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DESIGN ANALYSIS AND FABRICATION OF COPPER PATCH PANEL

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Abstract — *Patch panels are passive components along with structured cabling system (SCS) that are integral units of data centers in buildings and these components support the transfer of huge volume of information from source to end users. Patch panels have many advantages such as space saving, Reduce cable congestion, Ease of maintenance, Flexibility and scalability due to the high cost its usage has been restricted. The objective of the present research work is to reduce the cost of patch panel for that patch panel is designed by using the 3D modeling software i.e., solid modeling of patch panel for RJ45 connector has been carried out by using the creo parametric 2.0software.In the new design plastic molding parts are to be replaced and to maintain the same mechanical properties and functional conditions. Finite element analysis of the patch panel is carried out by using the Ansys14.5 software and fabrication of the patch panel is to be done according to the ISO8015 standards. The comparison of the cost of patch panels shows that some 65% cost saving is possible by maintain the same mechanical properties.*

Keywords- *Patch panel, 3D modeling software, Finite element analysis, Cost analysis.*

I. INTRODUCTION

Patch panel is an organized hardware assembly that houses connectors used to connect and manage incoming and outgoing LAN cables. Patch panel is also termed as patch bay, patch field or jack field. A panel that authorize various devices to be associated and control in a perfect manner. Computer networks, sound studios, television stations, and various other systems are using patch panels to deal with apparatus of their electronic systems. The patch panels for the most part engage a space of 1U in the network racks. All the cables from the desktops are brought on the way to the patch panels and they are ended at the back side of the patch panel as shown in fig . (The UTP cable contains of 4 Pairs, all these 8 cables are separated at the end and punched individually at the rear of the patch panel). UTP Patch cords connects the each individual port in the patch panel to the each of the individual ports in the network switch. This enable everlasting connection to the switch, which is not concerned and all adds, moves and changes are done at the patch panel level.

Network patch panels can also attach incoming wires on one panel to outgoing wires on another panel, with patch cables provided that the needed connections. Patch panels can also be used to hook up diverse devices. One port on a patch panel wired to another port creates a bridge between the ports. One can connect a device bounded to one port to a secondary device by changing the patch cord location. Patch panels plays a important role in network cable management, particularly in huge and intricate installations.

Network patch panels include RJ-45 ports houses on a standard 19-inch network rack mounting. The size of the panel varies from 12 ports to 96 ports. Each port has a number embossed on the mounting plate. Network engineers attach incoming lines to ports on the patch panel. Once wired, the incoming line links to a network device using a separate cable called a patch cable. As networking needs are increasing, further incoming lines can be added to the existing lines and additional network devices added or changed without having to rewire the whole thing.

Patch panels consists of the copper cables, RJ45 connectors (female), RJ45 patch chord (male) and patch panels (housed to racks) that are uses at different levels of arrangement to deal with the communication loop inside the building.

II. Objective

The objective of present wok is to reduce the cost of copper patch panel by designing and analysis of copper patch panel used in network connectivity that is 19 inches' width and 1u (1.75 inches) height. The finite element method of analysis is done on patch panel. Also further study of patch panel with cable manager is done using finite element analysis. The design and modeling of patch panel is accomplished by using CAD i.e., parametric design package (Creo parametric 2.0). By using this three dimensional model of patch panel and cable manager are developed. Finite element analysis is carried out theoretically and by using Creo Simulate programming. The design of the patch panel has to be carried out according to the ISO 8015 standards.

III. Design of Patch panel

Recently, concern for reducing the cost of patch panel to increase the usage as connecting and managing the cables is becoming necessary as the usage LAN is increasing rapidly this led to the design of patch panels. An investigation to reducing the cost of patch panel when the point load deformability and stiffness remain the same. In order to conduct the investigation to reduce the cost, essential studies were required. First is to collect the design of the existing and to remove the plastic molding parts of the existing patch panel by redesigning the panel and to maintain the same functional conditions and mechanical properties. In order to Perform this investigation, a model has been created in the three dimensional modeling software Creo and then with the help of finite element analysis software ANSYS analysis is performed. The existing design of copper patch panel is evaluated for the determination of cost and a new patch panel is designed and analysis is performed on the new patch panel to know the load carrying capacity and cost analysis is performed for the existing and new patch panel to determine the cost variation between the two.

3.1. Components of patch panel:

The different components of patch panel are

3.1.1. Structure:

Structure is the main component of patch panel as it houses the other components of patch panel such as structure, label and label holder, cable manager, fixation elements. Length of the front plate is 19 inches and the height of front plate is 1u i.e., 1.75 inches. Thickness of front plate is 1.5mm. These are equipped with a label holder and a cable manager at the rear.

3.1.2.Front Plate:

Front plate is mounted on the structure. and designed for patch plugs of corresponding patch cords (Patch plugs are called connectors i.e., female and patch cords i.e. Male). Structure consists of modular jack blocks. Each structure consists of 6 modular jack blocks. For a 24 port patch panel four structures are adopted. All the structures are arranged linearly on front panel.

3.1.3.Cable Manager:

Cable managers are used for the easy management of patch cables and link the cabling distribution areas. The necessity of cable management is due to the complexity, potential distance between solution components, and the increased number of cable connections.

