California State Polytechnic University Pomona

Aerospace Engineering

ARO4080

FEMAP FEM

Documentation Report

for

Project 09

by

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20 November 2018

Table of Contents

1.0 Introduction

1.1 Purpose

The Purpose of this report is to find the axial, shear and moment loads of the frame, floor and struts of a “simple” section of a fuselage created in FEMAP. And show the results (whether its right or not).

2.0 F.E.M. Documentation

2.1 Model Definition

Model of overall FEM is displayed in Figure 2.1.1, with constraints and applied forces

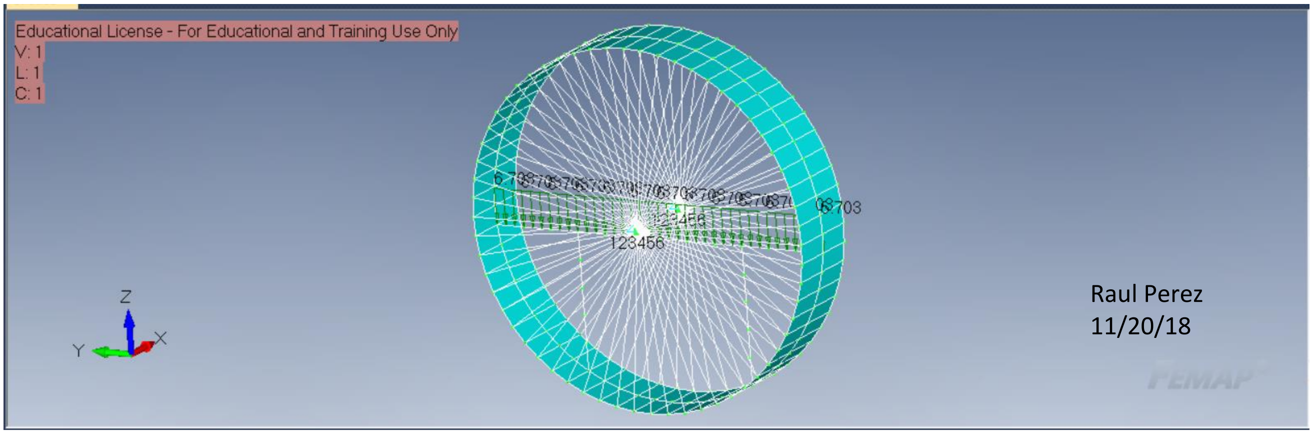

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Figure 2.1.1: FEM with Loads and Constraints

Note that constraints are applied to nodes 1,000 and 1,001 and the distrubuted load of 1,200 lb_f is applied to elements 181 to 192 as next Figures will show. (Note that nodes and elements are displayed in different Figures for the sake of clairty).

Nodes of the FEM are shown in the Figure 2.1.2 and Figure 2.1.3

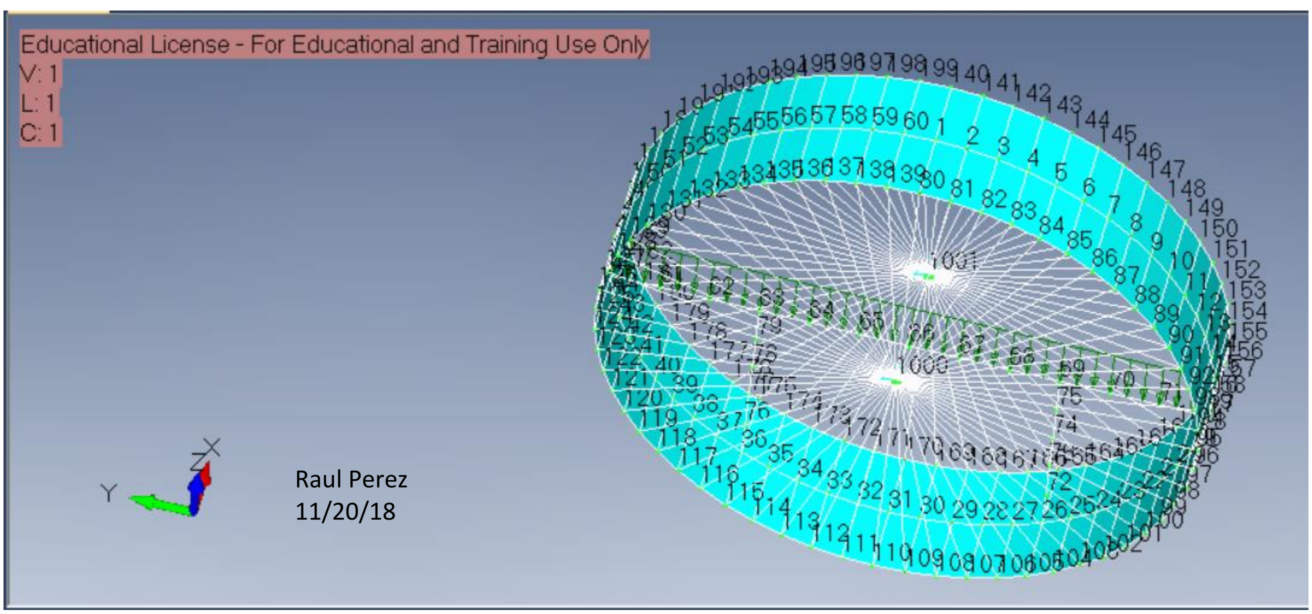


Figure 2.1.2: FEM Nodes

And the nodes that make up the floor and struts are shown in the next Figure

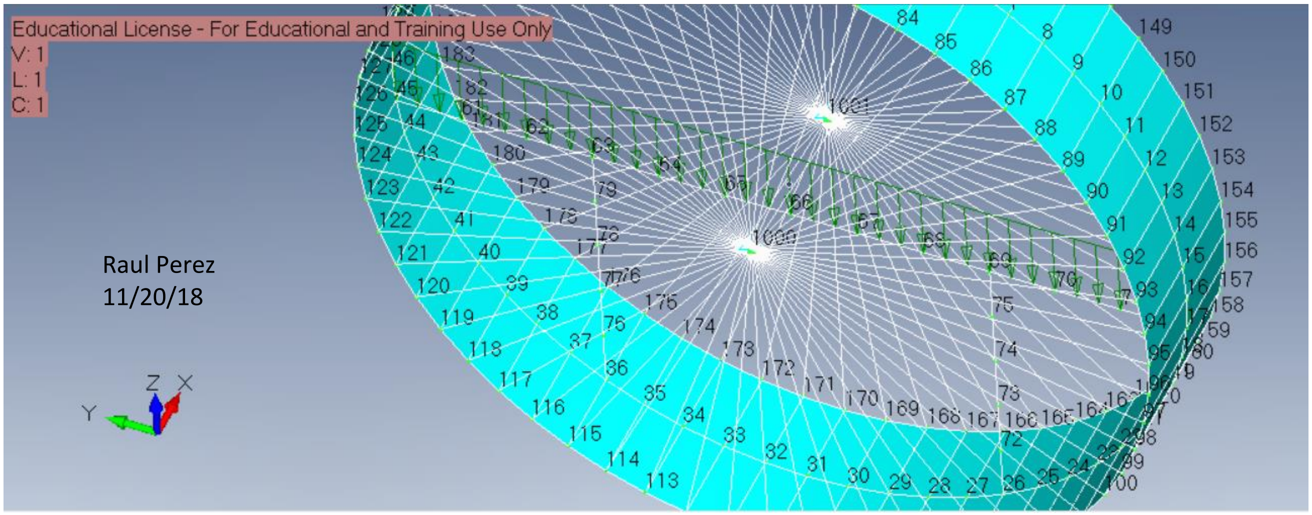


Figure 2.1.3: FEM Nodes of Floor and Struts

As you can see (hopefully) nodes 45, 61 to 71 (in sequential (seq) order) and 17 make up the floor nodes, nodes 36, 76 to 79 (in seq order) and 63 make up the right strut nodes. Nodes 26, 72 to 75 (in seq order) and 69 make up the nodes for the left strut.

