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contents

01 주제 및 팀명 선정 배경

주제 선정 배경

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팀명 선정 배경

안녕, 평창 (HY-PyeongChang)

Project 목표

안전한 무대 및 lifter 만들기

- 2개의 critical point(A점, E점)

Point A. mesh의 정확성을 높여가며 analytic solution과의 수렴 여부 판단

Point E. 가수들의 x축 위치 변화에 따른 응력 계산

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02 Design & MATLAB Calculate

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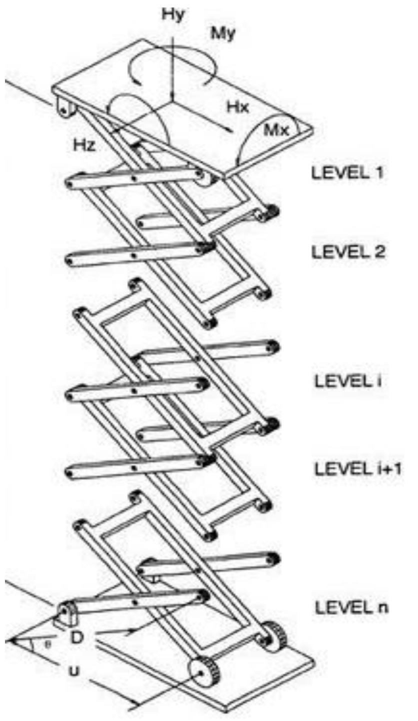
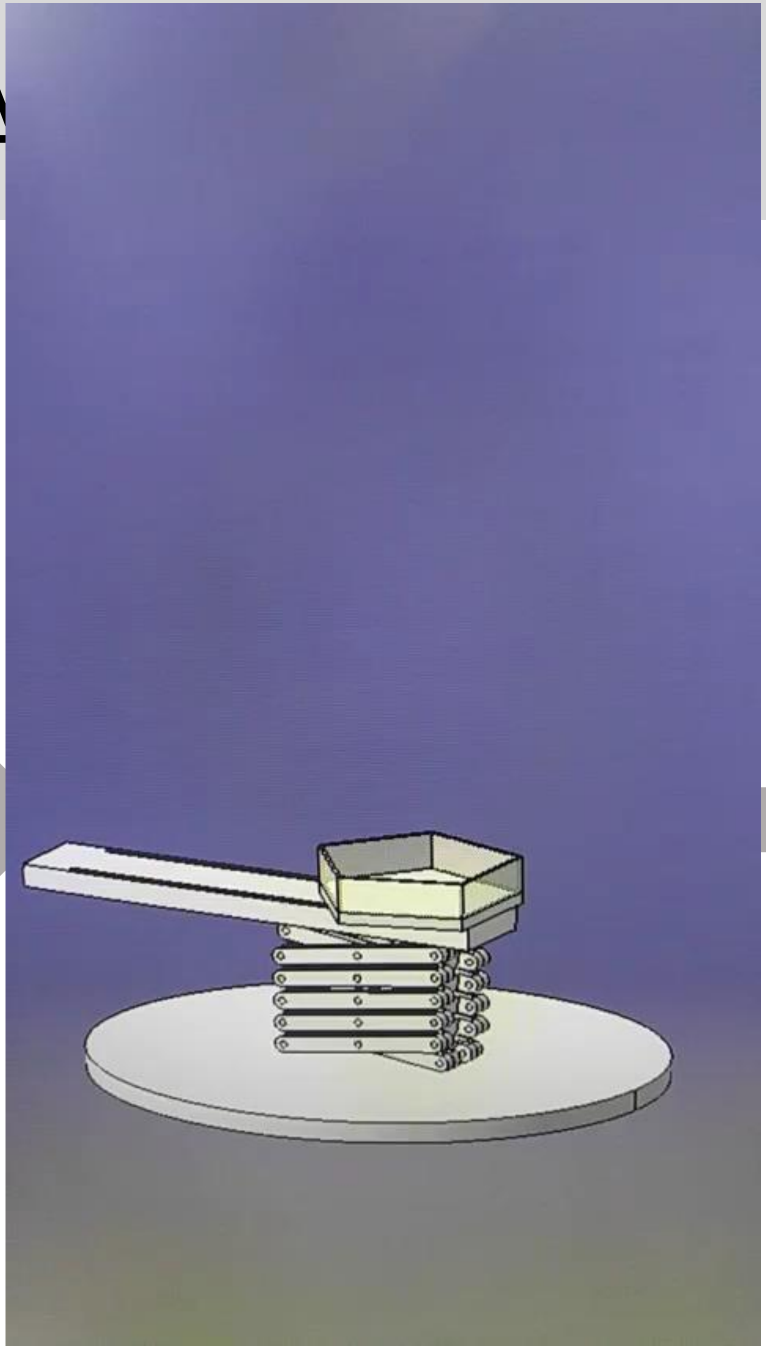
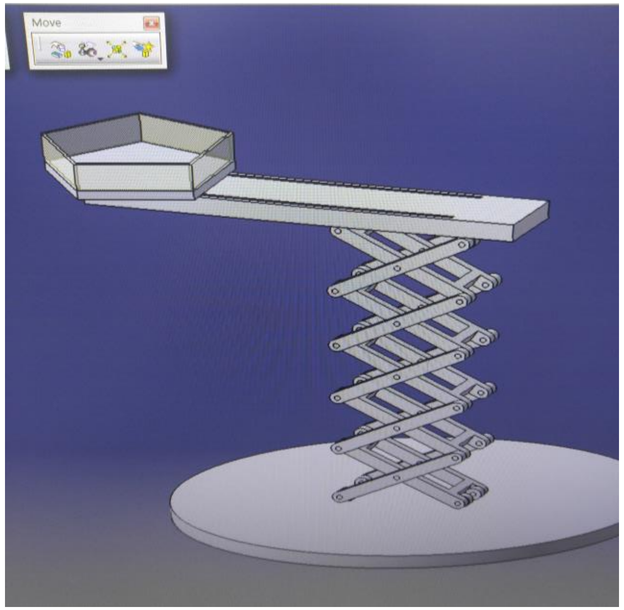
Design & MATLA