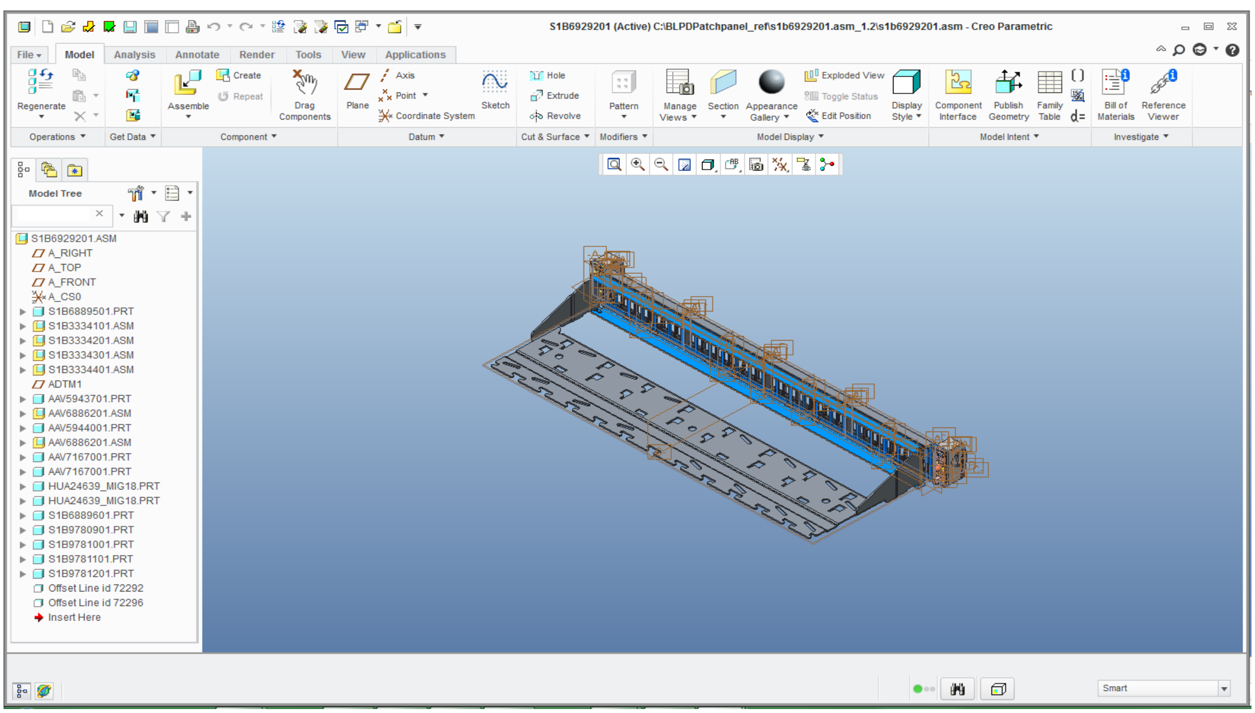


Fig. 1. Design of existing copper patch panel

3.2. Design of new copper patch panel:

Steps to be considered while designing of the patch panel is the standard dimensions i.e., the dimensions of the rack or wall bracket on which the flat patch panel is to be mounted. The size of the rack or wall bracket is depended on the number of ports in the patch panel. The size of the port is depended on the type of connector that is to be inserted in the port.

3.2.1. Design of face plate:

Figure 2 shows the solid modeling of the face plate and the standard dimensions of the face plate are described below
Length: 19 inches (482.6 mm)
Height: 1.75 inches (44.45 mm)
Thickness: 1. 5mm

Size of the port:
Length: 17.2mm
Breadth: 15.1 mm

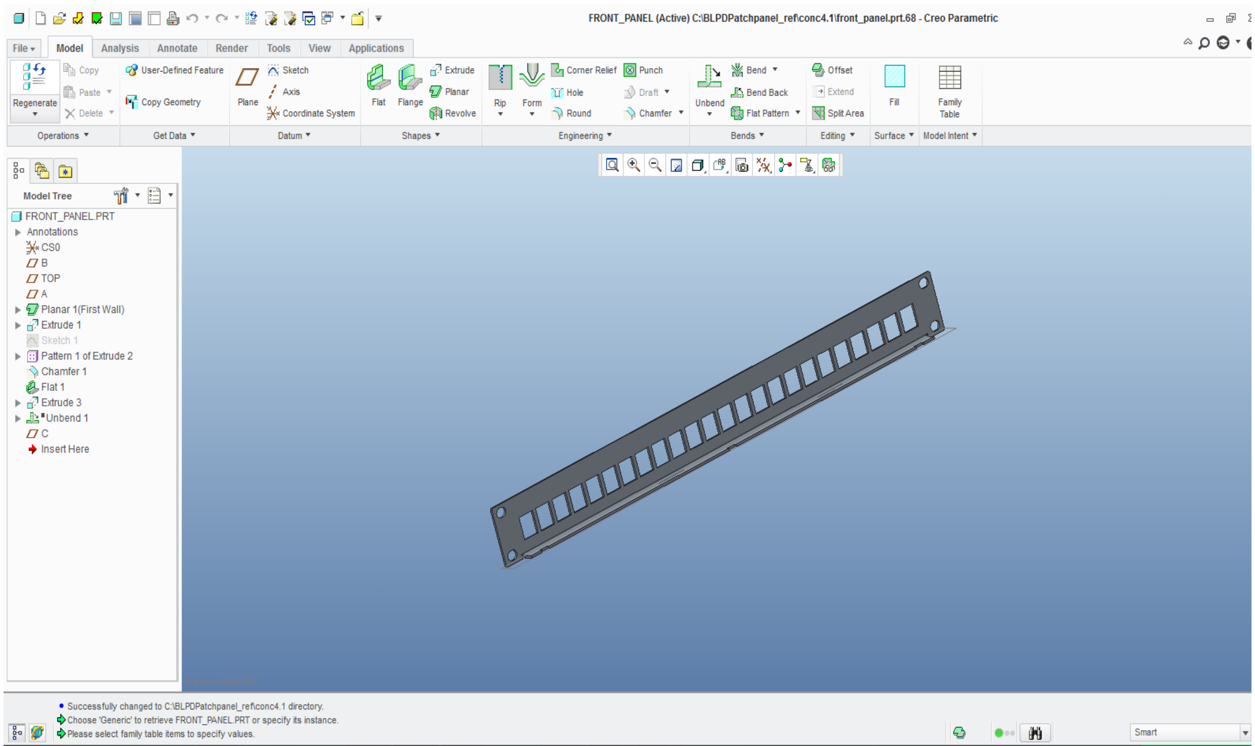


Fig. 2. Solid model of front plate

3.2.2. Design of support plate

The size of the Support Plate should be less than the size of the Face Plate and its length should cover all the ports. The length of the Support Plate is less than the Face Plate because the Face Plate has to be mounted on a wall bracket. Figure 3 shows the modeling of support plate in creo.
Length: 17.5 inches (447 mm)
Height: 1.75 inches (44.45 mm)
Thickness: 1. 5mm
Size of the port
Length: 19.6 mm
Breadth: 15.1mm