Elements numbers are shown in the next two Figures

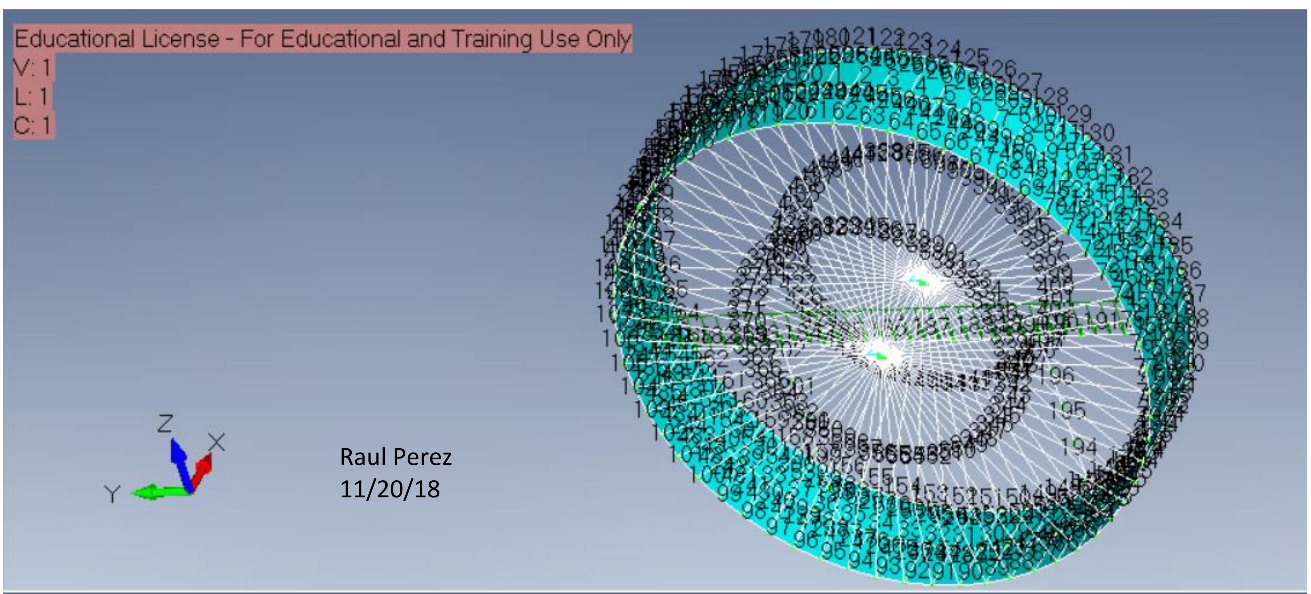


Figure 2.1.4: FEM Elements

As you can see, there are a lot of elements, 562 in total, so there no real eleigant way to display them all. But the elements making up the floor and struts are shown in the next Figure

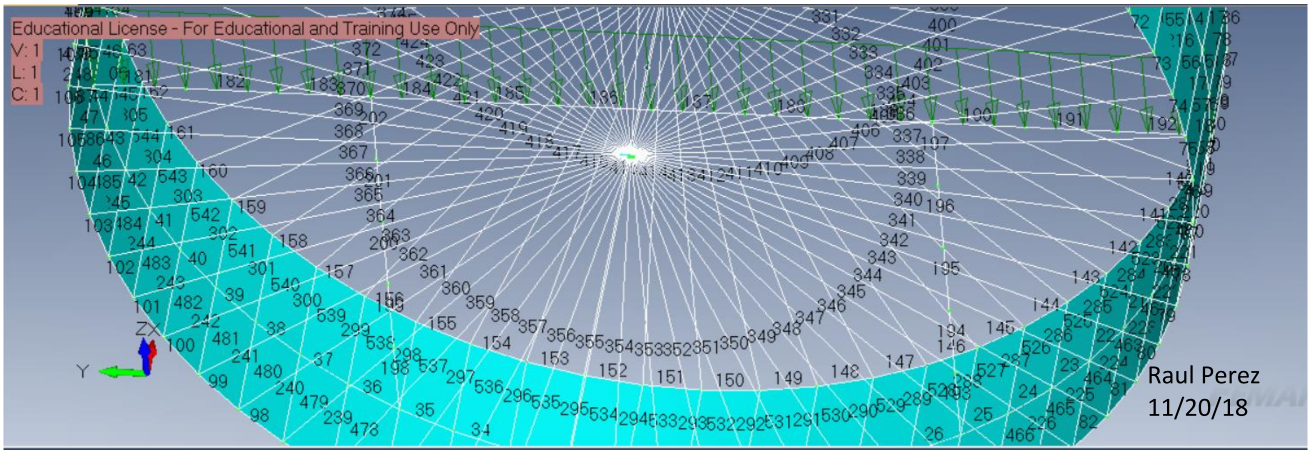


Figure 2.1.5: FEM Elements of the Floor and Struts

As you can see more clearly (hopefully), elements 181 to 192 (in seq order) make up the floor elements. The left struts elements are 193 to 197 and the rigth strut elements are 198 to 202.

2.2 Bulk Data File

Normally the Bulk Data form past project has been around 50 to 70 lines, this one has 837 lines, so for the sake of keeping this as small as possible, I won't include the bulk data file.

(Bulk data extracted from the .dat file if needed)

2.3 Material Properties

In this FEMAP file, only one Material card exist, with Elastic Modulus of 10 Msi, Modulus of Rigidity of 3.8 Msi and Poisson's ratio of 0.33 and density of 0.0975737 lbf/in^3. MAT1 card is shown below

```
MAT1 1 1.+7 3800000. .33   .0975437 0.0.
```

Properties on the other hand vary, Starting with the Frame property represented as CBAR (PBAR according to FEMAP), with characteristics of; A = 0.5in^2, I_1= 5.0 in^4, I_2 = 0.5 in^4, J = 0.05 in^4 , thus PBAR card is

```
PBAR           1       1      .5      5.      .5      0.     .05      0.
```

Next the Stringers are represented as rods, with the properties of; A = 0.3 in^2 and J = 0.03 in^4 thus the CROD (PROD) card generated is

```
PROD           2       1      .3     .03      0.      0.
```

Property number 3, property of the fuselage skin represented as CHSHEAR element (PSHEAR element in FEMAP) with the following characteristics; thickness of 0.05 in and F = 0, thus

```
PSHEAR         3       1     .05      0.      0.      0.
```

Next, property number 4, the vertical struts represented as a bar, with the characteristics of; A = 0.4in^2, I_1= 4.0 in^4, I_2 = 0.4 in^4, J = 0.04 in^4 , thus PBAR card is

```
PBAR           4       1      .4      4.      .4     .04      0.
```

Next, property number 5, floor property represented by a bar with characteristics of; A = 0.6 in^2, I_1 = 6.0 in^4, I_2 = 0.006 in^4, J = 0.06 in^4. Thus, the PBAR card generated is

```
PBAR           5       1      .6      6.    .006     .06      0.
```

Lastly, property number 6, wagon wheel property represented by a bar with the following characteristics; A = 0.002 in^2, I_1 = 200,000 in^4, I_2 = 20 in^4, J = 0.2 in^4. Thus, the PBAR card generated is

```
PBAR           6       1    .002 200000.     20.      .2      0.
```

2.4 Applied Loads

Applied loads like almost all elements in FEMAP are inputted graphically, but FEMAP stores elements, constraints, loads, etc. in the .dat file with the same name as the FEMAP model.