1. 리프트 초기 모델링



CONCEPT





PRODUCT

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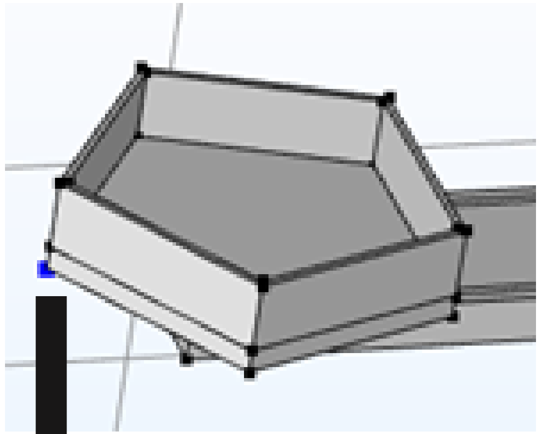
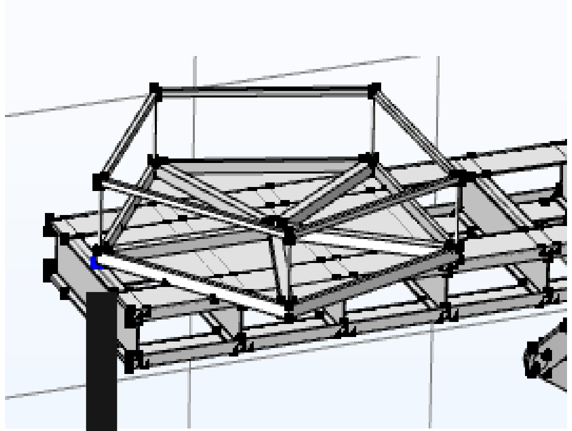
2. 초기 모델의 문제점



Total dis(m)=0.62954

경량화 모델



Total dis(m)=0.26145

무대 끝의 displacement(0.6m) 값이 커
무대 안정도에 영향을 줄 수 있다.

Displacement의 값(0.26m)이
감소했음을 확인할 수 있다.

