahedrons and Hex Dominant

Tetrahedrons			
Element Sizing (mm)	Number of Elements	Skewness	Max. Equivelant Stress (MPa)
40	1173	0.90456	49.369
Hex Dominant			
Element Sizing (mm)	Number of Elements	Skewness	Max. Equivelant Stress (MPa)
40	1313	0.89357	98.363

According to table 1 above, the Hex Dominant mesh has the better skewness with the same element sizing as compared with the Tetrahedrons. Therefore, the Hex Dominant mesh will be used for further analysing.

However, the bracket with the Hex Dominant mesh couldn't be analyse with the element sizing that lower than 38mm. The sizing that can be used in Hex Dominant mesh has the average skewness of 0.9 plus minus which means it couldn't get lower to obtain a good skewness. Therefore, using the Tetrahedrons mesh is the alternative way where the Tetrahedrons mesh can decrease the element sizing to obtain good average skewness.

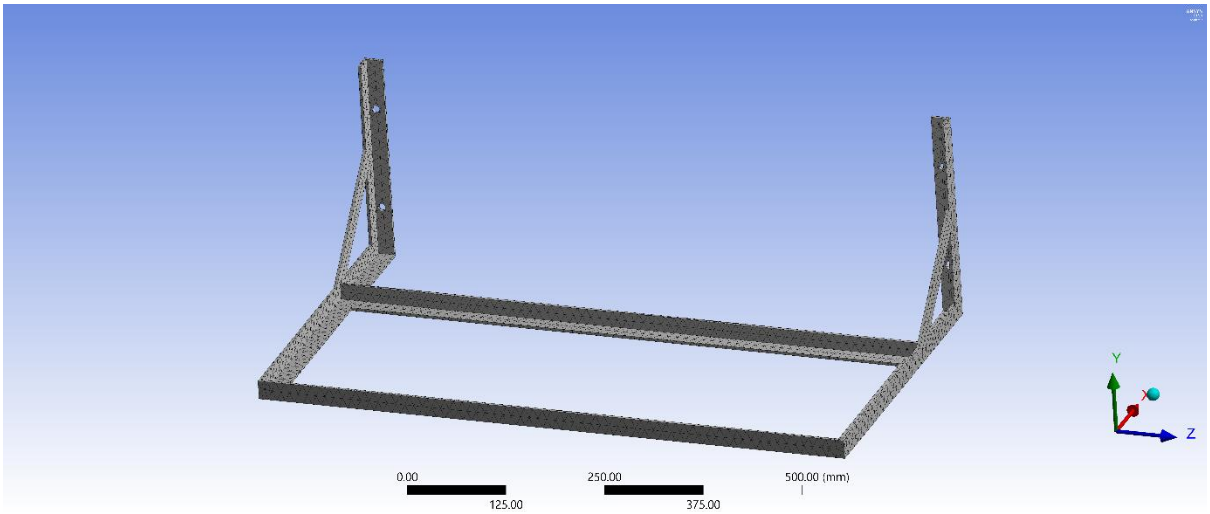

Figure 8: Tetrahedrons meshing with 12mm element sizing

Table 2: Tetrahedrons mesh results

Tetrahedrons			
Element Sizing (mm)	Number of Elements	Skewness	Max. Equivalent Stress (MPa)
15	5338	0.65436	54.665
14	5686	0.63844	59.467
13	6084	0.59701	59.365
12	6558	0.58069	65.173
11	7206	0.57409	68.926
10	9092	0.5416	66.076
9	12946	0.47817	65.143
8	15031	0.42082	66.156

