FINITE ELEMENT ANALYSIS OF 'A COLLAPSIBLE WALKER'

Ashutosh Kulkarni[1], Vinay Melavanki[1], Vineet Pavate[1], Zuber Riyazahmed Abbunavar[1]

[1]B.E, student, Department of Mechanical Engineering, KLE Technological University, Hubballi-580021.

Abstract - *A walker is the device used by elders and physically disabled people to maintain the balance. The material and structure of walker frame are the main features which will make a walker user-friendly and stable. In this paper the detailed finite element analysis is conducted on a walker frame which is foldable and contains a fabric seat which will help the user in taking rest during course of walking. To improve the stability and weight optimization, the walker has been analyzed by considering different metal combinations that are generally used in the design of the walker. The loads are applied on the various members of the walker frame to simulate both walking and seating case scenario. The results show equivalent stresses and total deformation in the walker frame after the application of the loads. The optimum metal combination is suggested for the design of walker after observing the results.*

***Key Words*: Walker with seat, Finite element analysis, Foldable walker, Weight optimization.**

1. INTRODUCTION

Development of a new product in contemporary production is very expensive economic activity. The process of designing walker with shortage of exact data. Sometime measurement is done on the own experience and engineering practice. It is not effective to carry out destructive test for testing of walker to validate the design. The introduction of FEM made easy to test the walker under various condition for its validation. In the past four decades the finite elements method has become the main method of numerical analysis with the application in solving boundary problems in mathematical physics and particularly continuum mechanics, whereas it still has not been applied in small scale walker manufacturing industry to the fullest degree. A walker is an equipment for disabled or elderly people who need additional support to maintain balance or stability while walking. The basic design consists of a lightweight frame that is about waist high, and slightly wider than the user. Modern walkers maintain a slight bend in their arms. This bend is needed to allow for proper blood circulation through the arms as the walker is used. The person walks with the frame surrounding their front and sides and their hands provide additional support by holding on to the top of the sides of the frame. A walker is picked up and placed a short distance ahead by the user. The user then walks to it and repeats the process for his movement. A walker is often used by those who are recuperating from leg or back injuries. It is also commonly used by persons having problems with walking or with imbalance. Almost all the walkers come with adjustable heights and other attachable accessories like wheels etc. The stability of these walkers is directly proportional to the material from which they are fabricated therefore it is very crucial to select the optimum material for the application of assistive device that provides assistance in mobility. This paper investigates the stress generated and deformation in the walker and how to minimize the stress by selecting optimum material combination.

1.1 Working

The frame of walker consists of 4 vertical metal tubes that holds the entire structure together. The front vertical supports house the main collapsible scissor mechanism. The frame for the seat is obtained by assembling 2 movable supports between the vertical metal tubes, in such a way that the frame is prone to minimum deflection. The relative motion between the supports is achieved by assembling the tubes with the laser cut and TIG welded joints and for the seat a special type of tough fabric is used. When the handles of the walker are pulled the entire structure will expand into a full-fledged walker and a manual locking action will lock the expanded position for walking. Further the seat can be brought into use when the user gets fatigue of walking by simple pull.

2. Design of the walker

The structural model of chair frame is created by using the 3D cad modeling software. The software used for designing is Solid works 2016 the chair model is shown below

Figure 1 : 3D CAD modelling of walker

Figure 2 : Physical model of walker

The walker consists of four metal tubes of them which two are slightly bent that support the entire structure, two cross tubes that helps in folding and unfolding of the device.

The seat is made up of three hollow tubes that form the seat frame. The lateral folding of the walker is allowed by the two short tubes as shown in the fig 2.2. All the tubes are joined together by the special joints to allow the desired movement.

The four long tubes act as columns, two cross tubes act as bar elements while all the tubes of the seat frame act as the beam element.

