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Modification of Glass Railing System Using Structural Analysis on ANSYS

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Abstract: We had invented a glass railing system, in which we had design a Oval shape base shoe that use a simple nylon fixture; that makes installation and un-installation of this system in a very simple process. Stainless steel anchors are used to mount in a horizontal base of a shoe and at some distance from each other for mounting on ground. Nylon fixture applies force on glass panel due to which opposite side of the glass panel settles against PVC compressive sheet which is on another side of glass panel; that makes installation and un installation of this system a very simple process. Due to Oval in shape dirt and water while cleaning or in monsoon doesn't settle on it.

Keywords: Frameless Glass Railing, Heavy Duty Glass Railing, Oval base railing, ANSYS, Equivalent stress diagram.

I. INTRODUCTION

Frameless Glass railing system forms the basis of the engineering industry and is involved either directly or indirectly in the manufacture of nearly every product of our modern civilization. This Frameless Glass railing system are constructed primarily of high-strength, high durability fiberglass and secondarily it has to be seen that it has to be overcome through an external forces or impacts on it. Since, Aluminium components have several advantageous characteristics such as resistance to corrosion and bad weather, higher mechanical resistance and are relatively light weight. Notably for these reasons, aluminium structure systems are widely used in the construction industry for the external perimeters of balconies, footbridges, staircases, etc. It suits many applications such as platforms, decks, mezzanines, balconies and staircases.

II. MATERIAL AND MECHANICAL PROPERTIES

In current case study; the Aluminium Alloy 6063 - T6 grade has been used to manufacture of Railing Systems. Since, it allows complex shapes to be formed with very smooth surfaces fit for anodizing and so is popular for visible architectural applications such as window frames, door frames, roofs and sign frames. The chemical composition of the Aluminium Alloy 6063 - T6 grade is as follows:

TABLE I
CHEMICAL COMPOSITION ALUMINUM ALLOY 6063 - T6

Al	97.5 - 97.6 %	Cu	0.10 %
Cr	0.10 %	Fe	0.35 %
Mg	0.90 %	Mn	0.10 %
Si	0.60 %	Ti	0.10 %
Zn	0.10 %	Other	0.05 - 0.15 %

The mechanical properties of Aluminium Alloy 6063 - T6; Poisson's ratio = 0.33, Modulus of elasticity = 2.1×10^{11} Pa and Density = 2700 kg/m^3 is given as data input in isotropic elasticity. The atmospheric temperature is consider 29 ℃. The tensile test results in the load v/s deflection diagram. This load v/s deflection diagram is converted to engineering stress strain curve using the mechanical properties obtained from the load v/s deflection diagram.

| 1	Plastic Strain (m m^-1)	Stress (MPa)
2	0	0.0013
3	0.0005	24.953
4	0.0009	51.175
5	0.0012	79.089
6	0.0016	101.51
7	0.0021	129.42
8	0.0024	153.1
9	0.003	175.94
10	0.0031	195.4
11	0.0035	207.66
12	0.004	212.74
13	0.0048	216.54
14	0.006	218.65
15	0.0075	222.87
16	0.0105	226.67
17	0.0133	230.04
18	0.016	232.57
19	0.0194	235.52
20	0.0218	237.63
21	0.0247	240.16
22	0.0296	243.52
23	0.0339	246.47
24	0.0379	248.57
25	0.0452	253.19
26	0.0511	255.71
27	0.0568	257.81
28	0.0631	261.17
29	0.0714	264.52
30	0.0772	265.77