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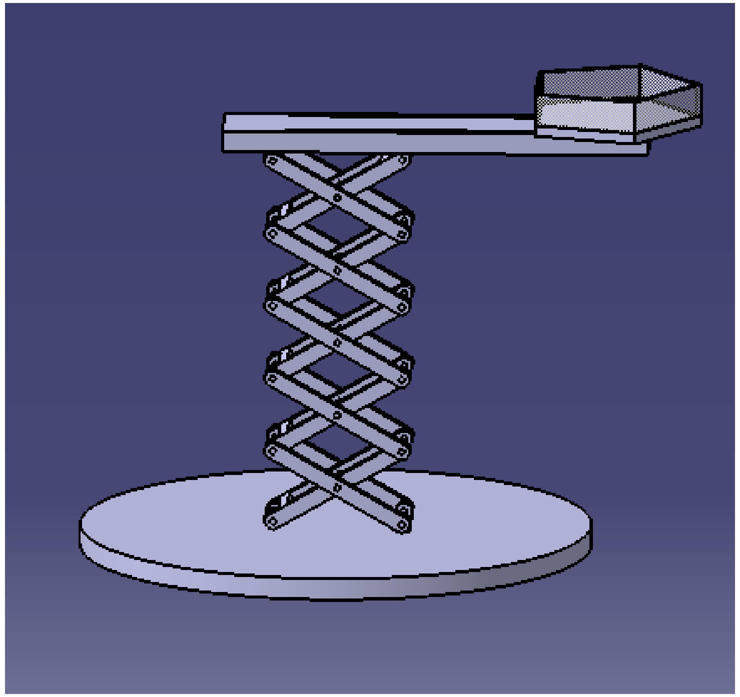
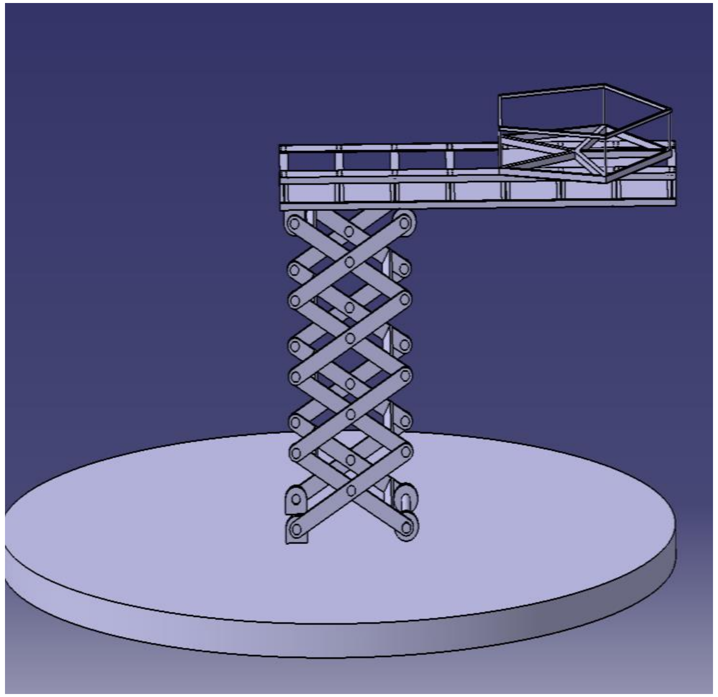
3. CATIA 모델의 변경