2.1. Loads acting on the walker

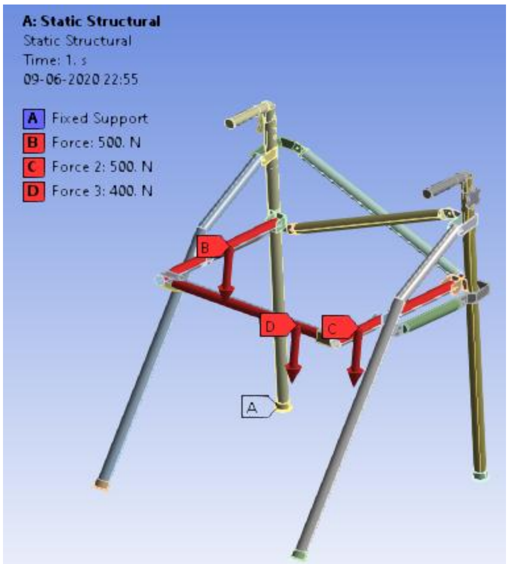

Figure 3 : Load application on the walker seat frame

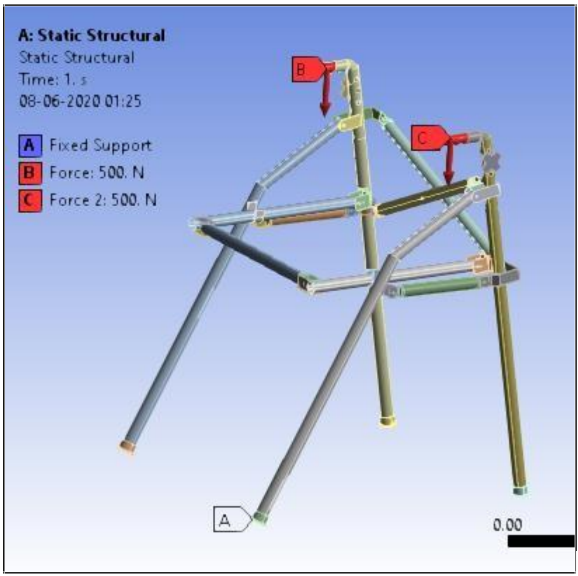

Figure 4 : Load application on the walker handle

The pipes of the seat frame of the walker acts as beam where in the load acts perpendicular to the axis of the pipe. Considering the weight of the average person to be 75 Kg and keeping a factor of safety as 2 for impact and dynamic conditions, the total load acting on the seat frame is taken as 1500 N. The 1500 N load is distributed uniformly among the three pipes of the seat frame.

The design of walker in completely generated using various types of modern tolls such as AutoCAD 2010 and solid works 2016 modelling software and the analysis is done using Ansys 14.5 workbench.

Figure 5 : Physical representation of walker in seating position

Figure 6 : Physical representation of walker in walking position

2.2. Materials of walker

After considering the various parameters such as

- Cost of the material
- Density of the material.
- Mechanical strength of the material.
- Modulus of the material.
- Weldability of the material.
- Availability of the material.
- Surface finish of the material.
- Aesthetic – Appearance, texture, colour.

The suitable materials are Aluminium, Stainless Steel, Titanium alloy, Fibre reinforced plastic. Further considering the availability and manufacturability, we finalized two materials for walker frame i.e. Stainless Steel and Aluminium

3. Properties of the selected material

Table -1: Properties of material considered for the study

Material	Modulus of elasticity (GPa)	Yield strength (MPa)	Ultimate strength (MPa)	Density (Kg/m^3)
Stainless Steel	193	292	586	7750
Aluminum alloy	71	270	310	2770

4. Solutions from ANSYS 14.5 Workbench

The walker described is analyzed in ANSYS 14.5 workbench for Total deformation and Equivalent stresses of various materials of walker such as Stainless Steel, Aluminium alloy, Titanium alloy, Fiber reinforced plastic and in the final instance the combination of aluminium alloy and Stainless Steel was considered. The combination of materials for analysis in the final instance is the result of the observations from the first four results. It was observed that stresses were very low on the cross pipes between the front legs of the walker and also low on the pipes connecting the front legs and the rear legs. Therefore, this resulted in choosing the materials of cross pipes and the pipes connecting the front legs and the rear legs as aluminium and the rest of the walker was considered to be Stainless Steel. The aluminium was used to reduce the weight of the walker so that it will only help the user and the stainless-Stainless Steel material was used for strengthening of the walker.