Figure 1 Data of Stress v/s Strain
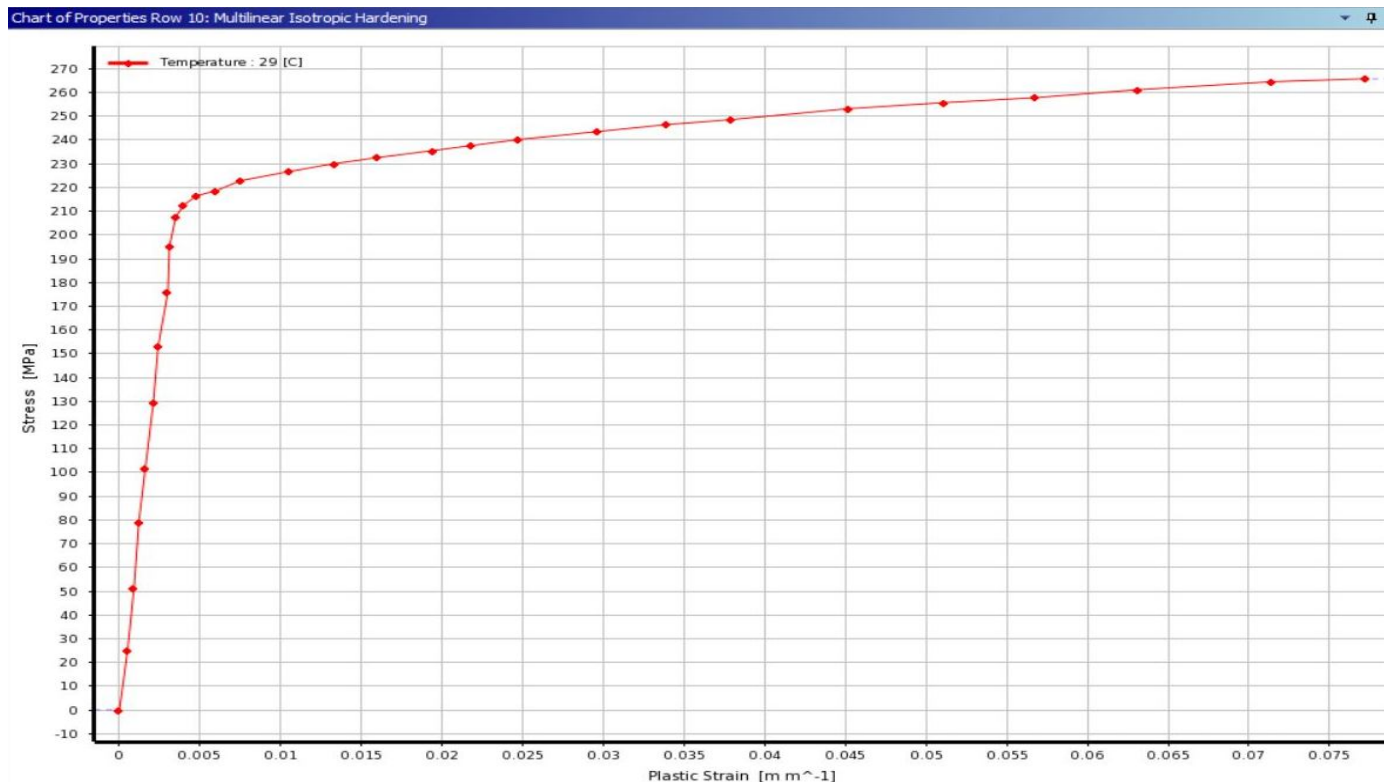
Figure 2 Graphical representation of Stress v/s Strain Curve

From the above data, we came to know that ultimate tensile load is 265.77 MPa

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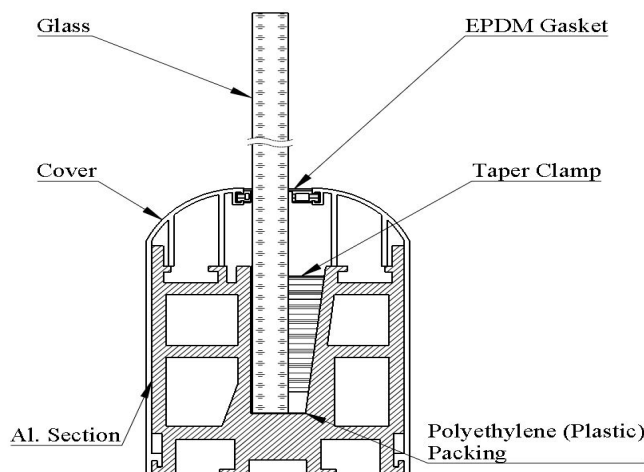
III.DETAIL OF SYSTEM

Figure 3 Heavy Duty Glass Railing System 2D View

A. Gasket

EPDM Rubber (ethylene propylene diene monomer (M-class) rubber) material has been used for packing the gaps which has form after installation. EPDM rubber is a terpolymer of ethylene, propylene and diene-component. The ethylene content is around 45% - 85 %. The higher the ethylene content, higher the loading possibilities of the polymer, better mixing and extrusion.