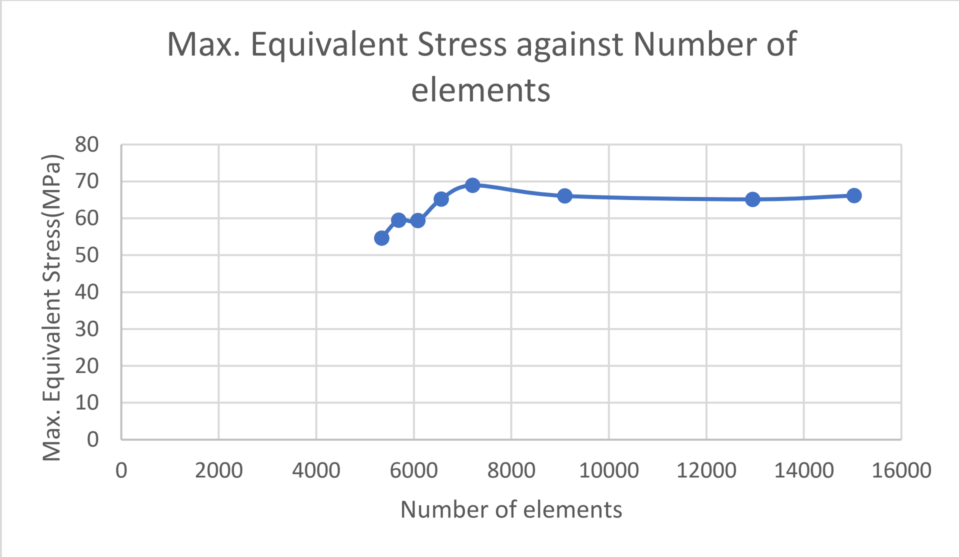

Figure 9: Max. Equivalent Stress against Number of Elements Graph

Based on the graph in figure 9, the stagnant point will be at 65.173MPa which indicates that element sizing of 12mm will be the suitable element sizing for the analysis. The element sizing of 12mm will be the starting point where the equivalent stress will be getting saturated. By using the element sizing of 12mm, refinement will be taking place to refine the point where the maximum equivalent stress will be accumulated at.