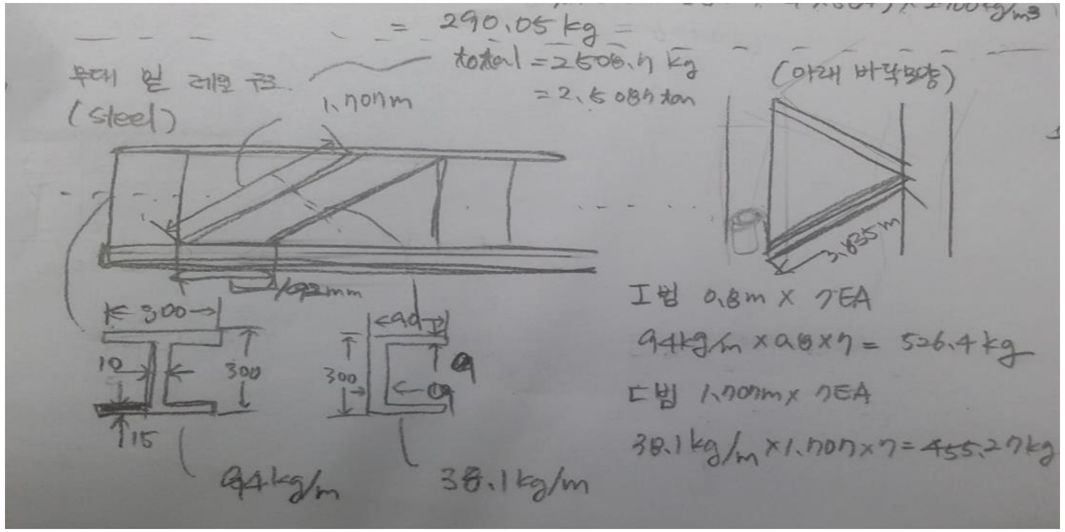
무대와 갑판의 경량화

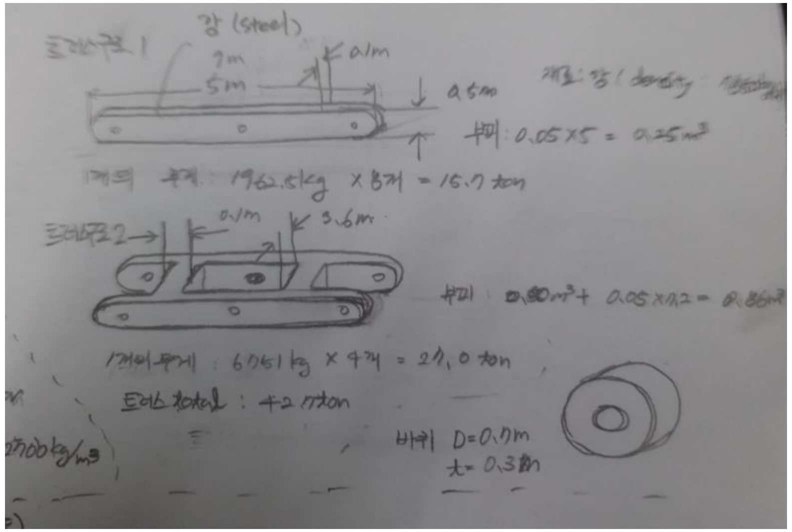
리프트 구조의 경량화

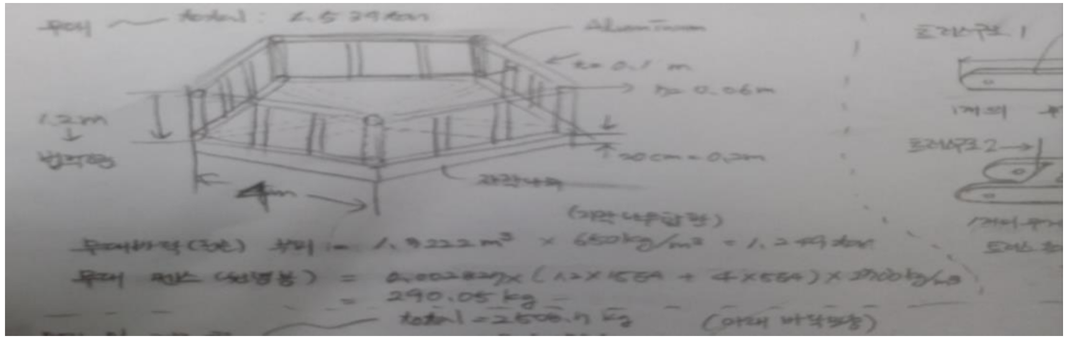


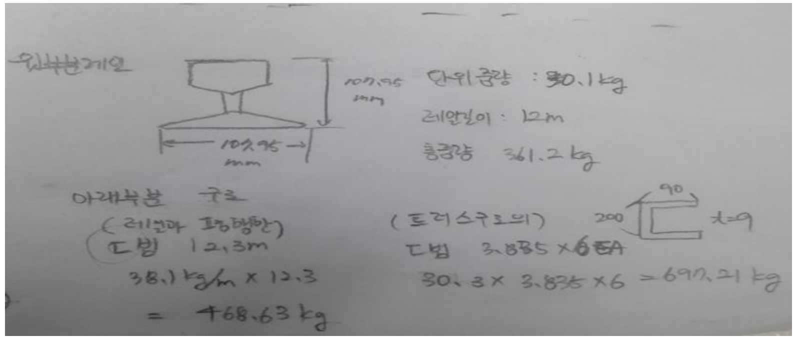
Design & MATLAB Caculate

4. 각 부분의 수치와 재질, 밀도의 선정





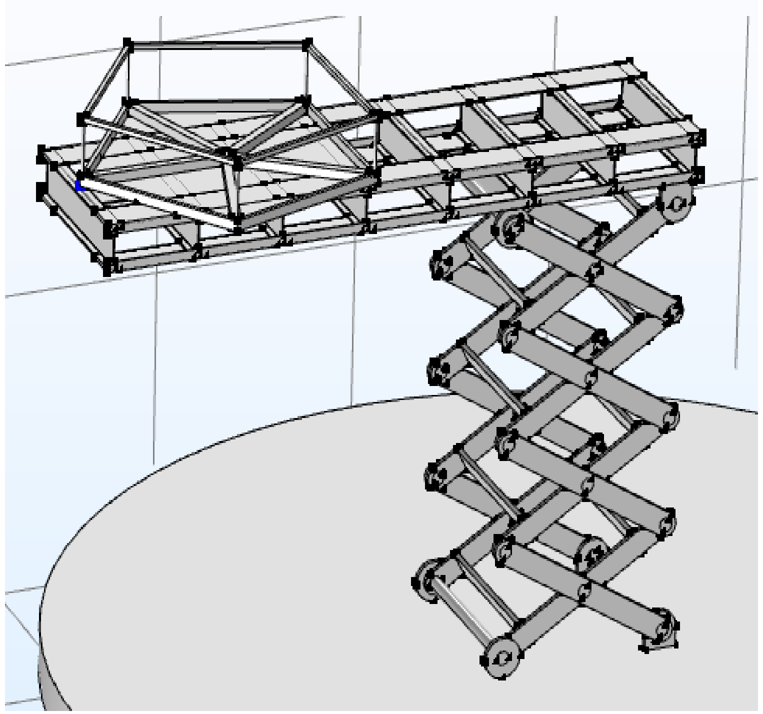




AISI 4340
밀도 : 7850kg/m^3

Design & MATLAB Caculate

5. MATLAB을 통한 parameter 지정



```
g= 9.81;
sy1 = 580*10^6 ; %    AISI1050CD     %
sy2 = 807*10^6 ; %    AISI1050QNT    %
sy3 = 1590*10^6 ;%    AISI4340QNT    %
dp = 0.31; % 핀의 지름%
ds = 0.3; %샤프트의 지름%
hb = 0.5; %바의 폭%
ht = 0.1; %바의 두께%
hl = 5;%바의 길이%
l1 = 9.7;
l2 = 4.3;%리프트의 폭%
l = l1+l2;
ls = 6.155;%무대 폭%
fp = 600*g;%사람 및 무대장치의 무게%
fs = 1539*g;%무대의 무게%
f1 = 1738.17*g;%l1 만큼의 철골 구조 무게%
f2 = 770.53*g;%l2 만큼의 철골 구조 무게%
fl = f1+f2;%철골 전체의 무게%
wt = hb*ht*hl*7850*g; %바 하나의 무게%
x = 1%무대 중심에서 부터의 거리%
lt= 4% 무대의 한 변%
```