The Distributive load of 1,200 lb_f over the length (179 in) of the entire floor is applied to all floor elements as shown by the PLOAD1 cards

```
PLOAD1    1    181    FZ    FR    0.  -6.703    1.  -6.703
PLOAD1    1    182    FZ    FR    0.  -6.703    1.  -6.703
PLOAD1    1    183    FZ    FR    0.  -6.703    1.  -6.703
PLOAD1    1    184    FZ    FR    0.  -6.703    1.  -6.703
PLOAD1    1    185    FZ    FR    0.  -6.703    1.  -6.703
PLOAD1    1    186    FZ    FR    0.  -6.703    1.  -6.703
PLOAD1    1    187    FZ    FR    0.  -6.703    1.  -6.703
PLOAD1    1    188    FZ    FR    0.  -6.703    1.  -6.703
PLOAD1    1    189    FZ    FR    0.  -6.703    1.  -6.703
PLOAD1    1    190    FZ    FR    0.  -6.703    1.  -6.703
PLOAD1    1    191    FZ    FR    0.  -6.703    1.  -6.703
PLOAD1    1    192    FZ    FR    0.  -6.703    1.  -6.703
```

(Note; 1200 lb_f /179in = 6.703 lb_f/in downward, thus a negative sign is used)

(Just like I said below Figure 2.1.5 elements 181 to 192 make up the floor)

2.5 Constraints

Constraints shown in Figure 2.1.1, with only node 1000 and1001 being fixed, the constraint inputted into FEMAP, and the SPC card generated is shown below, extracted from the .dat file

```
SPC1  1  123456    1000
SPC1  1  123456    1001
```