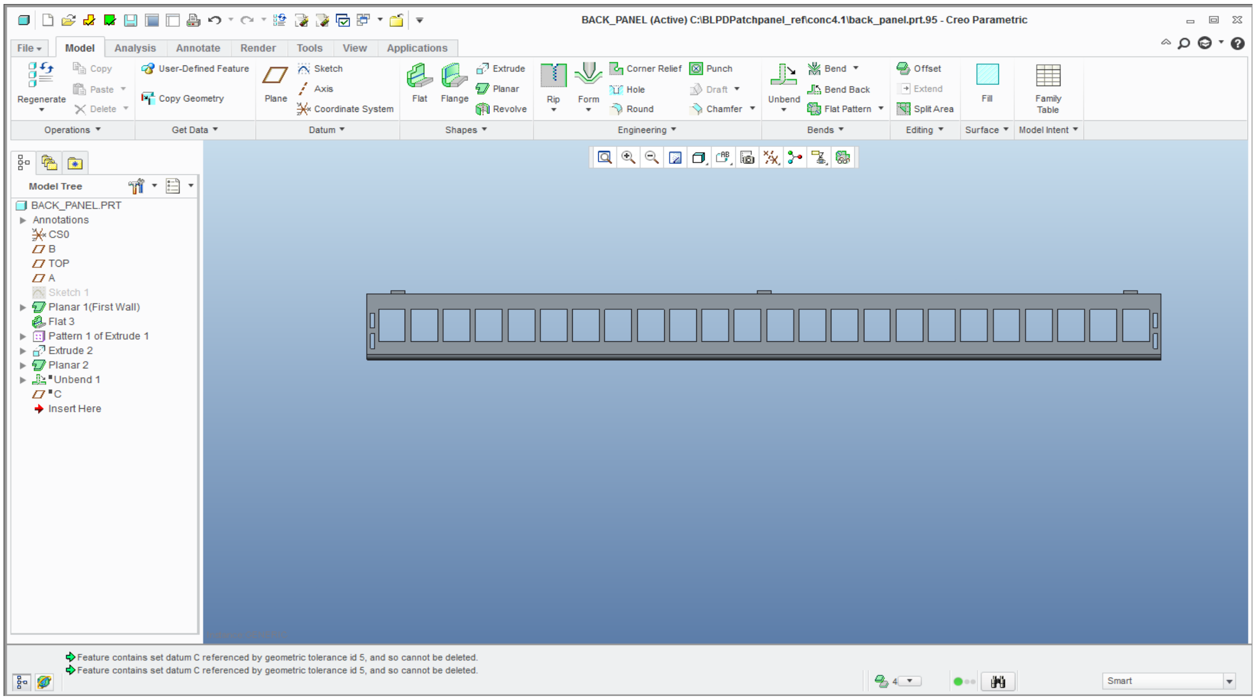


Fig. 3. Solid model of support plate

3.2.3. Design of Cable manager:

The size of cable manager is to be less than the size of the Support Plate and thickness of the cable manager is equal to 1.5 mm. The cable manager dimensions are varied from the design to design. Current design of cable manager is of self locking type. So the length of the cable manager should be less than the support plate. Figure 4 shows the the details of cable manager designed in the 3D modeling software.

Dimensions of cable manager:

Length: 430 mm

Breadth: 95 mm

Thickness: 1.5mm

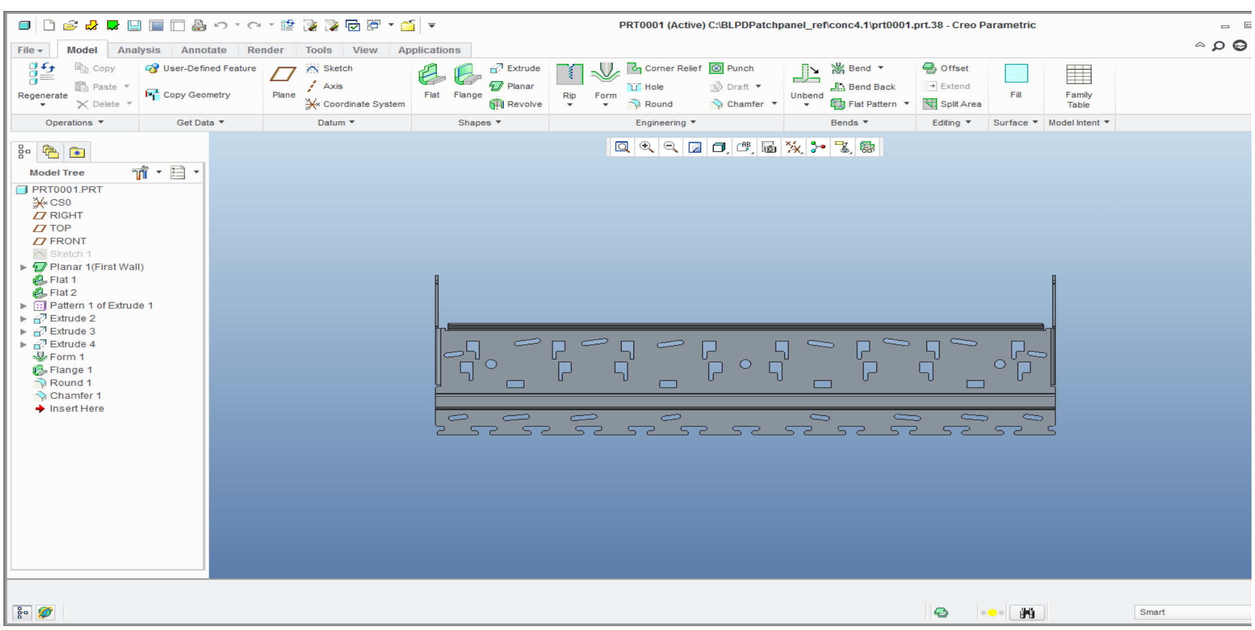


Fig.4.Solid model of cable manager

3.2.4. Assembly of face plate, Support plate and cable manager:

Figure 5 shows the assembly of face plate, support plate and cable manager. Cable manager is self locked to the support plate. Support plate is welded to the face plate at the three places such that the slots of connector in the support plate and face plate are perfectly aligned. The face plate is screwed to the rack or wall bracket.