B. Taper Clamp

Taper clamp is made up of Nylon 69. This packing's i.e. clamp; are made up of hard, though slightly resilient material, so as to permit a very limited degree of turning movement of the edge region of the panel in the holder under an applied transverse load, the nature of the packing material being such that it does not damage or abrade the panel while undergoing slight compressive deformation, but yet it can be fully restored to its original shape in the channel when the panel is unloaded.

C. Anchor

The anchor and faster has been used to mount this system. Those anchors are made up of SS 202 and SS 316 material. Since, density of SS is on higher side with respect to Aluminium, so it is preferable to go with application of SS Anchors.

D. Polyethylene (Plastic) Packing

The Polyethylene plastic is used is between glass surface and section i.e. its base and wall. Due to which there will be a minimum amount of chances of glass panel to get damage. It acts like a protective film for glass panel.
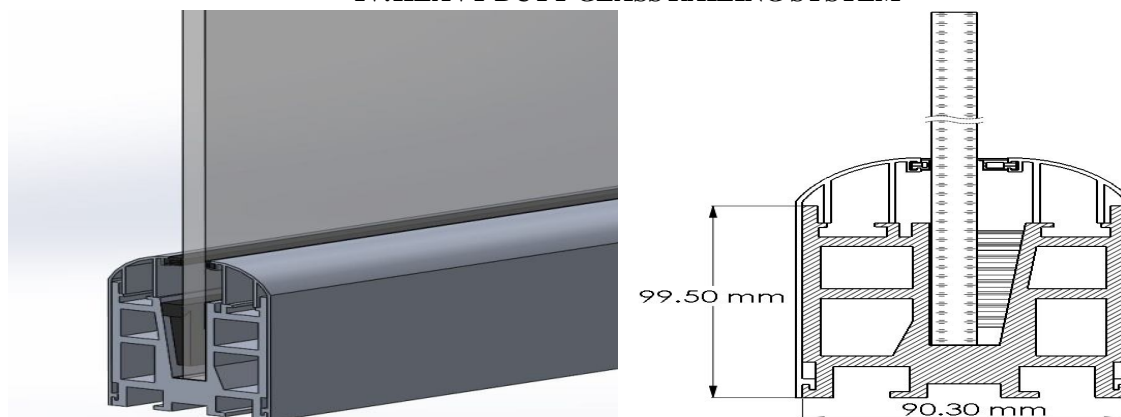
IV.HEAVY DUTY GLASS RAILING SYSTEM

Figure 4 Heavy Duty Glass Railing System 2D Dimensional View and 3D Model View

A. Geometry of Heavy Duty Glass Railing System

Properties of this heavy duty glass system (1000 mm) :

TABLE II
Properties Of Heavy Duty Glass System - Aluminum Alloy 6063 - T6

Mass	4870 Grams
Volume	1803360 mm^3
Density	2700 Kg/m^3
Young's Modulus	71250 MPa
Poisson's Ratio	0.33
Tensile Yield Strength	214 MPa
Tensile Ultimate Strength	241 MPa

B. Meshing of Heavy Duty Glass Railing System

Initially a relatively medium mesh is generated with 75 thousand nodes. This mesh contains cells (Hexahedral cells) having quadrilateral faces at the boundaries. Care is taken to use structured cells (Hexahedral) as much as possible, for this reason the geometry is divided into several parts for using automatic methods available in the ANSYS 18.2 meshing client. It is meant to reduce numerical diffusion as much as possible by structuring the mesh in a well manner, particularly near the wall region.
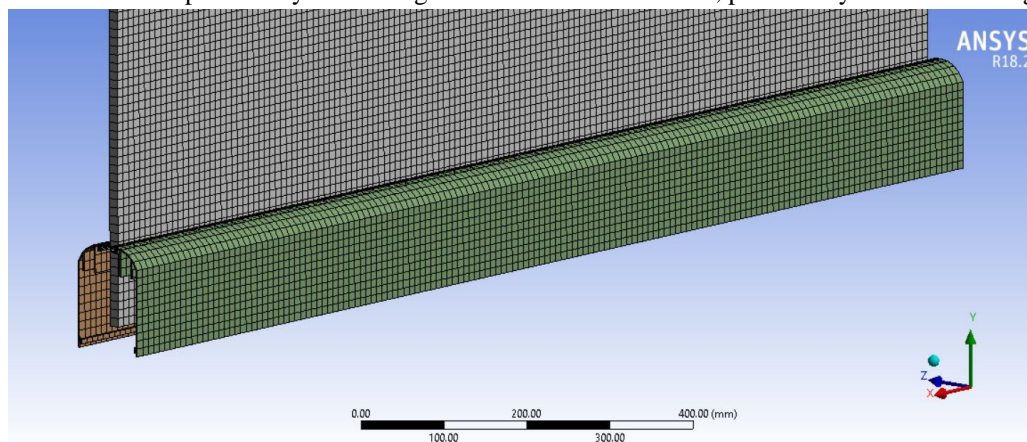