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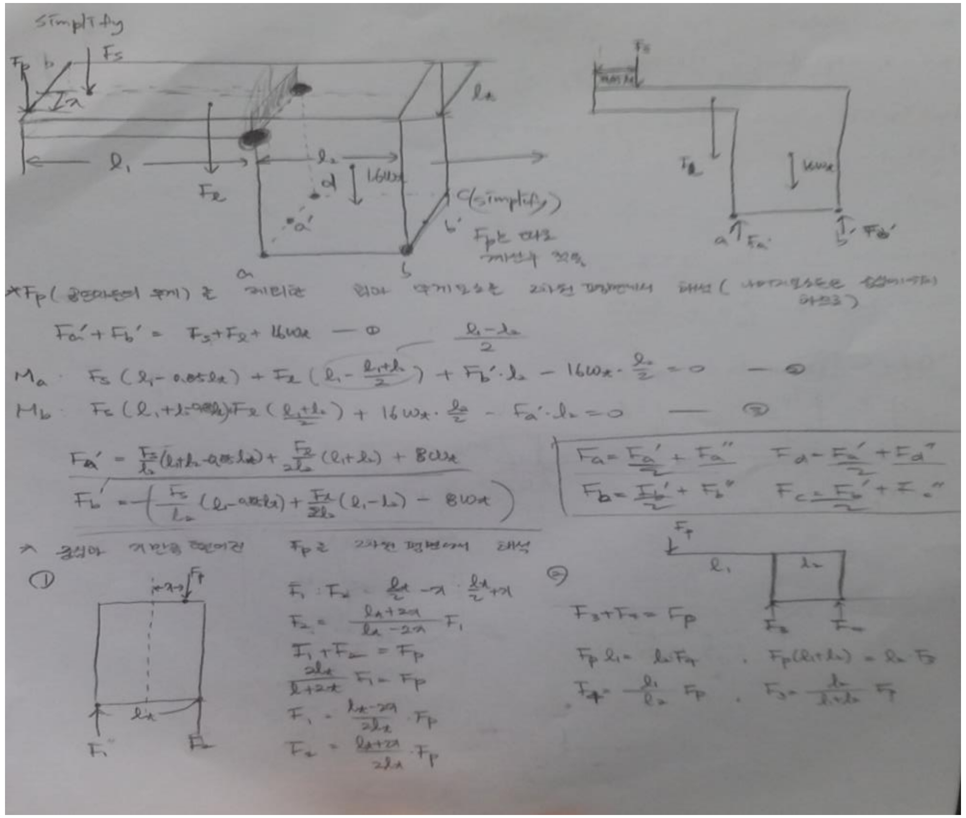
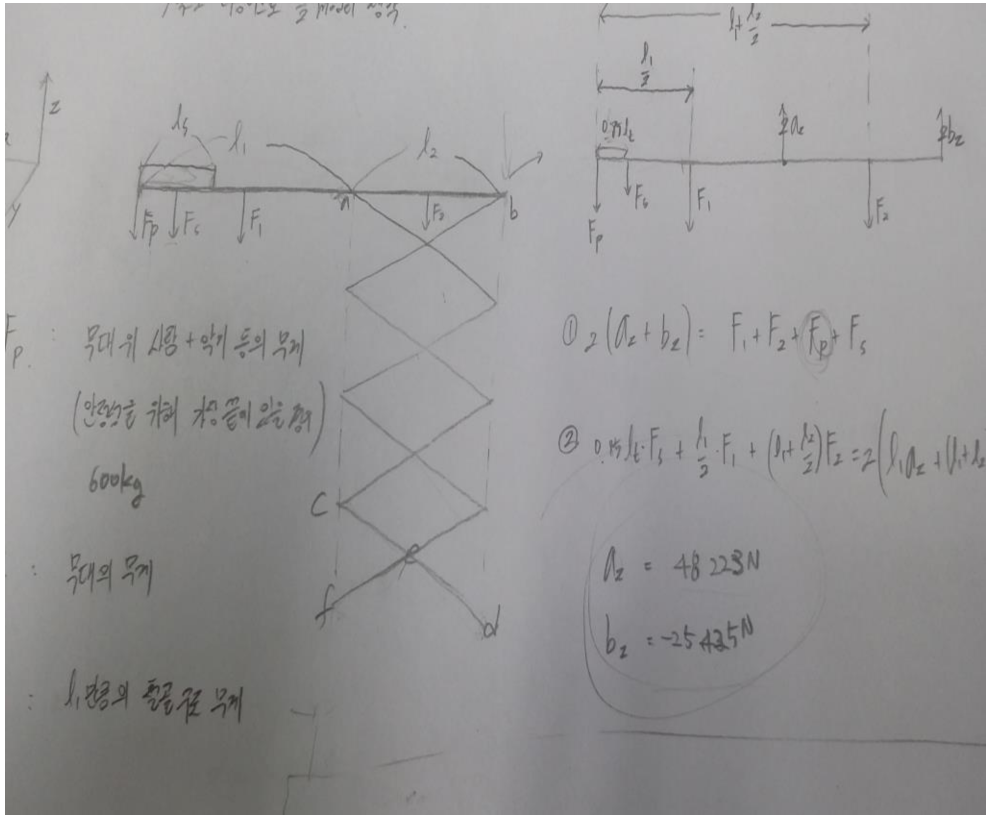
6. 각 부분에 작용하는 하중, 모멘트, 비틀림 계산