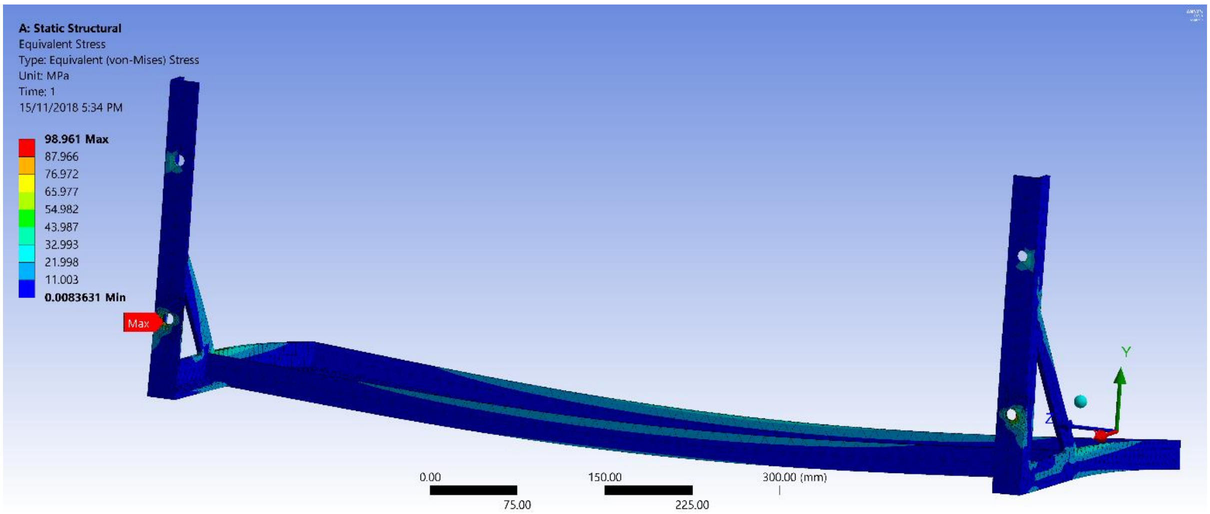

Figure 10: Position of Max. equivalent stress that accumulated at

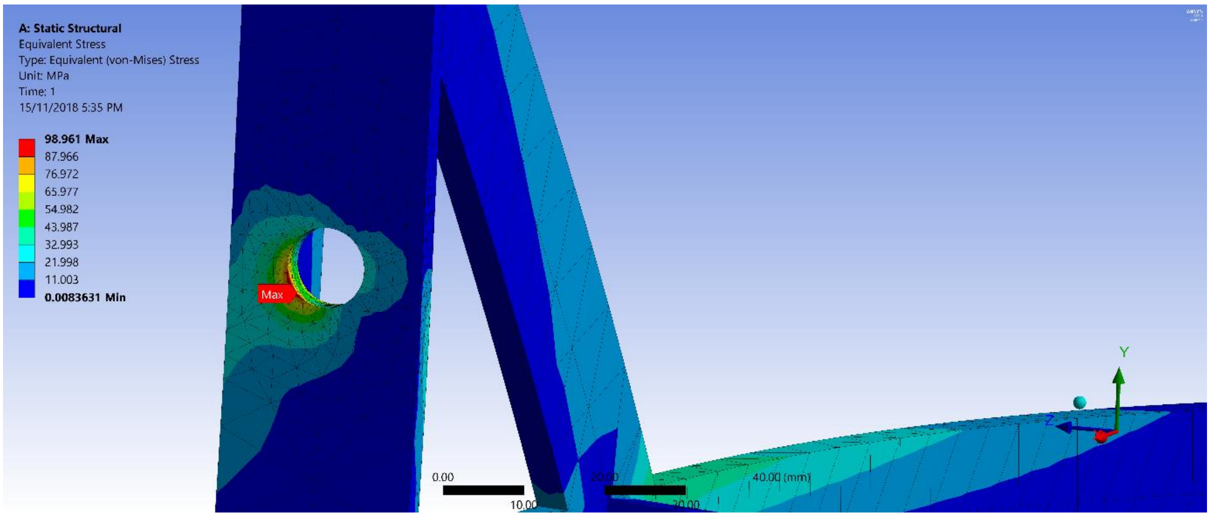

Figure 11: edges to be refined

The maximum equivalent stress is accumulated at both symmetrical edges of the screw hole. The edges of these two screw holes will be selected to carry out the refinement. The refinement will be carried out in 3 levels which mean it will be refined by three times. The selected faces or edges to be refined means that the elements sizing at that faces or edges will be decrease but not the element sizing of the whole body but the selected faces or edges. By doing so, it can help to improve the efficient usage of the computing system by getting the analysis done more efficient. By decreasing the element sizing at the faces or edges, the results to be obtained will be more accurate as the elements are small enough to provide the reliable data.

Table 3: Refinement table

Tetrahedrons					
Element Sizing (mm)	Number of Elements	Skewness	Max. Equivelant Stress (MPa)	Safety Factor	
12	6558	0.58069	65.173	4.2349	
12	7631	0.57441	85.627	3.2233	refinement 1
12	9526	0.56481	92.468	2.9848	refinement 2
12	14384	0.55584	98.961	2.789	refinement 3

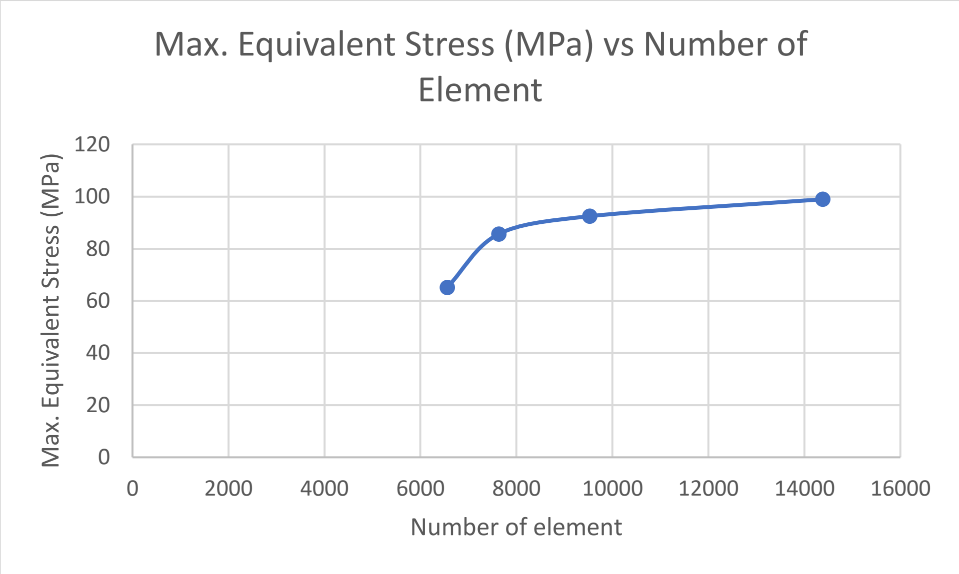

Figure 12: Max. Equivalent Stress vs Number of Element graph

The data obtained from the analysis are plotted into graph shown in above. After the refinement are done, we are now comparing the maximum equivalent stress and the safety factor among the original value and the refinement value. As we can see that the maximum equivalent stress and the minimum safety factor are getting saturated which means that the results are now reliable and accurate. After the bracket undergoes the refinement 3 times, the minimum safety factor that obtained will be 2.789. The outdoor aircon unit bracket should have a minimum safety factor of 1.5 where this bracket that being analysed is having a minimum safety factor of 2.789 which is a lot more than the requirement. Therefore, the bracket can be optimised by reducing the material usage to have a minimum safety factor that close to the requirement and saving the manufacturing cost. The weight of 1 horsepower aircon outdoor unit is usually fix and having a maximum weight of 36kg, therefore the safety factor can be lower to be near to the requirement of 1.5 safety factor. Modification for the aircon bracket can be done and the analysis will be using the same element sizing to analyse the modified aircon bracket.