Figure 5 Meshing diagram of Heavy Duty Glass Railing

C. Boundary Condition of Heavy Duty Glass Railing System

The force has been applied perpendicular to the glass panel of 3800 N. Since the base has been kept fixed and gravitational force is acting in negative Y direction.
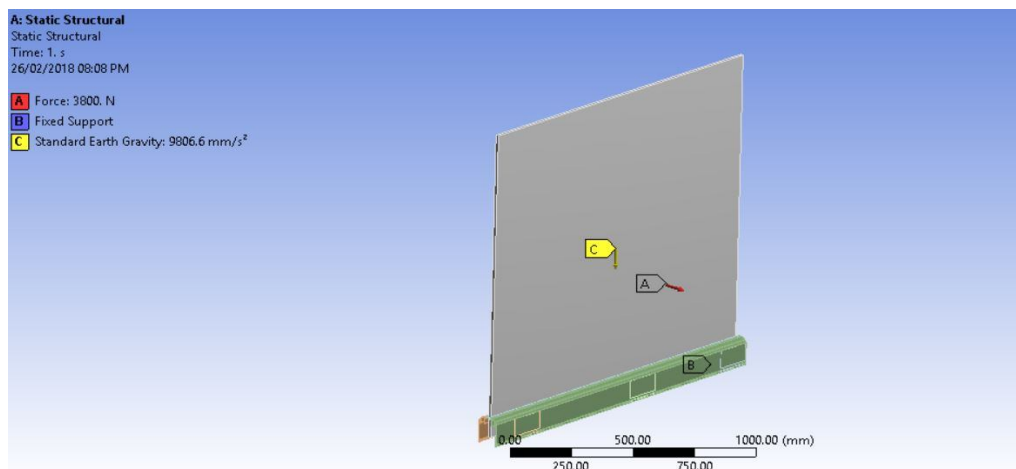

Figure 6 Boundary Condition diagram of Heavy Duty Glass Railing

D. Analysis of Heavy Duty Glass Railing System

After the analysis done which has been done on Ansys 18.2. The Maximum Stress which has been occur is 46.03 Mpa.
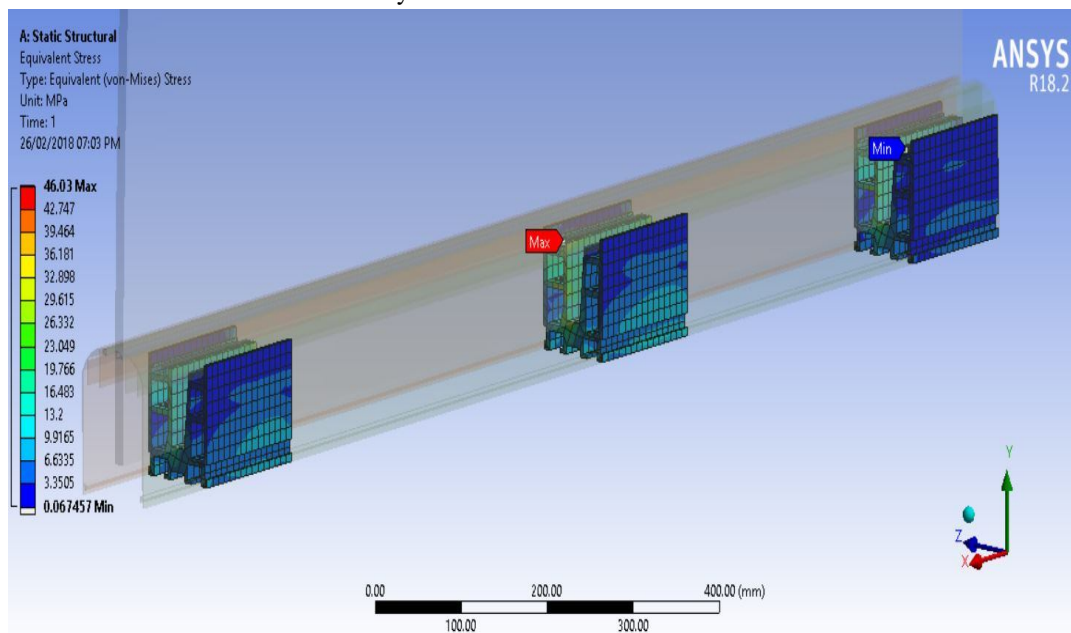