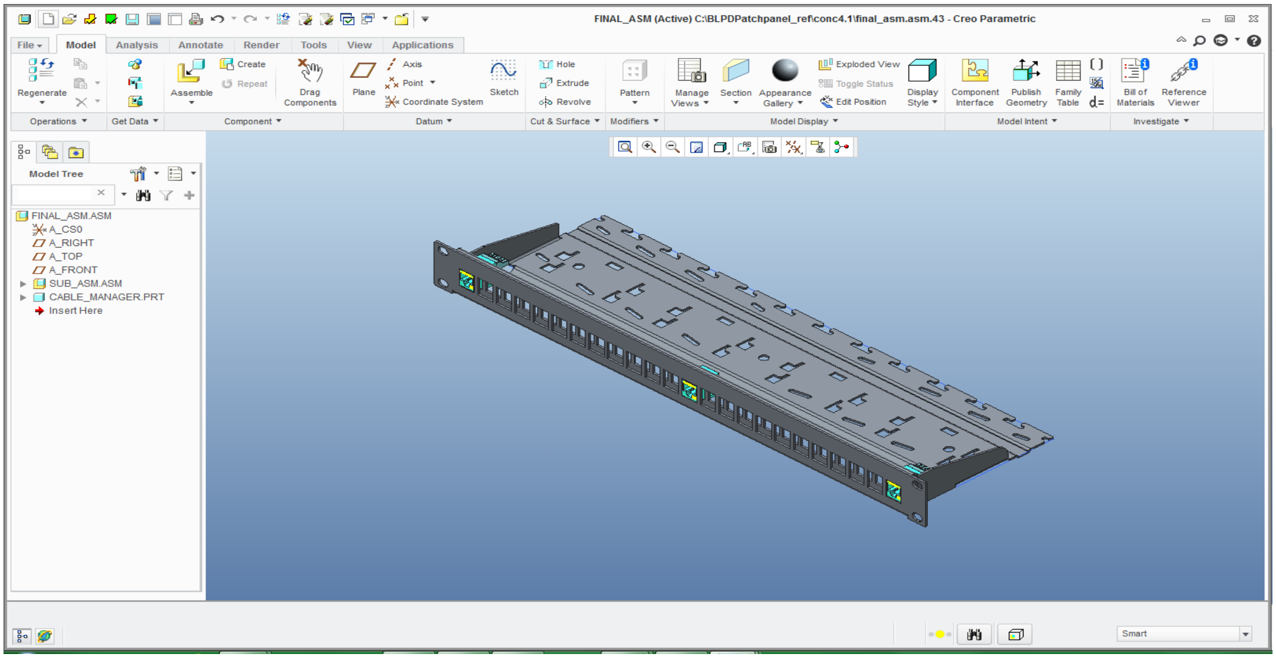


Fig.5. Assembly of face plate, Support plate and cable manager

3.2.5. Exploded view of face plate, support plate and cable manager:

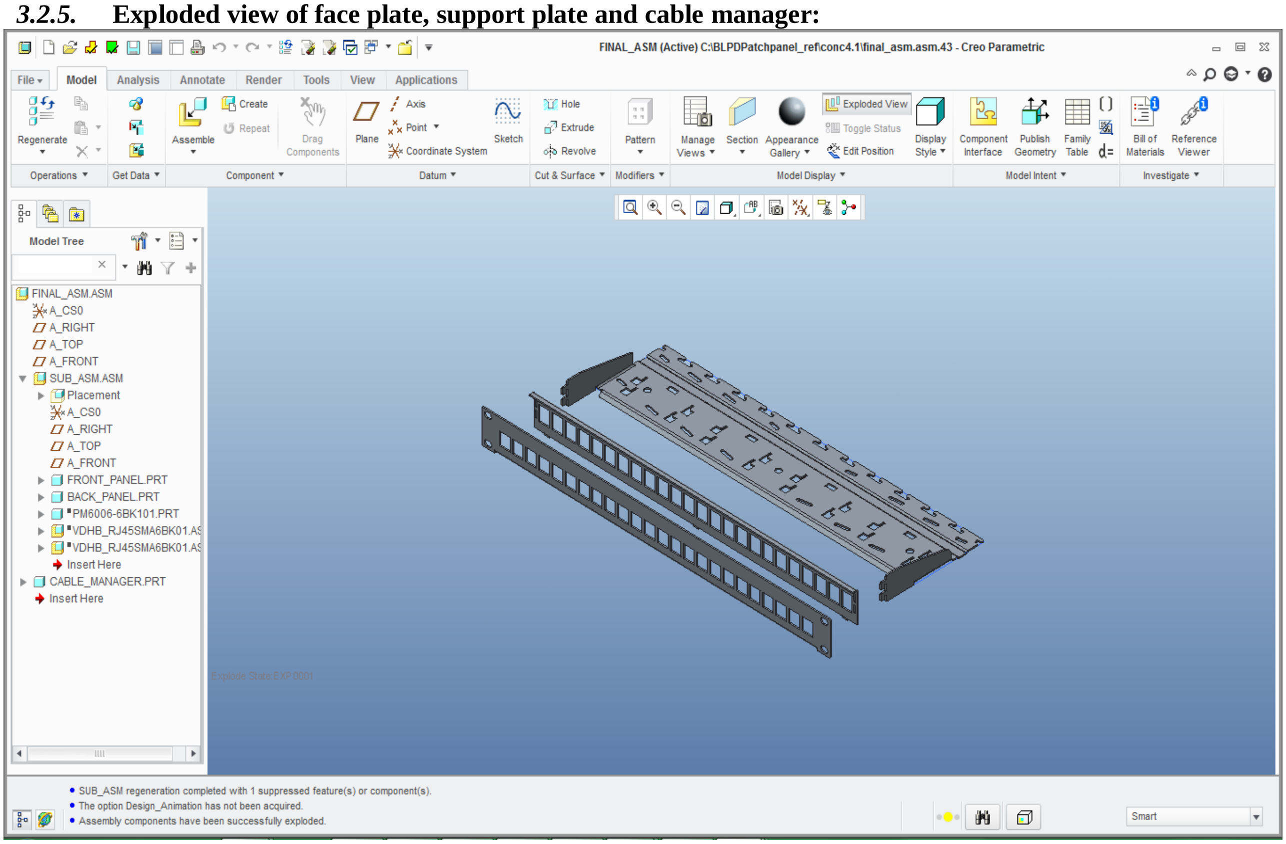


Fig.6. Exploded view of face plate, support plate and cable manager

IV. Analysis of Patch panel

Analysis of Patch panel is performed using the ANSYS software for determining the load carrying capacity of the cable manager. Analysis was undertaken based on the assumption that the point load strength of the patch panel and irregularly shaped particles to be equal and tensile point loads of different particle sizes are acting normal to the plate. For the analysis of the of the patch panel, the solid model of the patch panel is converted into IGES file and then this file is called for the analysis. Load Distribution along the Patch Panel: The Parameter which controls the design of patch panel is the load distribution. This hypothetical distribution was only concerned with the total loading force .The maximum deformation is calculated by using the formula:
The maximum deformation of abeam which is supported at the two ends is usually takes place at the center.