3.0 FEM Results

3.1 Nodal Displacements

Displacements of the entire model is shown in the four Figures below

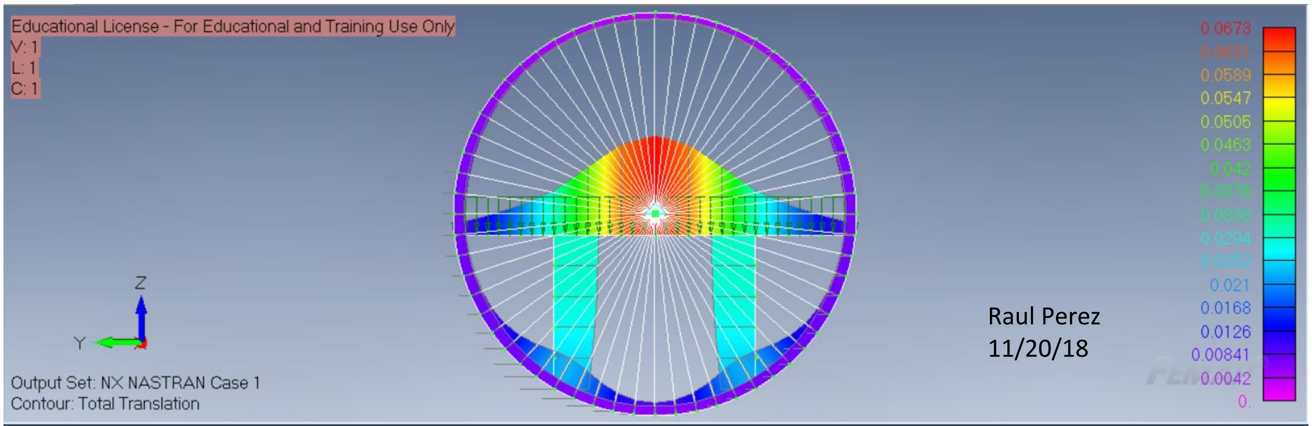


Figure 3.1.1: FEM Transational Displacement Front View

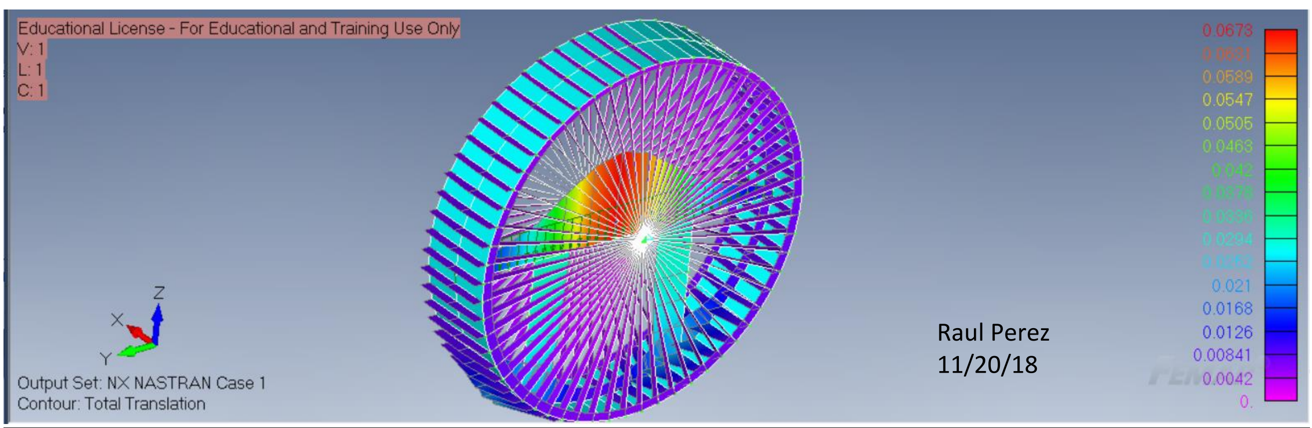


Figure 3.1.2: FEM Transational Displacement Top Right Side View

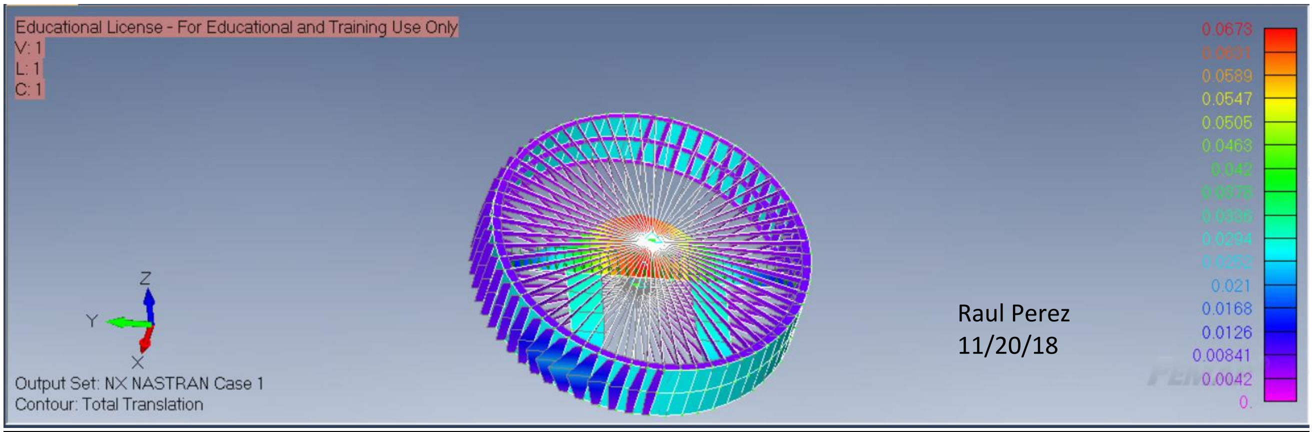


Figure 3.1.3: FEM Transational Displacement Bottom Right Side View

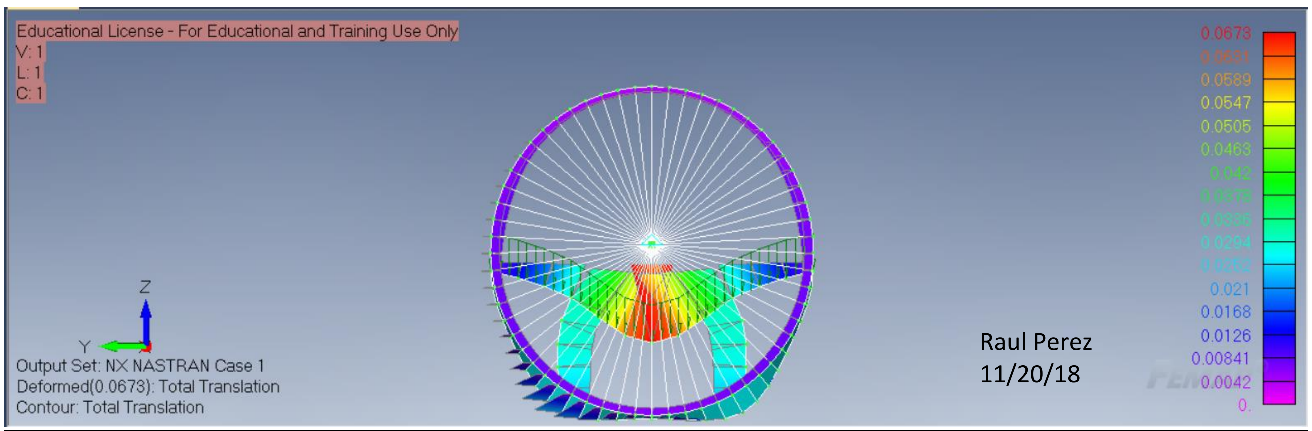


Figure 3.1.4: FEM Transational Displacement with Defromed View

3.2 SPC Forces

SPC (Constraint) Forces are shown below from the .dat file,

F O R C E S   O F   S I N G L E - P O I N T   C O N S T R A I N T

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
1000	G	8.974089E-03	9.835422E-05	5.999656E+02	-1.027259E-02	-5.892161E+03	6.896540E-01
1001	G	-8.974089E-03	-9.835423E-05	5.999648E+02	1.027259E-02	5.892146E+03	-6.857198E-01