Figure 7 Equivalent Stress diagram of Heavy Duty Glass Railing
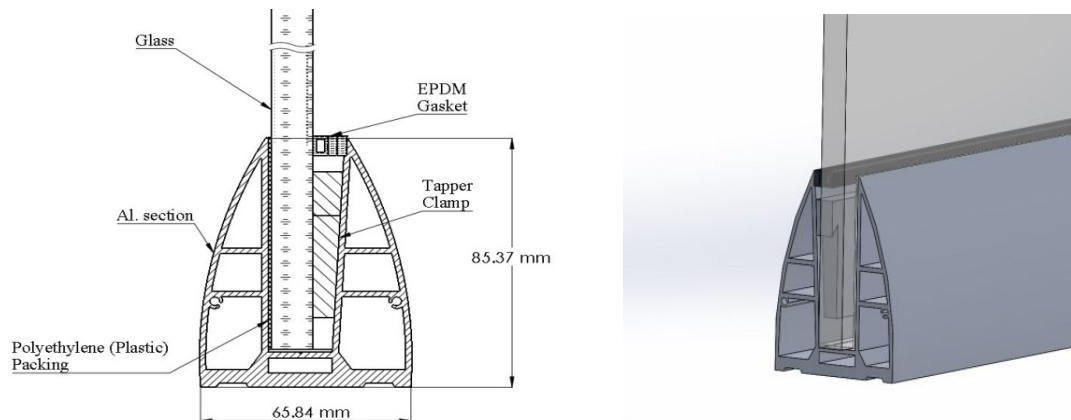
V. FRAMELESS GLASS RAILING SYSTEMS

Figure 8 Frameless Glass Railing Systems 2D Dimensional View and 3D Model View

A. Geometry of Frameless Glass Railing System

Properties of this frameless glass railing system (1000 mm) :

TABLE III

Properties Of Frameless Glass Railing System - Aluminum Alloy 6063 - T6

Mass	3176.52 Grams
Volume	1176490 mm^3
Density	2700 Kg/m^3
Young's Modulus	71250 MPa
Poisson's Ratio	0.33
Tensile Yield Strength	214 MPa
Tensile Ultimate Strength	241 MPa

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B. Meshing of Frameless Glass Railing System

Initially a relatively medium mesh is generated with 75 thousand nodes. This mesh contains cells (Hexahedral cells) having quadrilateral faces at the boundaries. Care is taken to use structured cells (Hexahedral) as much as possible, for this reason the geometry is divided into several parts for using automatic methods available in the ANSYS 18.2 meshing client. It is meant to reduce numerical diffusion as much as possible by structuring the mesh in a well manner, particularly near the wall region.
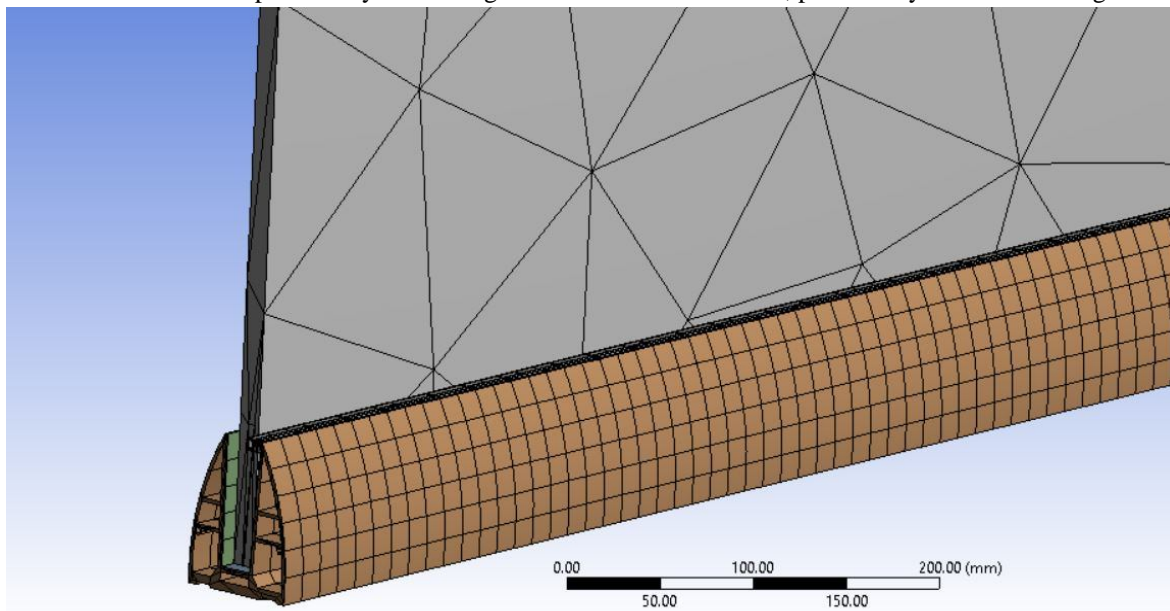