$$\delta_{max} = \frac{WL^3}{48EI}$$

4.1. Applying Material

Before the Structural Analysis module used for the FEA model, it must have material assigned to it. Each material in ANSYS has mechanical properties for computing the analysis for different materials but it has a facility to edits and add some material properties for other parts. For the analysis of patch panel galvanized steel is used, because of its ease of availability, electrical conductivity and reliability. Figure 8 Shows the applying material properties in ansys software. Mechanical Properties of galvanized steel are:

Young's modulus (E) – 200Gpa
Density (ρ)-7750kg/m^3
Ultimate Tensile Strength (Su) -400Mpa
Yield Strength (Sy) - 250Mpa

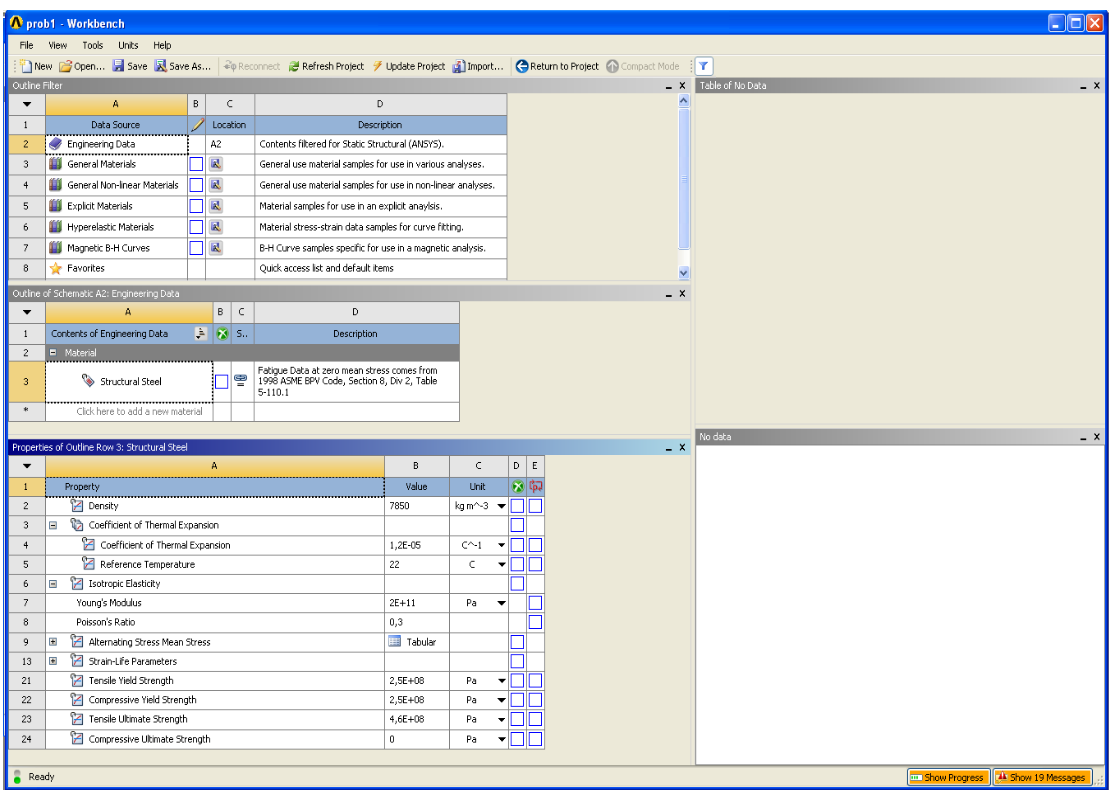


Fig.8.Showing applying material properties

4.2. Apply Boundary Conditions

Boundary condition for patch panel is simply supported i.e. the both ends are supported due to which panel is acting as a simply supported; figure shows the fixed point of panel.
Boundary conditions are applied to the cable manager by selecting the two fixed points of the cable manager
Figure 9 shows the fixing of boundary conditions in Ansys for the model imported from the Creo software.