1 ANALYSIS NOVEMBER 19, 2018 NX NASTRAN 5/23/18
PAGE 18

3.3 Axial Load Diagram

Reaction axial load diagram is shown in the following two Figures

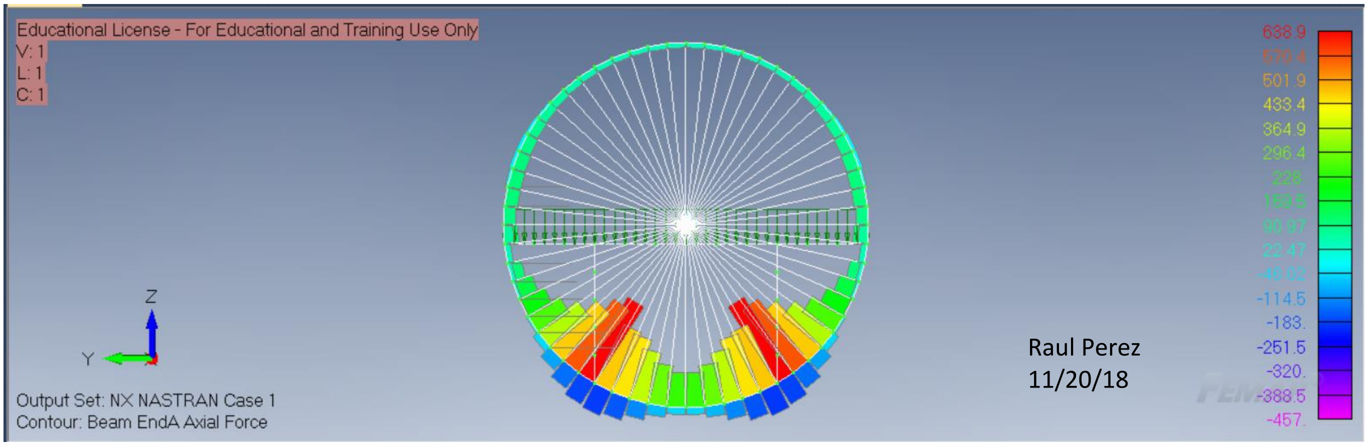


Figure 3.3.1: Reaction Axial Diagram from the Front View

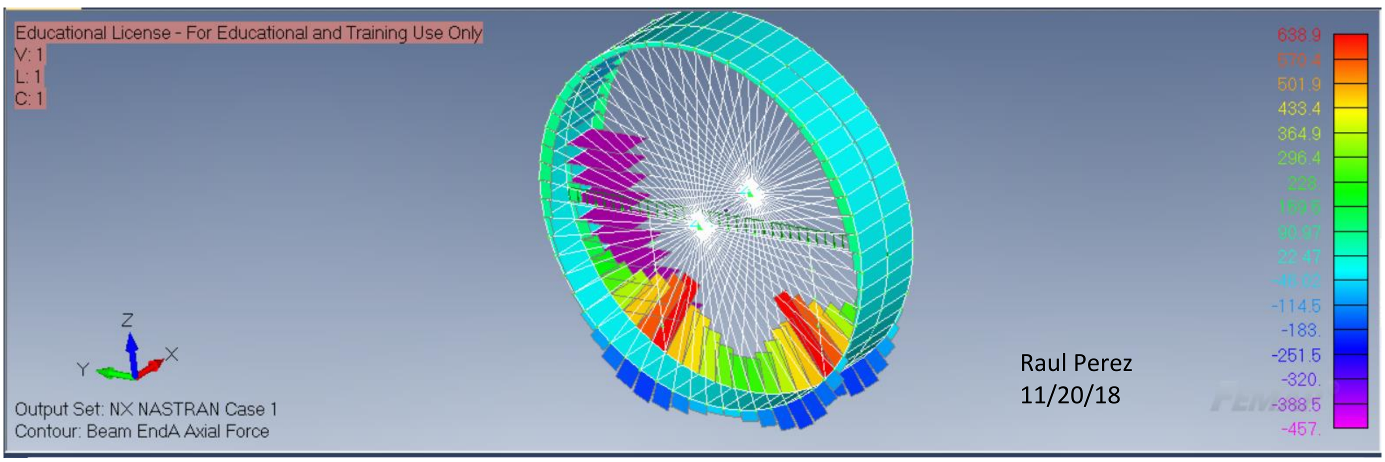


Figure 3.3.2: Reaction Axial Diagram from the Top Left View

3.4 Shear Load Diagram

Reaction Shear load diagram is shown in the following two Figures

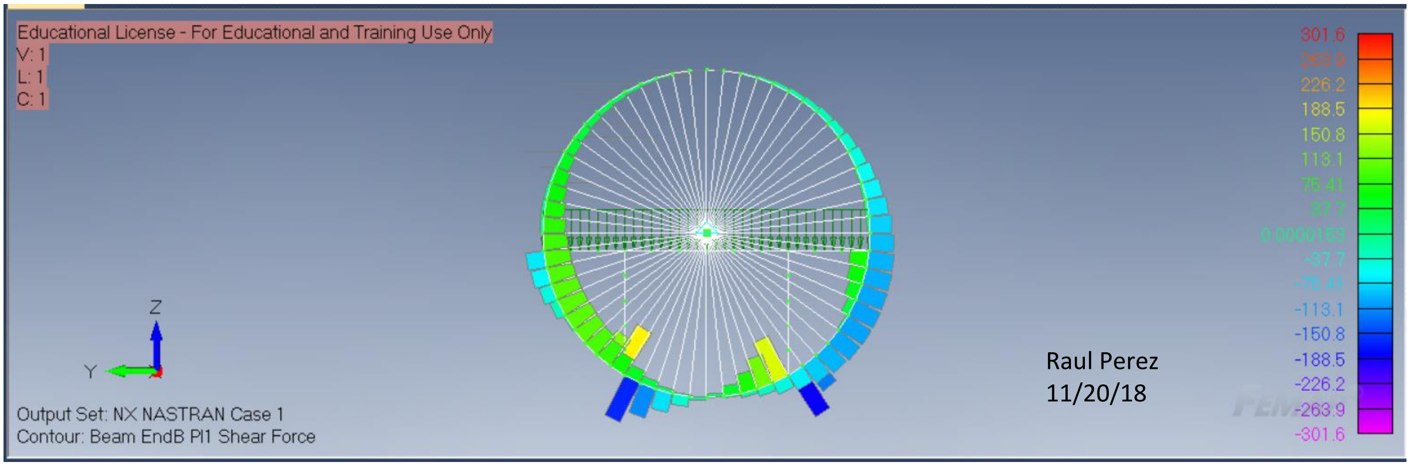


Figure 3.4.1: Reaction Shear Diagram from the Front View

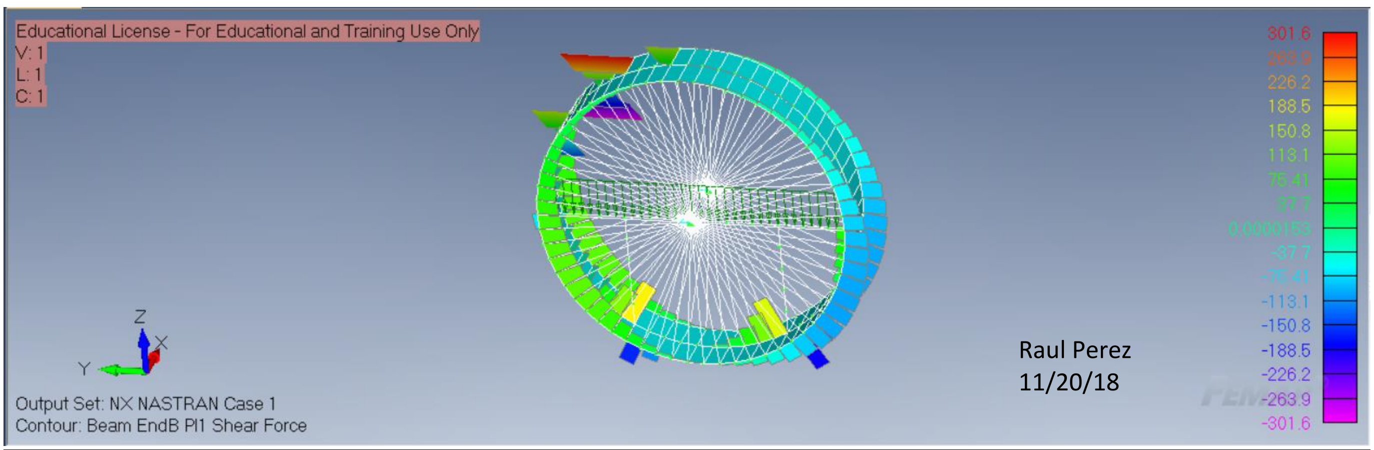


Figure 3.4.2: Reaction Shear Diagram from the Top Left View

3.5 Moment Diagram

Reaction Moment diagram is shown in the following three Figures

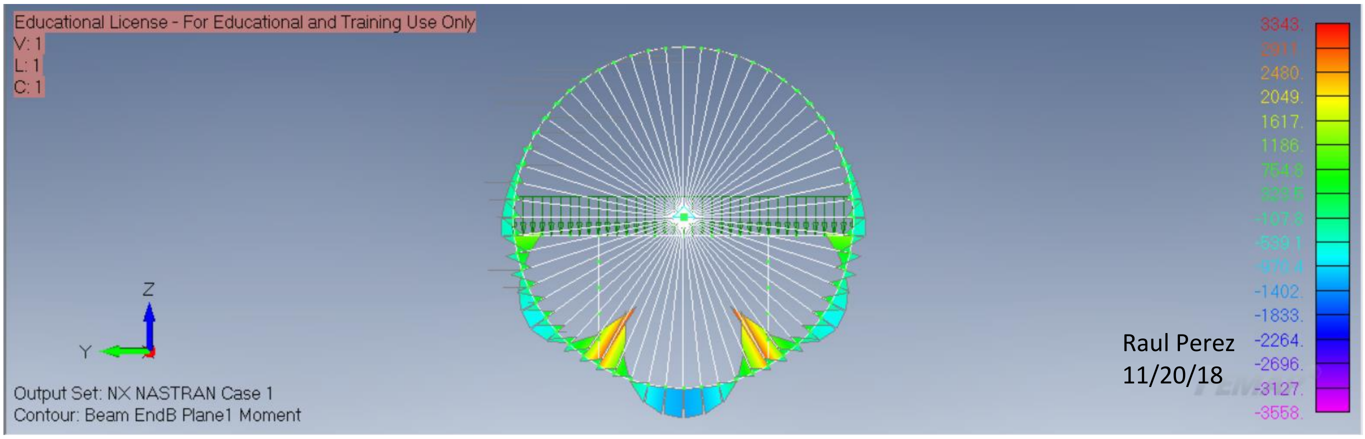


Figure 3.5.1: Reaction Moment Diagram from the Front View

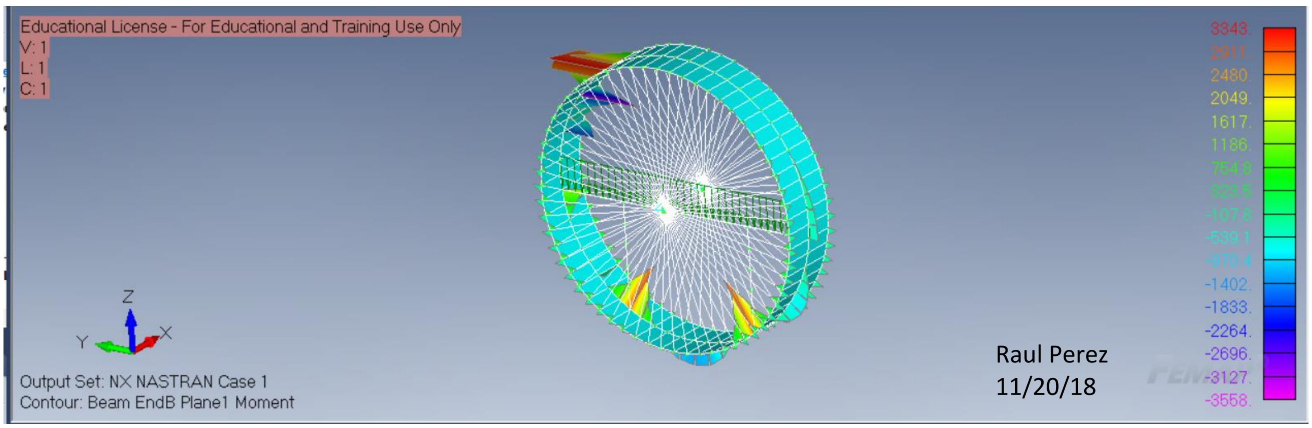


Figure 3.5.2: Reaction Moment Diagram from the Top Left View

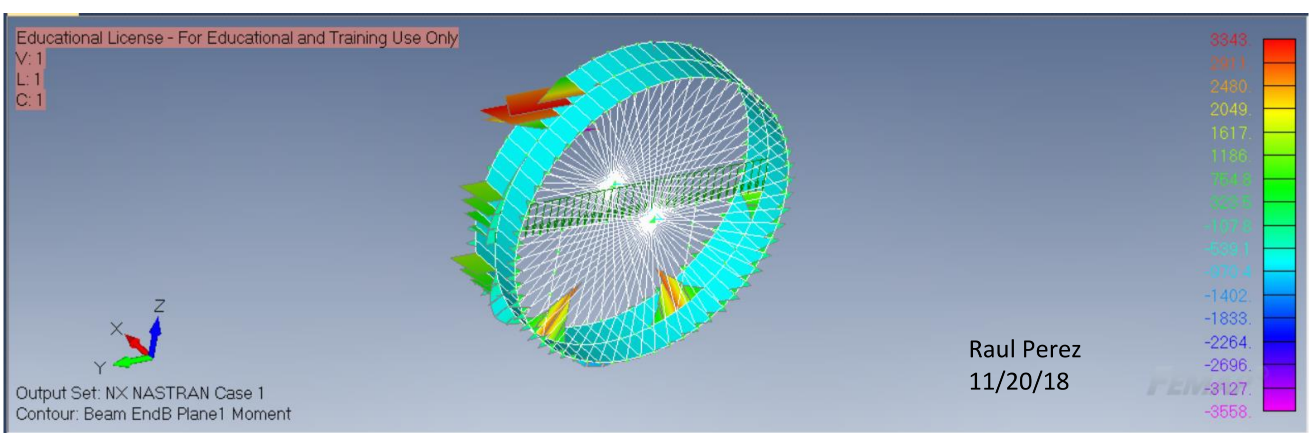


Figure 3.5.3: Reaction Moment Diagram from the Top Right View

4.0 Evaluation

4.1 What was Learned from the Project

What I've learned from this project, well I learned how to copy a selection of elements and be able to move them to a selected location, thus saving me time. I learned to how to get the "bars" to display on the load diagrams by selecting the beam diagram option in view select. Learned how to use distributive loads as well in FEMAP. That's about it, for the new techniques I learned in FEMAP while building this project.

4.2 Assessment of the Difficulty of the Project