Figure 9 Meshing diagram of Frameless Glass Railing

C. Boundary Condition of Frameless Glass Railing System

The force has been applied perpendicular to the glass panel of 3800 N. Since the base has been kept fixed and gravitational force is acting in negative Y direction.
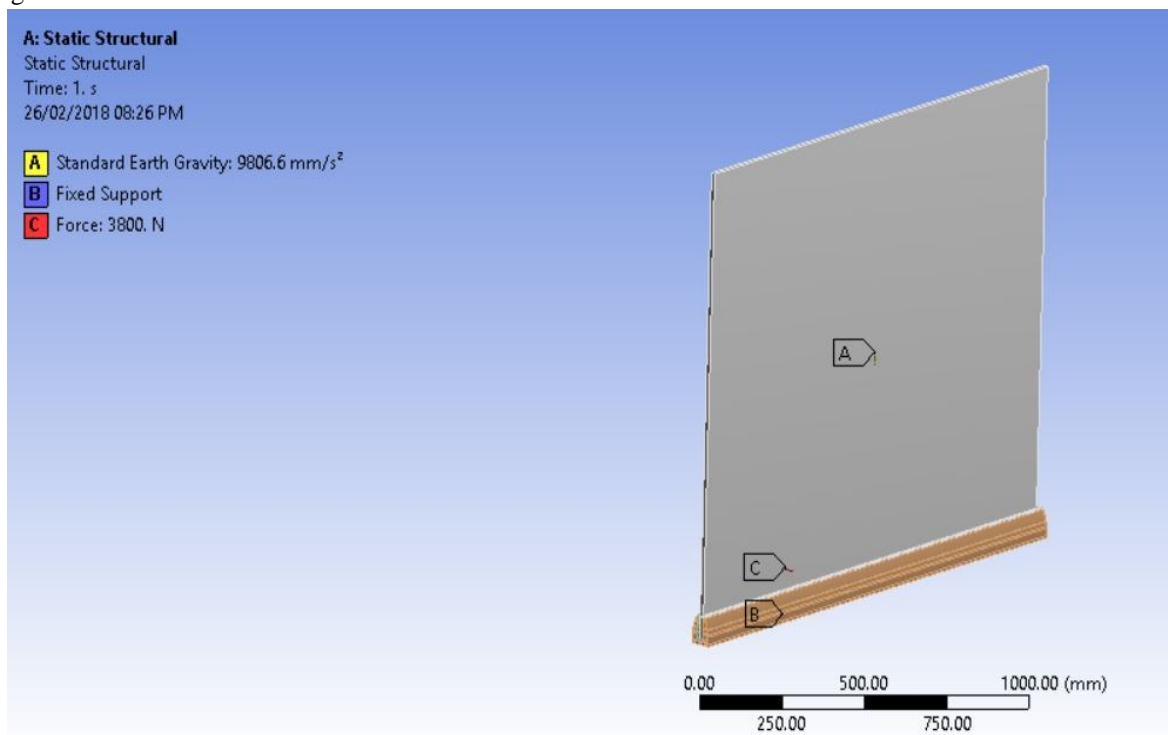

Figure 10 Boundary Condition diagram of Frameless Glass Railing

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D. Analysis of Frameless Glass Railing System

After the analysis done which has been done on ANSYS 18.2. The Maximum Stress which has been occur is 54.515 MPa.