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```
%-------------------사람무게 고려 x-----%
fa1= (fs/l2*(l1+l2-0.85*lt)+fl/2/l2*(l1+l2)+8*wt)/2;
fb1= -(fs/l2*(l1-0.85*lt)+fl/2/l2*(l1-l2)-8*wt)/2;
fc1= fb1;
fd1= fa1;


%---------사람위치에 따른 사람 및 무대 무게만 고려했을때의 걸리는 힘-----%
fa2 = fp/(1-l1/(l1+l2)-l1*(lt+2*x)/(l1+l2)/(lt-2*x)+(lt+2*x)/(lt-2*x));
fb2 = -fa2*l1/(l1+l2);
fd2 = fa2*(lt+2*x)/(lt-2*x);
fc2 = -fd2*l1/(l1+l2);
%----------------------------------------%
 %----모멘트---%
 me = fs*(l1-0.85*lt)+fl*(l1-(l1+l2)/2)+fp*l1;
 ma=lt/2*(fs+fl)+lt*8*wt+fp*(lt/2+x)-(fc+fc)*lt;
 mb= ma;

 mbar =(fa-wt)*cos(pi/6)*hl+wt*cos(pi/6)*hl/2;

 %----토션----%

 te=lt/2*(fs+fl)+fp*(lt/2+x)+lt*(fg-fh);
```

```
%------전체----%

fa = fa1+fa2;
fb = fb1+fb2;
fc = fc1+fc2;
fd = fd1+fd2;

fe1= (fs/l2*(l1+l2-0.85*lt)+fl/2/l2*(l1+l2))/2;
ff1 =-(fs/l2*(l1-0.85*lt)+fl/2/l2*(l1-l2))/2;
fg1 = ff1;
fh1 =fe1;

fe2 =fa2;
ff2 =fb2;
fg2 =fc2;
fh2 =fd2;

fe = fe1+fe2;
ff = ff1+ff2;
fg = fg1+fg2;
fh = fh1+fh2;
```

Load
Moment
Torque

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Design & MATLAB Calculate

```
%%----우리가 관심 있는 부분 a,b,e의 응력----%%

%---a---%
stress_ma = ma*32/pi/dp^3;
stress_va = 4*fa/(3*pi*dp^2/4);
von_a = sqrt(stress_ma^2+3*stress_va^2);
```

Stress

```
%---b---%

stress_mb = mb*32/pi/dp^3;
stress_vb = 4*fb/(3*pi*dp^2/4);
von_b = sqrt(stress_mb^2+3*stress_vb^2);

%---e---%
stress_fe =fe/0.000486;
stress_me = me*10^6/309*150/10^3;
stress_te = te*0.0252/((309+644)/10^6);

von_e =sqrt((stress_fe+stress_me)^2+3*stress_te^2);
```

```
%-----bar------%
stress_fbar = fbar/(hb*ht);
stress_mbar = mbar*hb/2/(ht*hb^3/12);
von_bar = sqrt((stress_fbar+stress_mbar)^2);