The solutions from the analysis of walker from the ANSYS 14.5 workbench are tabulated in Table 2. The total deformation was least in the walker being considered as Stainless Steel and maximum with aluminium. The combination of aluminium and stainless material resulted in total deformation of 1.8563mm compared to 1.7826 mm in Stainless Steel alone.

Therefore, the difference in results of total deformation and equivalent stresses in combination of aluminum - Stainless Steel and Stainless Steel alone was very negligible but the combination yielded in less weight compared to the weight of the walker in Stainless Steel alone. Hence the combination of Stainless Steel and aluminium alloy was considered the right fit for the walker since it had excellent strength and also light weight.

The walker is also analyzed by applying load on the handles alone. The results are tabulated below (table 3). Here the total deformation and equivalent stress obtained after the application of load is well under the safety limits and hence, we can conclude that the walker frame is safe when the load is acted on the handles alone.

Table -2: Solutions of Total deformation and equivalent stress in ANSYS 14.5 when load is applied on seat frame

Material	Total deformation in mm		Equivalent stress in MPa	
	Min	Max	Min	Max
Stainless Steel	0	1.7826	0	248.03

Aluminium alloy	0	5.4665	0	334.46
Stainless Steel and aluminium alloy	0	1.8563	0	264.98

Table -3: Solutions of Total deformation and equivalent stress in ANSYS 14.5 when load is applied on handle

Material	Total deformation in mm		Equivalent stress in MPa	
	Min	Max	Min	Max
Stainless Steel	0	0.65006	0	272.76
Aluminium alloy	0	1.7174	0	280.9
Stainless Steel and aluminium alloy	0	0.67714	0	284.13