This project is not difficult, but it is long, took me 1 and ½ hour to rebuild the model once I realize that all the CBEAM elements were supposed to be CBAR elements. Over all I give it a 5/10 in terms of difficulty and 10/10 in terms of length, unless your Jordan, he manage to build it in minutes but I didn't want to risk something going wrong.

4.3 Usefulness of the Project

How useful this project is, well I say it useful to model to a part of an aircraft, but without a way we know if were right or wrong, it just more of just modeling practice than analysis practice.

Speaking of which I should mention this here; originally, I accidentally used CBEAMs rather than CBARS in my first model, but the thing is the diagrams on with the CBEAMs look more "right". Here are some Figures

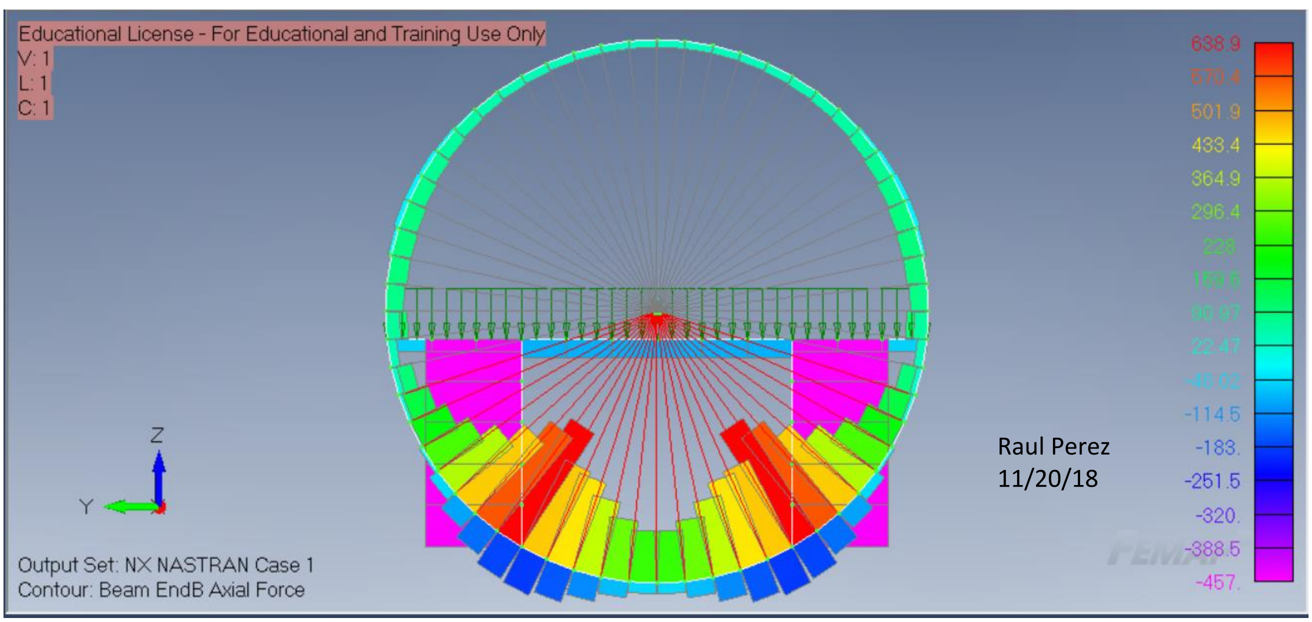


Figure 4.3.1: Reaction Axial Load Diagram from the Front View using CBEAMs

As you can see theres is load on the verical struts and on the floor. Other than that it looks just like the Axial Diagram using CBARS (Figure 3.2.1), it even has the same max and min loads.

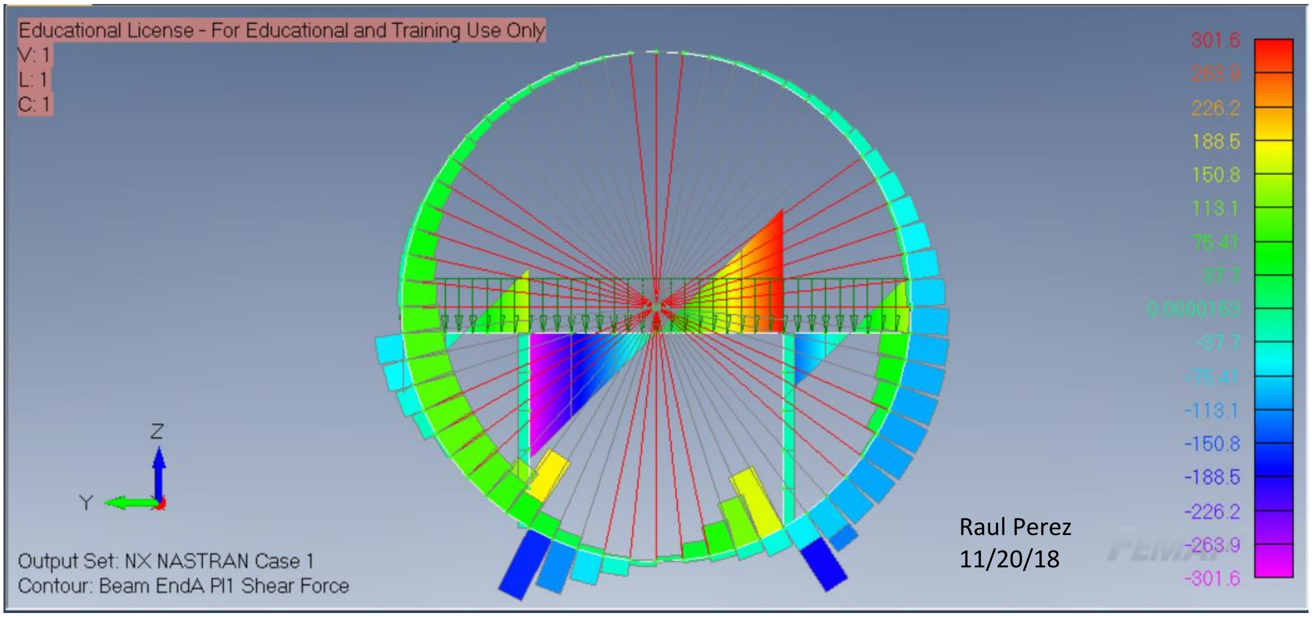


Figure 4.3.2: Reaction Shear Load Diagram from the Front View using CBEAMs

Now this was the one that convince me that something was off, Again there is a load on the vertical struts and on the floor and the shape of the shear load on the floor makes sense since theres a distributive load. Other than that, except for the “spikes” at the top right on Figure 3.4.2, the shear diagrams look the same.