% safety factor%
safety_a1=sy1/von_a;
safety_a2=sy2/von_a;
safety_a3=sy3/von_a;
safety_b1=sy1/von_b;
safety_b2=sy2/von_b;
safety_b3=sy3/von_b;
safety_e1=sy1/von_e;
safety_e2=sy2/von_e;
safety_e3=sy3/von_e;
safety_bar1=sy1/von_bar;
safety_bar2=sy2/von_bar;
safety_bar3=sy3/von_bar;
```

Safety factor

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8. Parameter 와 Result 값

dp	0.3100
ds	0.3000
f1	1.7051e+04
f2	7.5589e+03
fa	1.2044e+05
fa1	1.1565e+05
fa2	4.7909e+03
fb	5.4903e+04
fb1	5.8222e+04
fb2	-3.3194e+03
fbar	6.0220e+04
fc	4.8264e+04
fc1	5.8222e+04
fc2	-9.9583e+03
fd	1.3002e+05
fd1	1.1565e+05
fd2	1.4373e+04
fe	4.3431e+04
fe1	3.8640e+04
fe2	4.7909e+03
ff	-2.2106e+04
ff1	-1.8786e+04
ff2	-3.3194e+03

fg	-2.8745e+04
fg1	-1.8786e+04
fg2	-9.9583e+03
fh	5.3013e+04
fh1	3.8640e+04
fh2	1.4373e+04
fl	2.4610e+04
fp	5886
fs	1.5098e+04
g	9.8100
hb	0.5000
hl	5
ht	0.1000
l	14
l1	9.7000
l2	4.3000
ls	6.1550
lt	4
ma	3.2703e+05
mb	3.2703e+05
mbar	4.7984e+05
me	2.1866e+05

stress_ma	1.1182e+08