5.0 Appendix

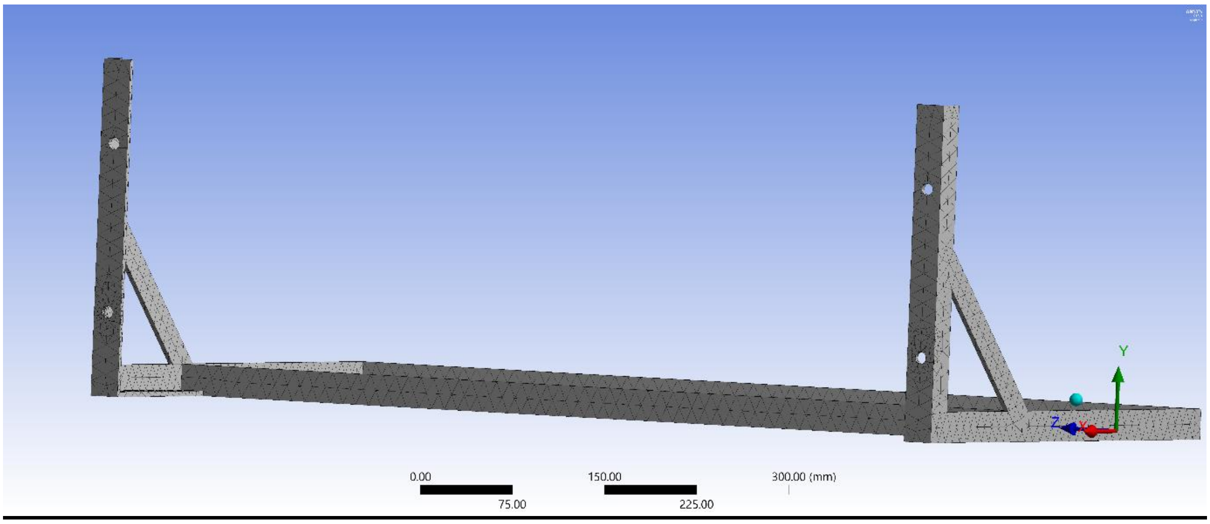

Figure 13: refinement 1

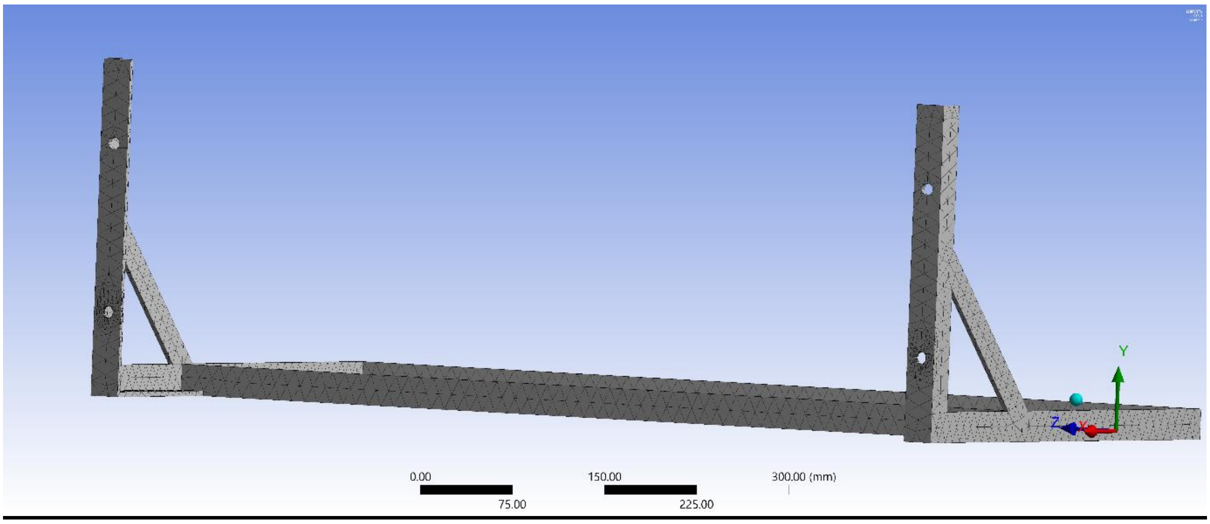

Figure 14: refinement 2

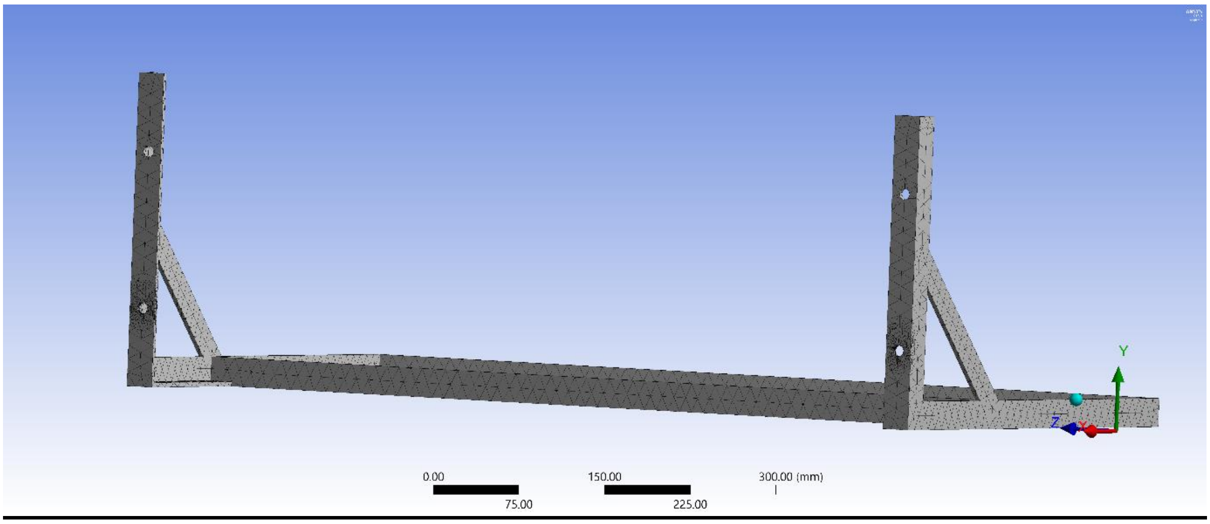

Figure 15: refinement 3

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Equivalent (von-Mises) Stress
By	Time
Display Time	Last
Calculate Time History	Yes
Identifier	
Suppressed	No
Integration Point Results	
Display Option	Averaged
Average Across Bodies	No
Results	
Minimum	8.3018e-003 MPa
Maximum	65.173 MPa
Minimum Occurs On	4mm bracket
Maximum Occurs On	4mm bracket
Information	

Figure 16: Max Equivalenent stress (12mm)

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Equivalent (von-Mises) Stress
By	Time
Display Time	Last
Calculate Time History	Yes
Identifier	
Suppressed	No
Integration Point Results	
Display Option	Averaged
Average Across Bodies	No
Results	
Minimum	8.3527e-003 MPa
Maximum	85.627 MPa
Minimum Occurs On	4mm bracket
Maximum Occurs On	4mm bracket
Information	

Figure 17: Max Equivalent Stress (refinement 1)

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Equivalent (von-Mises) Stress
By	Time
Display Time	Last
Calculate Time History	Yes
Identifier	
Suppressed	No
Integration Point Results	
Display Option	Averaged
Average Across Bodies	No
Results	
Minimum	8.3575e-003 MPa
Maximum	92.468 MPa
Minimum Occurs On	4mm bracket
Maximum Occurs On	4mm bracket
Information	

Figure 18: Max Equivalent Stress (refinement 2)