And finally, the moment diagram

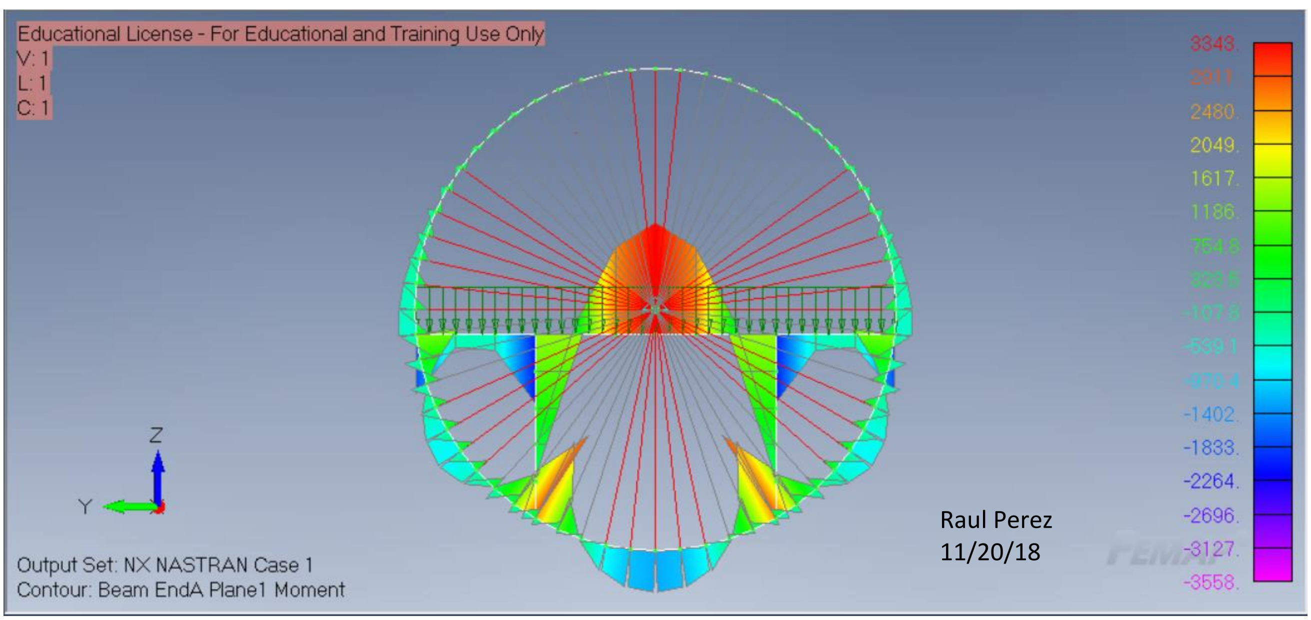


Figure 4.3.3: Reaction Moment Diagram from the Front View using CBEAMs

Well it looks like Figure 3.5.1 except theres a moment load at the center of the floor and theres a moment on the wagon wheel bars

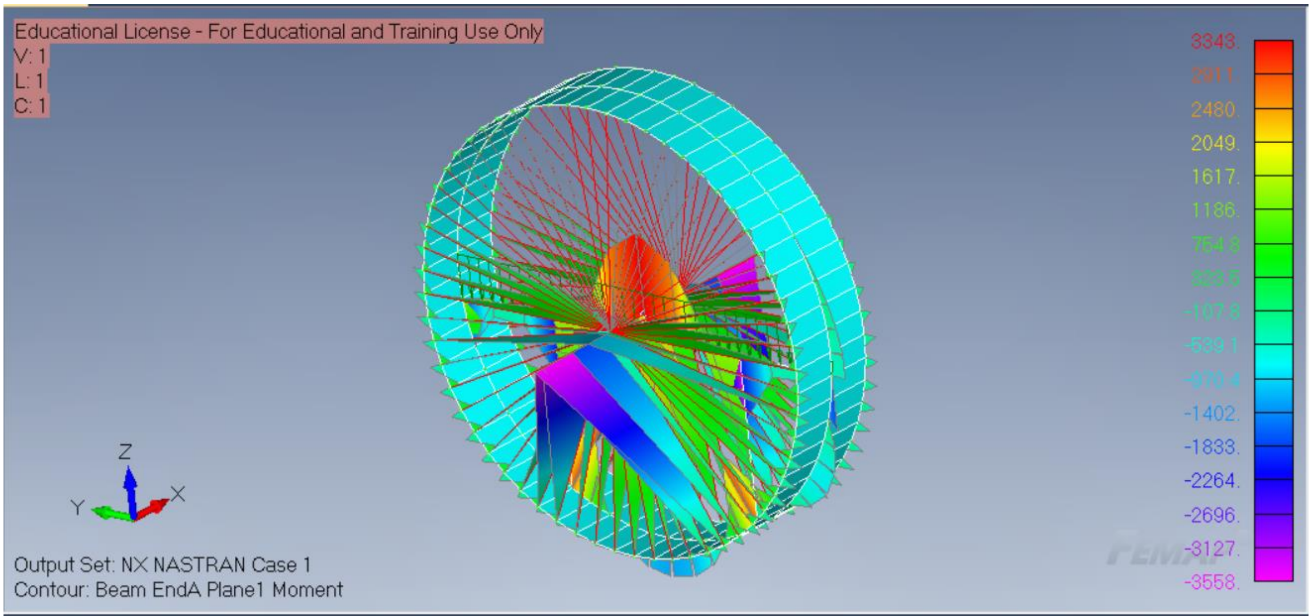


Figure 4.3.4: Reaction Moment Diagram from the Top Left View using CBEAMs

But the funny thing is the displacements and reactions forces are the same, so I don’t what to believe, In my opinion the model using CBEAM is more accurate.

4.4 Effectiveness of FEMAP

Well FEMAP if you know what your doing, is a really effective tool that can get more results and faster than just by hand analysis, if you know what your looking at.

A FEM Lumping, Property & Material Hand Calculations

ARO 4080 HW#13 11/6/18 Raul Perez

20/20

1) Given

Project 9

Fuselage diameter = 130 in, r = 90 in

stringers occur at every 6° increment CCW

Floor is located at the 1st stringer below the centerline

Vertical structs located at y = ±45 in

CBAR between stringers

vertical strut modeled using CBAR, using 5 evenly spaced

Floor modeled using 12 evenly spaced CBAR

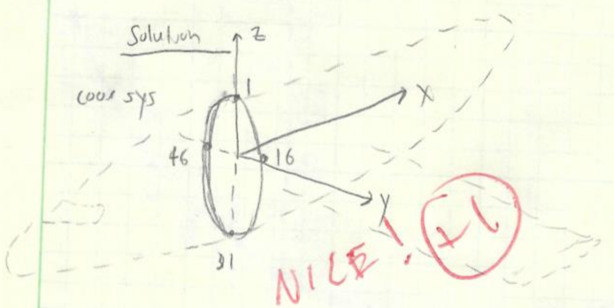
1200 lbf load evenly distributed across the floor