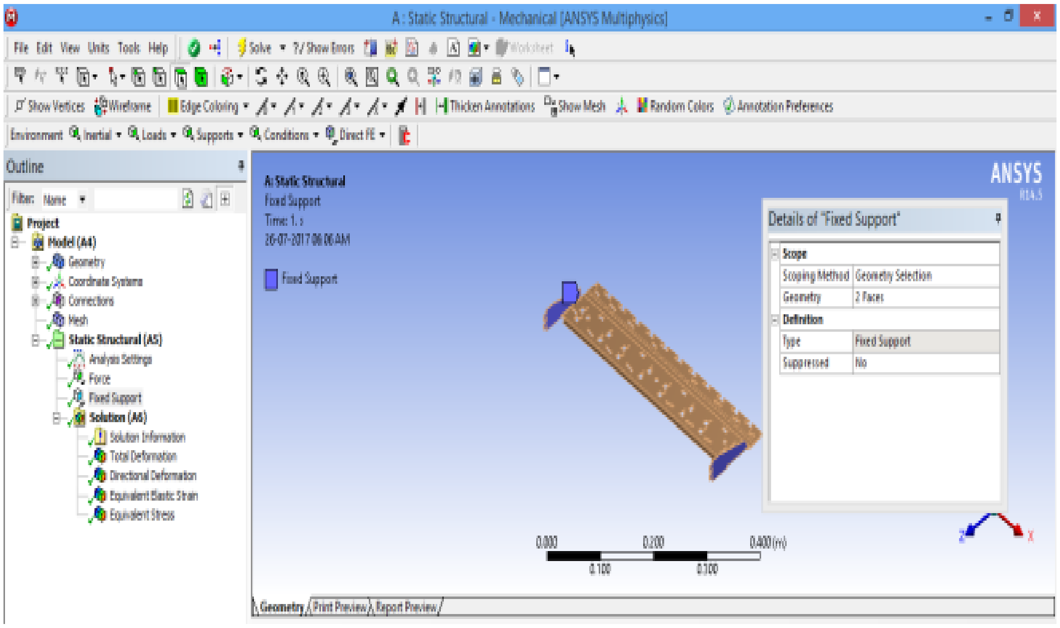


Fig.9.Showing fixed boundary conditions of cable manager

4.3. Applying Loads

Figure shows applying a load of 500N on the surface

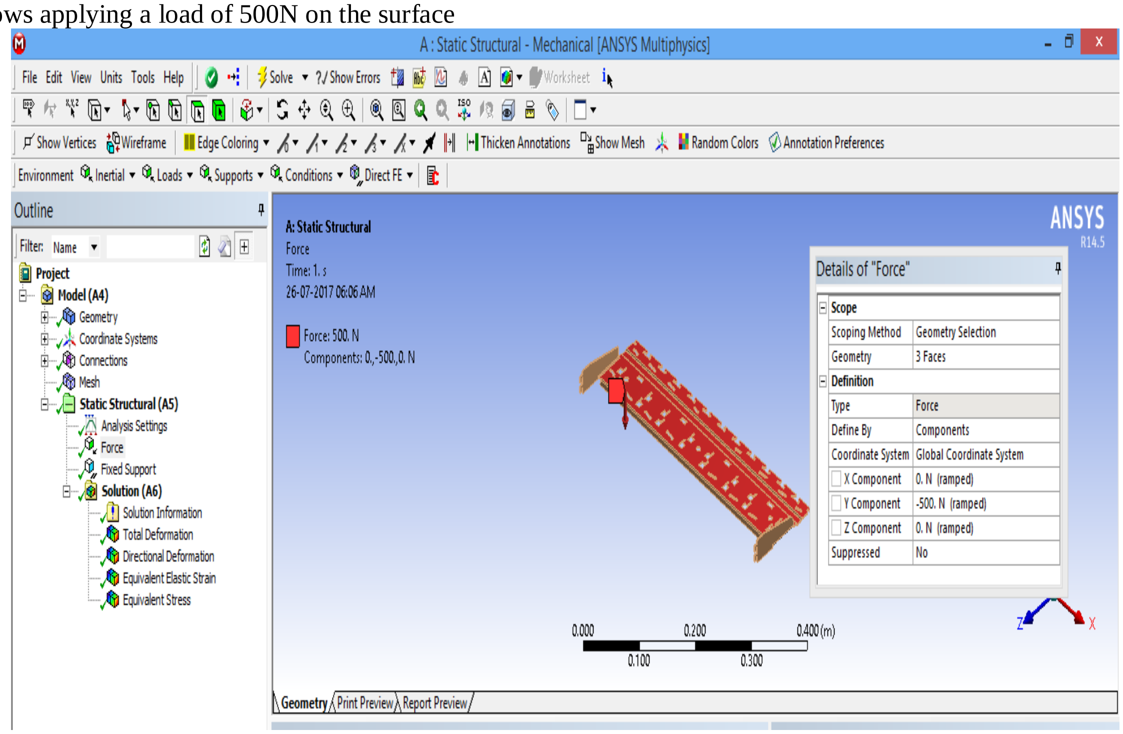


Fig.10. Applying loads

4.4. Static Stress analysis results for the existing patch panel:

4.4.1. Total deformation analysis:

Figure 11 showing the total deformation of the Cable manager of the existing patch panel.