5. Seating Position

5.1. All Aluminum

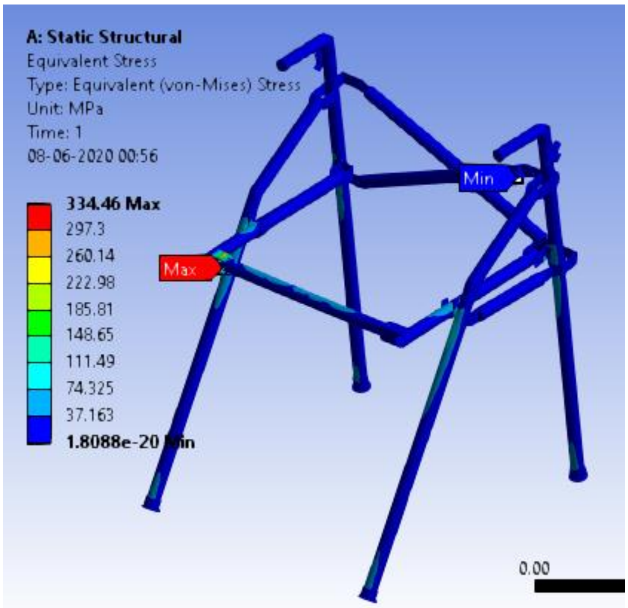

Figure 7 : Equivalent stress

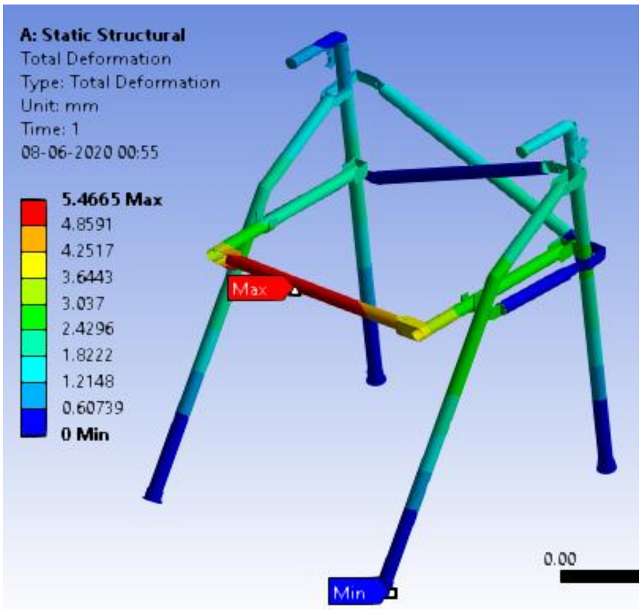

Figure 8 : Total deformation

5.2. All Stainless Steel

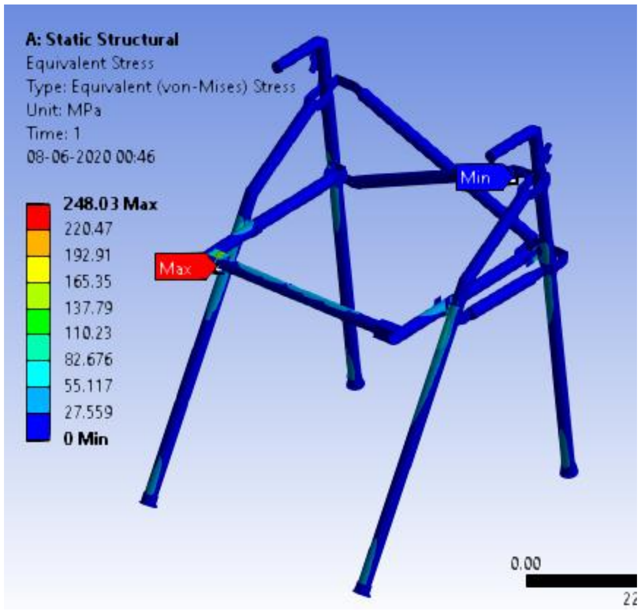

Figure 9 : Equivalent stress

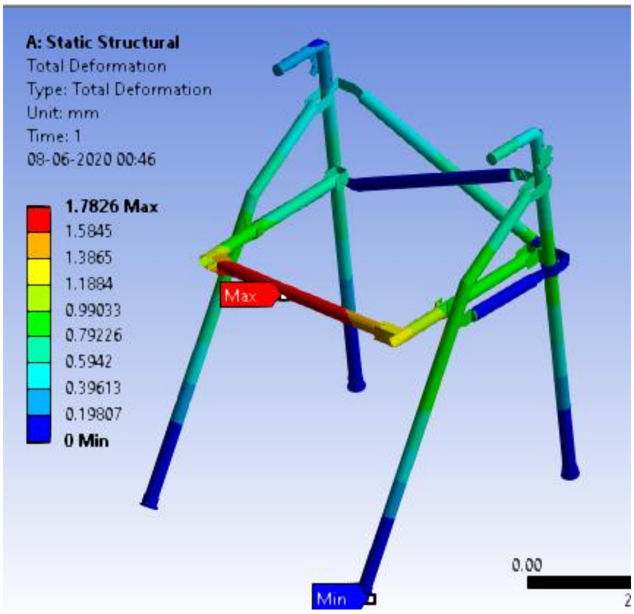

Figure 10 : Total deformation

5.3. Custom

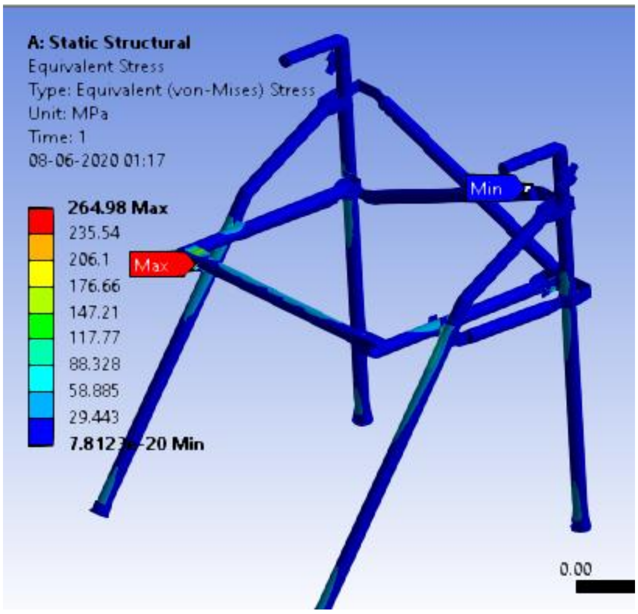

Figure 11 : Equivalent stress

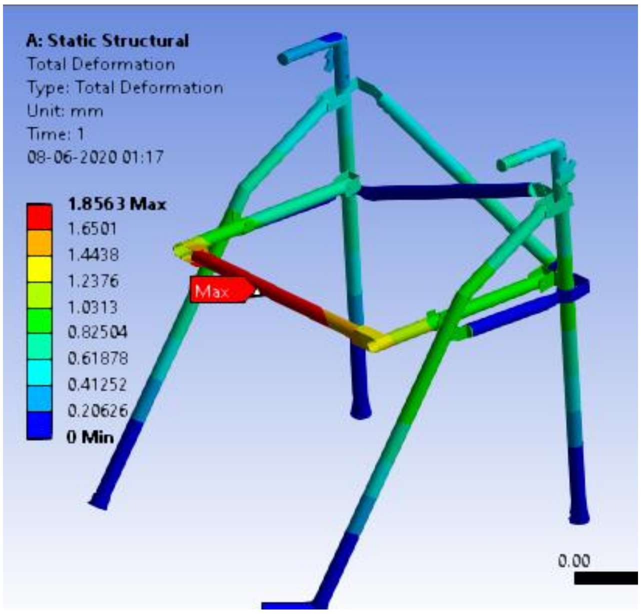

Figure 12 : Total deformation

6. Walking position

6.1. All Aluminum

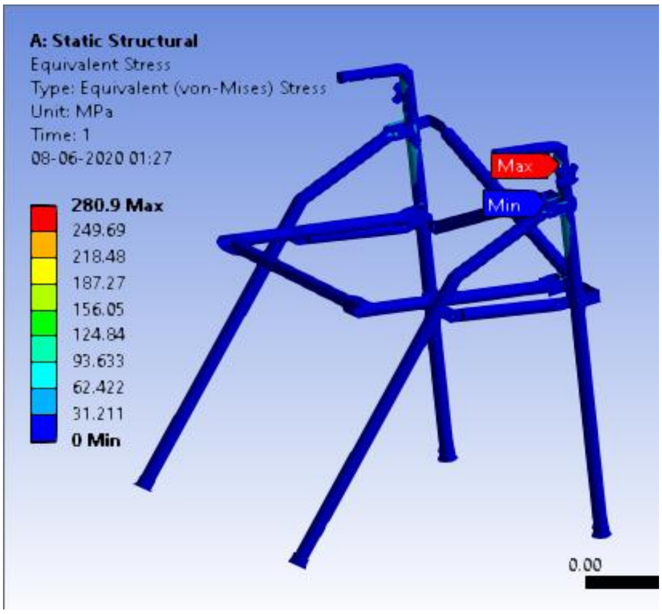

Figure 13 : Equivalent stress

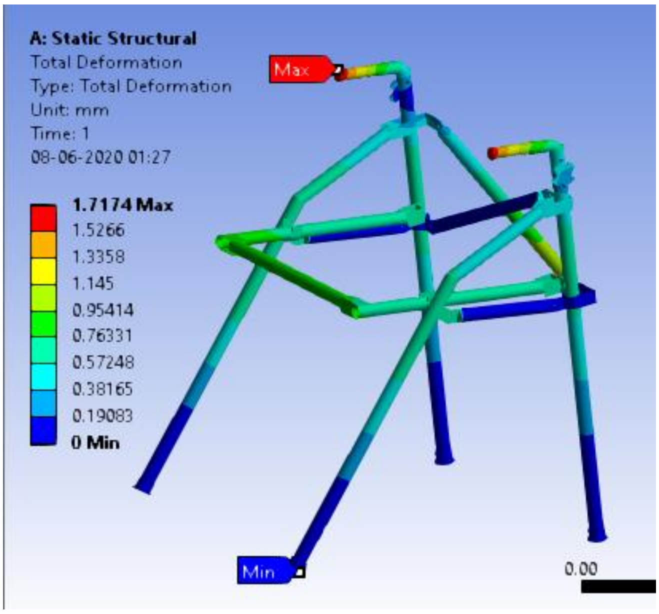

Figure 14 : Total deformation

6.2. All Stainless Steel

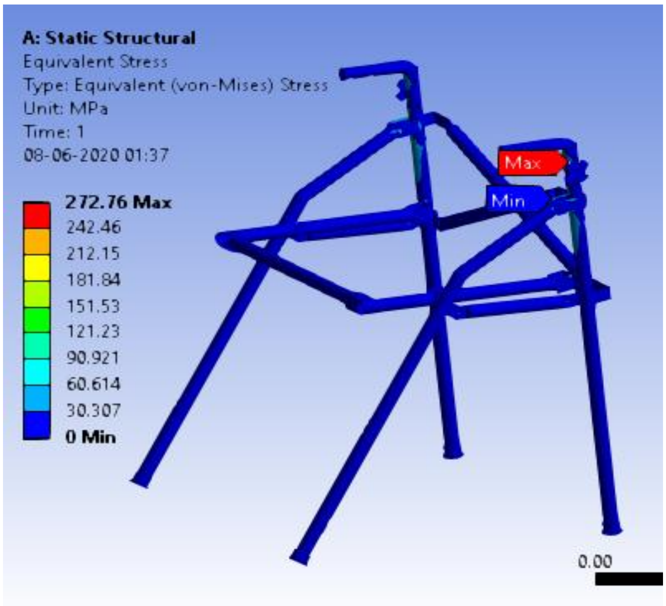

Figure 15 : Equivalent stress

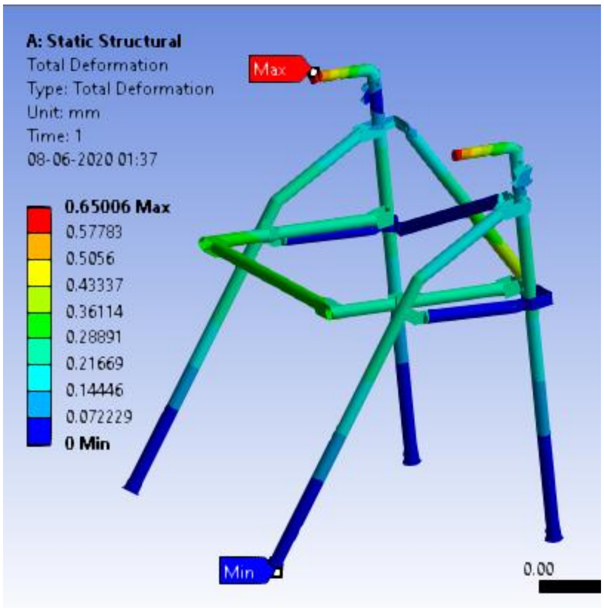