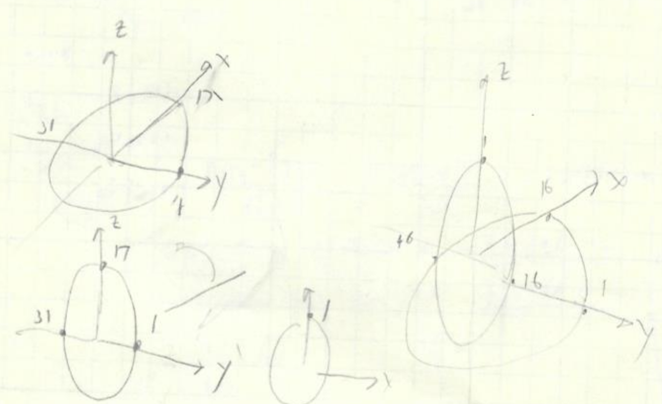
Find

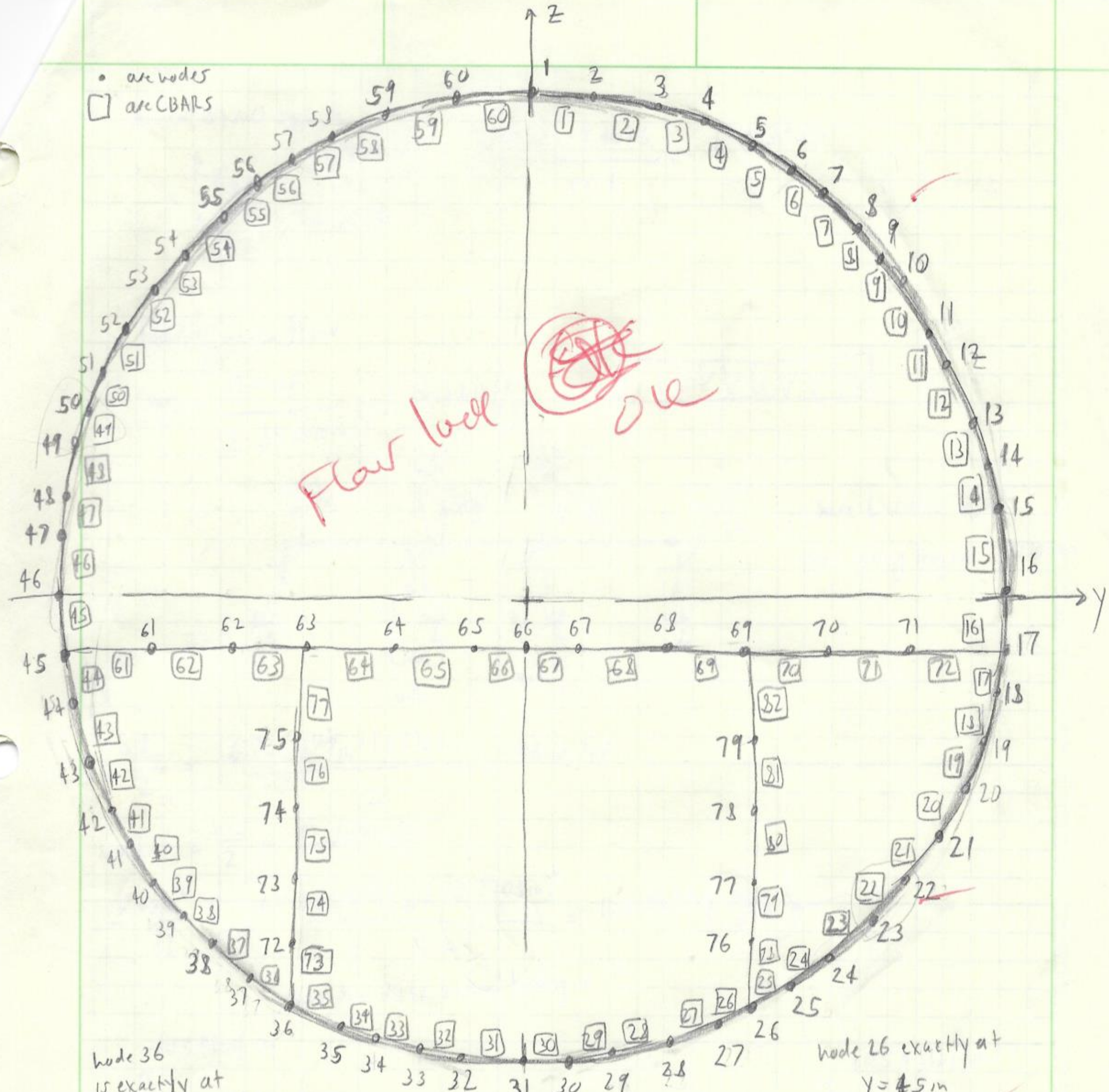
Draw a view of the frame of the Fuselage with all nodes & CBAR Ids

Solution

coor sys







node 36 is exactly at $y = -45$ in

node 26 exactly at $y = 45$ in

floor

$R_{y_{45}} = -85.507$ in

$R_{y_{17}} = 89.507$ in

spacing at floor $= \dfrac{R_{y_{17}} - R_{y_{45}}}{12+1} = \dfrac{2 \cdot 89.5070}{13}$ in $= 13.7703$ in

$-89.5070\text{ in} + 13.7703\text{ in} \cdot 3 = \underline{-48.1961\text{ in}}$

$-89.5070\text{ in} + 13.7703\text{ in} \cdot 10 = \underline{48.196\text{ in}}$

ok so heres a problem with 12 equally space CBAR representing the floor & having 2 vertical struts at $y = \pm 45$ in, shouldn't the floor be at the center

(+1)

$\underline{52}$ 144

$\underline{59}$ —

vertical strut spacing

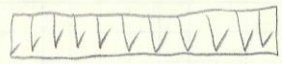
$R_{Z_{26}} = -77.9423 \text{ in}$

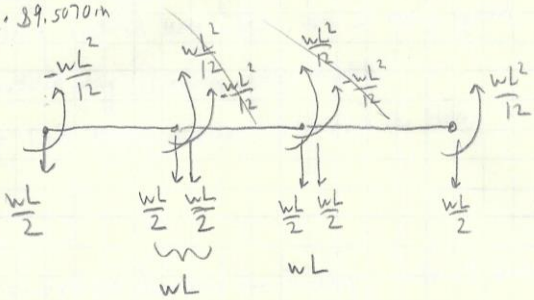
$R_{Z_{17}} = -9.4076$

$$\frac{77.9423-9.4076}{5+1} = 11.42245 \text{ in}$$

loading on the floor

$$w_0 = \frac{1200 \text{ lbf}}{2 \cdot 89.5070 \text{ in}} = 6.70338 \text{ lbf/in}$$





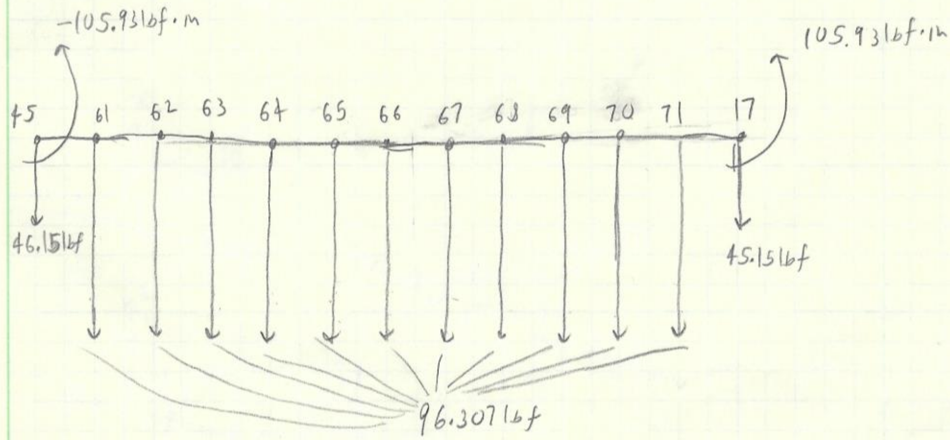
, where L is the equal floor spacing length 13.7703in

$$\frac{wL}{2} = \frac{6.70338 \text{ lbf/in} \cdot 13.7703 \text{ in}}{2} = 46.153 \text{ lbf}$$

$$wL = 2 \cdot \frac{wL}{2} = 92.307 \text{ lbf}$$

$$\pm \frac{wL^2}{12} = \frac{6.70338 \text{ lbf/in} \, (13.7703 \text{ in})^2}{12} = 105.925 \text{ lbf} \cdot \text{in}$$

thus the distributive loading is



B Hand Analysis Support

Not needed

References

[DLe5] Daryl Logan. A First Course in the Finite Element Method. 5th Edition. Cengage Learning. 2012.