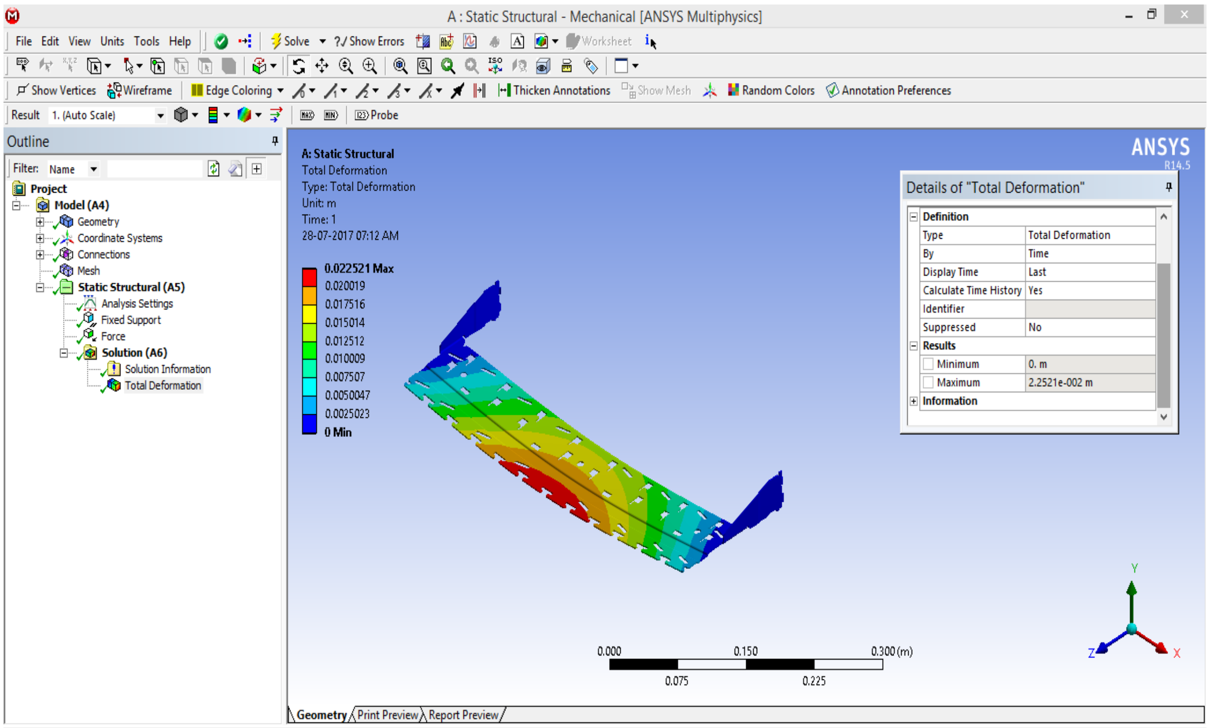


Fig.11.Total deformation analysis

4.4.2. Von Mises stress analysis

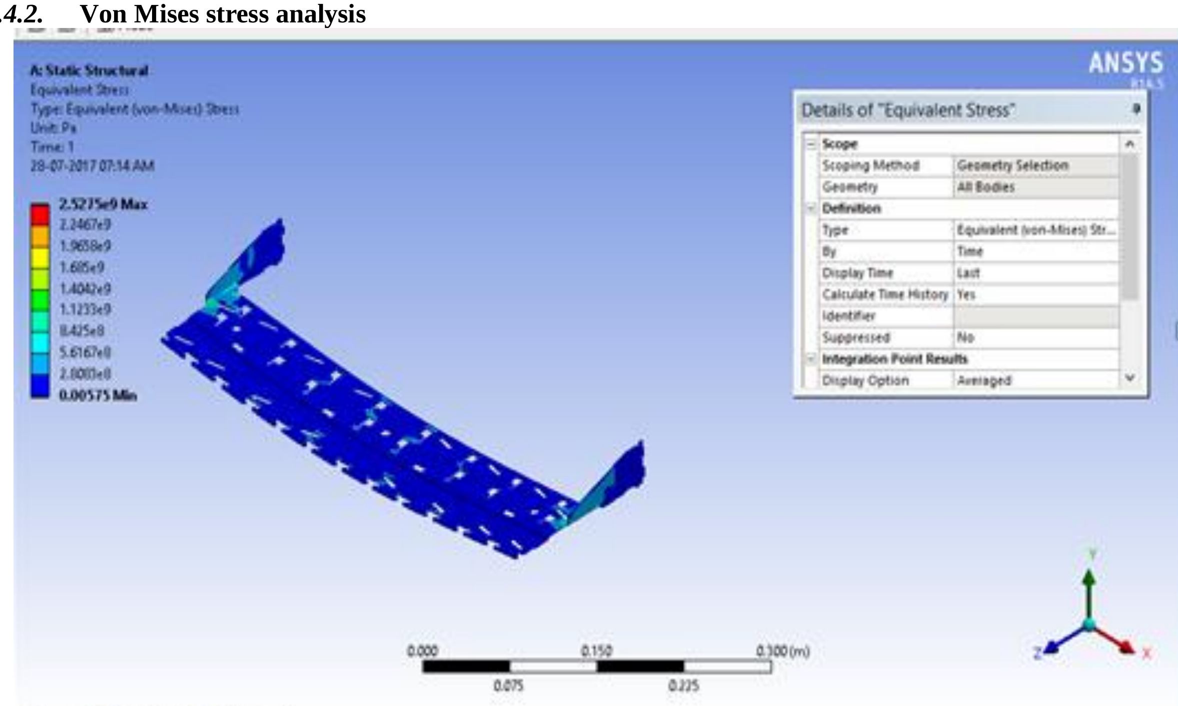


Fig.12.