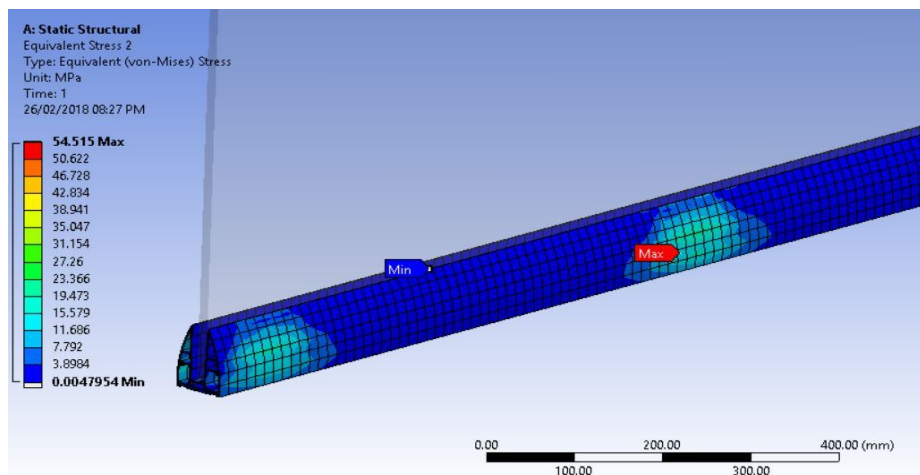
Figure 11 Equivalent Stress diagram of Heavy Duty Glass Railing

VI. RESULTS AND DISCUSSION

As per result of analysis, came to know that the Stresses generated after the whole process is less than that of Ultimate tensile stress of the Material. So, there is no chance of failure of system.
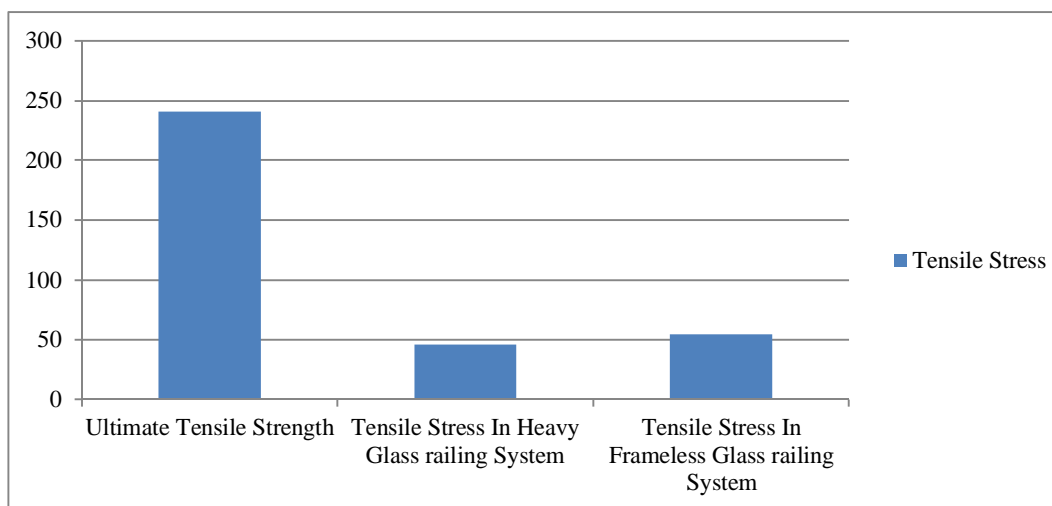

Figure 12 Graph of Ultimate Tensile Stress

Mass of the existing heavy glass railing system is 4870 Grams and there is reduction of mass in new frameless glass railing system which has been noted as 3176.52 Grams. so there is mass reduction of 1693.48 Grams i.e. saving of 1.69 kg in every 1000 mm of the system.

VII. CONCLUSION

In this case study, Aluminium 6063 - T6 has been used for manufacturing of glass railing system. From the above result, we came to know that there are some changes can be occurs after the application of new frameless glass system. Following important conclusions can be drawn from the results of the case study:

A. There is increase of about 18 % in Maximum Stress of new frameless glass railing system as compare to Heavy glass railing system but the Stress value is very low compare to Ultimate tensile strength of the material, there is very low chances of failure of the system.

B. There is mass reduction of about 34% to 35% in new frameless glass railing system as compare to Heavy glass railing system. So, we can say that there has been material save. Due to which cost has been reduced for manufacturing and retail purpose.

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