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Equivalent (von-Mises) Stress
By	Time
Display Time	Last
Calculate Time History	Yes
Identifier	
Suppressed	No
Integration Point Results	
Display Option	Averaged
Average Across Bodies	No
Results	
Minimum	8.3631e-003 MPa
Maximum	98.961 MPa
Minimum Occurs On	4mm bracket
Maximum Occurs On	4mm bracket
Information	

Figure 19: Max Equivalent Stress (refinement 3)

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Safety Factor
By	Time
Display Time	Last
Calculate Time History	Yes
Identifier	
Suppressed	No
Integration Point Results	
Display Option	Averaged
Average Across Bodies	No
Results	
Minimum	3.2233
Minimum Occurs On	4mm bracket
Information	

Figure 20: min safety factor (refinement 1)

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Safety Factor
By	Time
Display Time	Last
Calculate Time History	Yes
Identifier	
Suppressed	No
Integration Point Results	
Display Option	Averaged
Average Across Bodies	No
Results	
Minimum	2.9848
Minimum Occurs On	4mm bracket
Information	

Figure 21: min safety factor (refinement 2)

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Safety Factor
By	Time
Display Time	Last
Calculate Time History	Yes
Identifier	
Suppressed	No
Integration Point Results	
Display Option	Averaged
Average Across Bodies	No
Results	
Minimum	2.789
Minimum Occurs On	4mm bracket
Information	

Figure 22: min safety factor (refinement 3)