Figure 16 : Total deformation

6.3. Custom

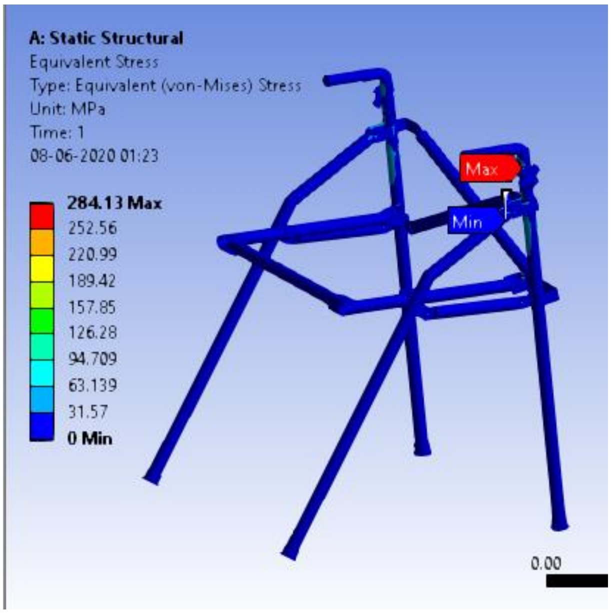

Figure 17 : Equivalent stress

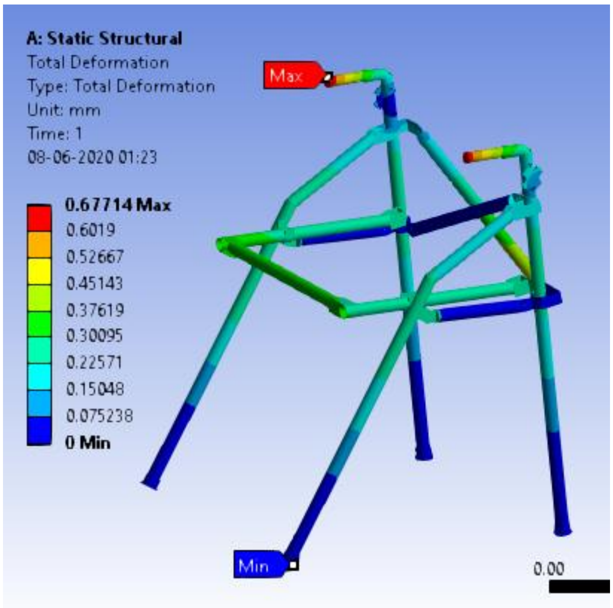

Figure 18 : Total deformation

7. CONCLUSIONS

The stress analysis of the walker was studied using ANSIS 14.5 and results are discussed in below. From the results is obtained it is conclude that

- Comparison between Von-Misses stress vs Load for Aluminium walker show that the maximum stress induced in the walker is 334.46 MPa in seating and 280.9 MPa in walking condition which is more than the yield strength of the Aluminium. Using this material for the walker will result in permanent deformation in the high stress region therefore this is not a suitable metal for the design under study.
- Comparison between Von-Misses stress vs Load for Stainless Steel is walker show that the maximum stress induced in the walker is 248.03 MPa in sating and 272.76 MPa in walking condition which is comparable to the yield strength of the Stainless Steel. From the Strength perspective this metal is satisfactory but there will be drastic increase in the weight of the walker which not only causes discomfort to the user but can also pose serious health concerns in the long run. Therefore is not a suitable metal for the design under study.
- Comparison between Von-Misses stress vs Load for Aluminium and Stainless Steel combination walker show that the maximum stress induced in the walker is 264.928 MPa in seating and 284.13 MPa in walking condition which is comparable to the the yield strength of the Stainless steel. Using this material will not satisfy the strength requirements but also the weight gets reduced drastically. Although the maximum stress induced in the walker is more than that of aluminium but from the fig 17 we can see that the member with maximum stressed area is of Stainless Steel. Therefore this material combination is best suited for the design under study of the walker.
- Comparison between Total deformation vs Load for all types of selected material combination are comparable in both seating and walking condition and all the values are within the acceptable limits.

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BIOGRAPHIES

Student, Department of Mechanical Engineering KLE Technological University Hubli-580021

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Student, Department of Mechanical Engineering KLE Technological University Hubli-580021