Von Mises Stress analysis

4.5. Static stress analysis results for new patch panel

4.5.1. Total deformation analysis:

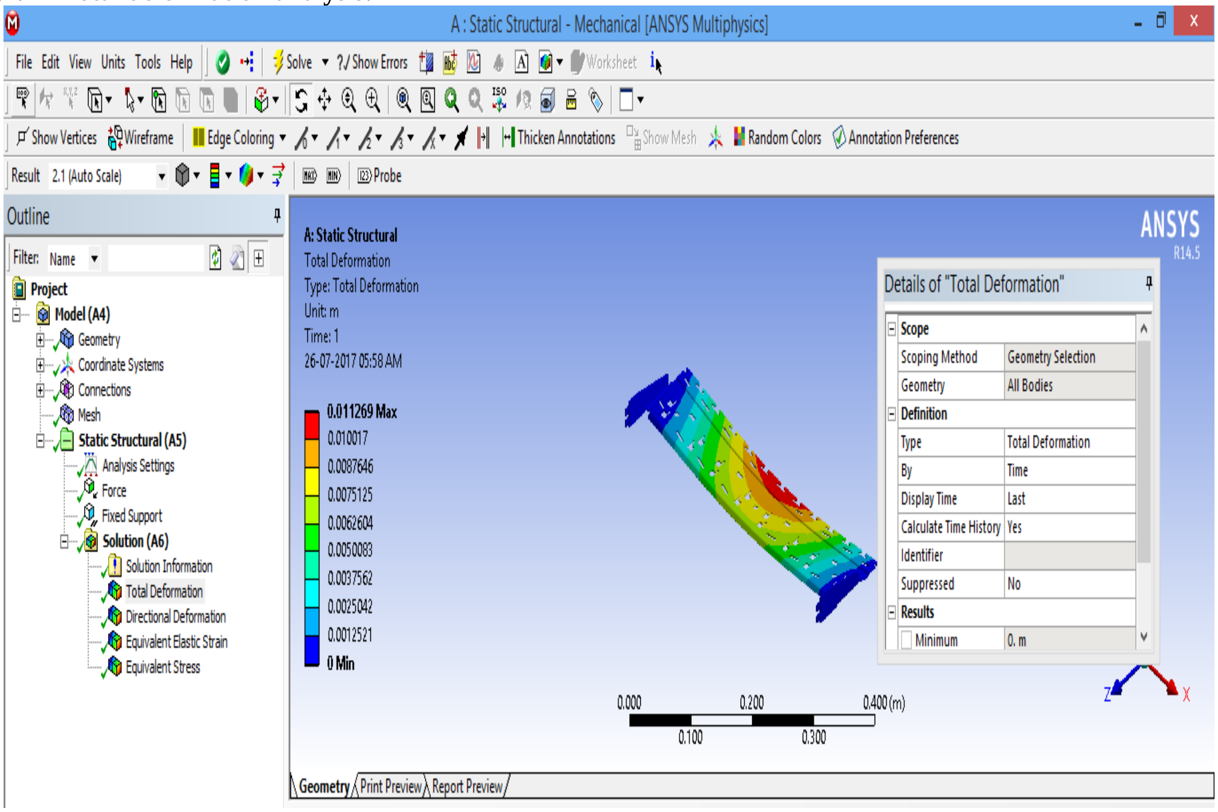
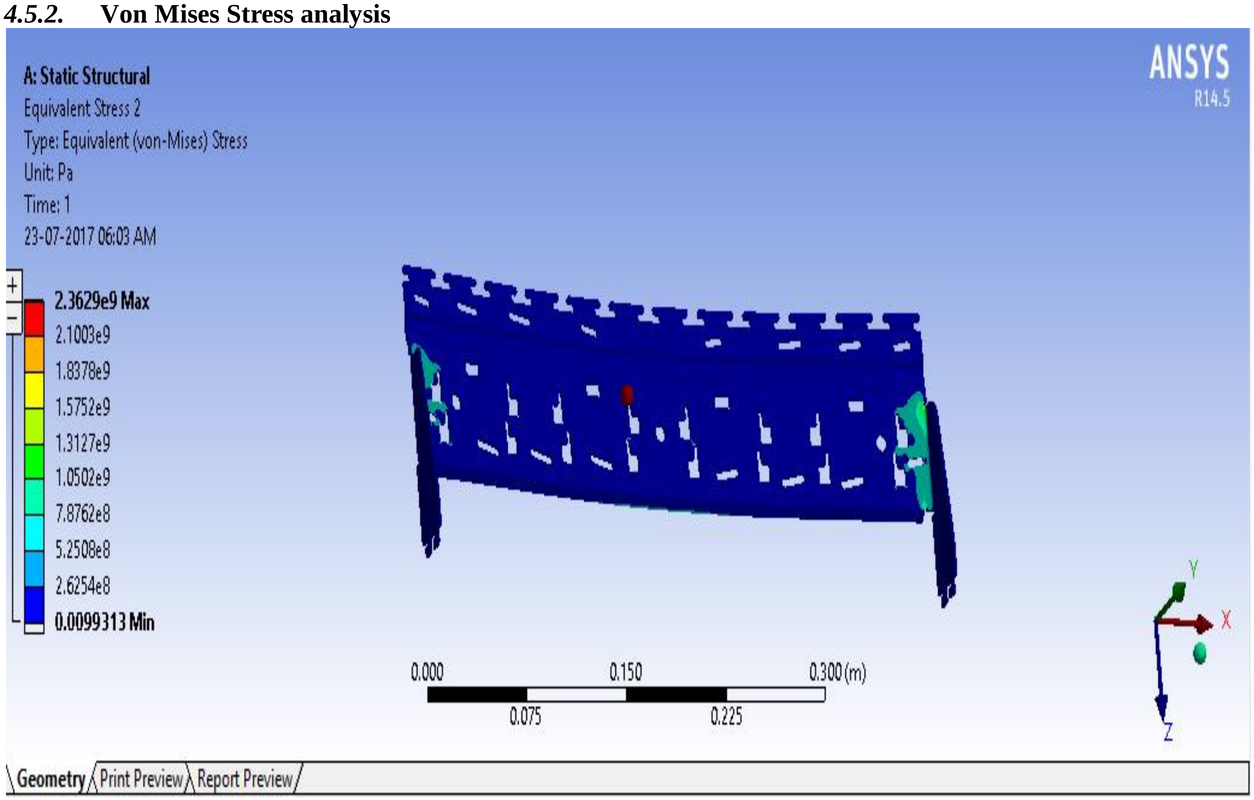


Fig.13. Total deformation analysis

4.5.2. Von Mises Stress analysis



V. RESULT AND CONCLUSION

5.1. Analysis Results:

FEA models using ANSYS is employed to calculate the total deformation and von mises stress.
Table shows the analysis results of total deformation and von mises stress analysis at a load of 500 N

TABLE I. STATIC STRUCTURAL ANALYSIS RESULTS:

	Total deformation (mm)	**Von mises analysis (Pa)**
Existing patch panel	2.252	2.5e9
New patch panel	1.126	2.35e9

5.2. Cost of existing patch panel:

Total cost = Material cost + Machining cost + Labour cost + Tool cost
Cost of sheet metal /kg = Rs.80
Labour cost/hr = Rs.50
Machining cost/hr = Rs.120
Tool cost = Rs.20000 for 10000 unit

TABLE II. COST OF EXISTING PATCH PANEL

S.NO	**Part Name**	**Material**	**Quantity in No's**	**Weight(Kg)**	**Cost(Rs)**
1	Structure	Sheet Metal	1	0.343	32
2	Front plate	Sheet Metal	4	1.85	152
3	Cable manager	Sheet Metal	1	0.9	78
4	Labels	Polyethylene	4	0.04	0.5
5	Quick Fix	Plastic	2		131
6	Cage Nuts	Stainless steel	2		1
					Total cost = 394.5

TABLE III. COST OF NEW PATCH PANEL

S.NO	**Part Name**	**Material**	**Quantity in No's**	**Weight(Kg)**	**Cost(Rs)**
1	Front panel	Sheet Metal	1	0.343	32
2	Back panel	Sheet Metal	1	0.295	30
3	Cable manager	Sheet Metal	1	0.84	72
4	Labels	Polyethylene	4		0.5
5	Cage Nuts	Stainless steel	4		2
					Total cost = 136.5

From the above tables difference of cost between the existing and new patch panel can be noted.
Percentage change in cost can be calculated as

Percentage change in cost = $\frac{Initial\ cost - final\ cost}{Initial\ cost} * 100$

Percentage change in cost= $\frac{394.5-136.5}{394.5} * 100$

Change in cost = 65%

CONCLUSION

Finite element analysis of patch panel cable manager is carried out, to predict the behavior when it is subjected to point loading under simply supported boundary conditions.

In the new design of patch panel, the plastic parts are eliminated, so there is reduction in cost of 65% by maintaining the same functional conditions.

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