stress_mb	1.1182e+08
stress_mbar	1.1516e+08
stress_me	1.0614e+08
stress_te	-6.0807e+06
stress_va	2.1276e+06
stress_vb	9.6988e+05
sy1	580000000
sy2	807000000
sy3	1.5900e+09
te	-2.2996e+05
von_a	1.1188e+08
von_b	1.1183e+08
von_bar	1.1637e+08
von_e	1.9579e+08
wt	1.9252e+04
x	1

safety_a1	5.1843
safety_a2	7.2133
safety_a3	14.2121
safety_b1	5.1865
safety_b2	7.2164
safety_b3	14.2182
safety_bar1	4.9843
safety_bar2	6.9351
safety_bar3	13.6639
safety_e1	2.9623
safety_e2	4.1217
safety_e3	8.1208
stress_fbar	1.2044e+06
stress_fe	8.9365e+07

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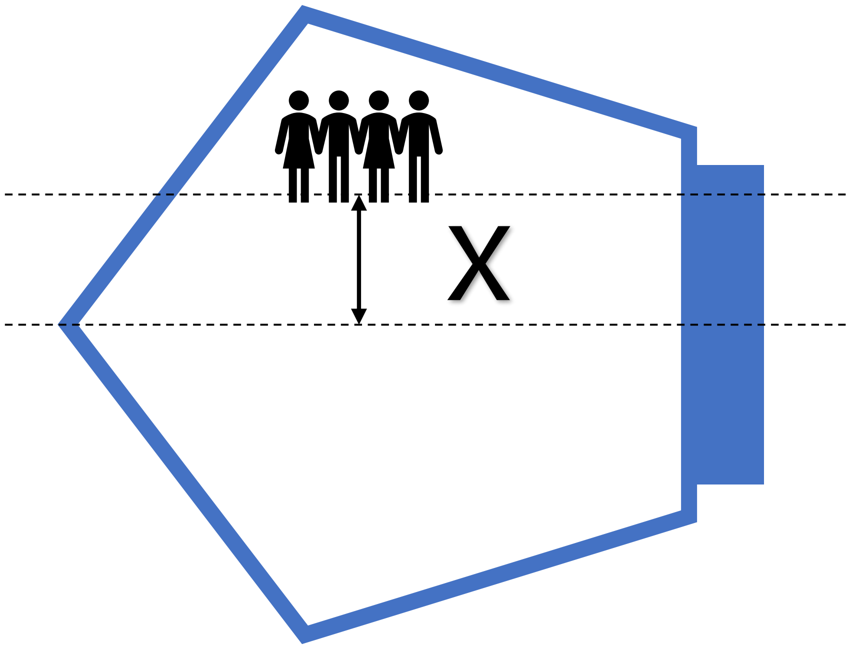
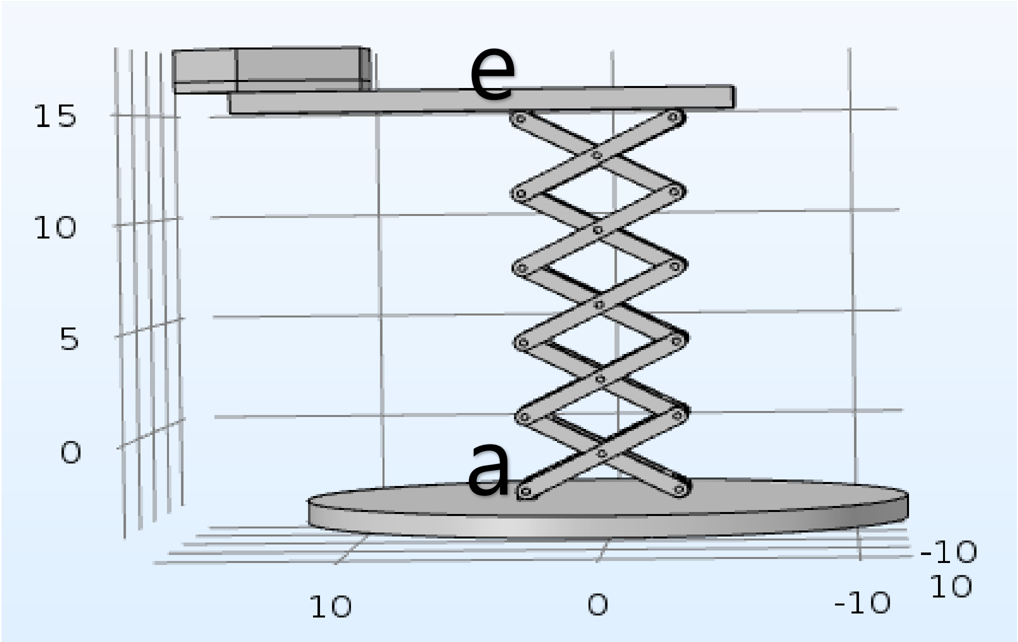
Design & MATLAB Calculate

9.(사람의 위치) 변화에 따른 응력 분석





03 COMSOL Interpretation

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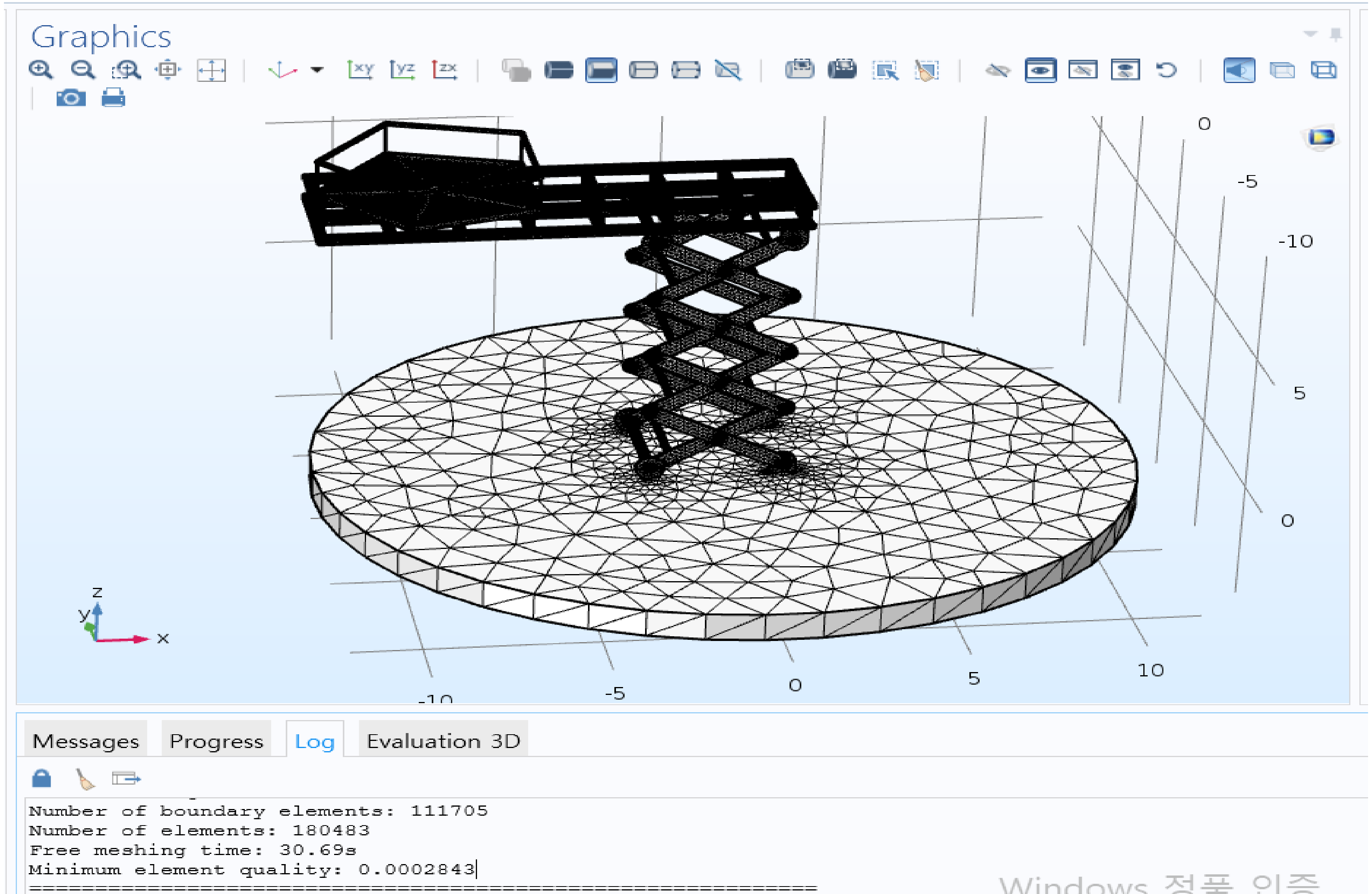
초기 mesh 모델



Number of boundary elements :111705

Number of elements:180483

Free meshing time: 30.69s

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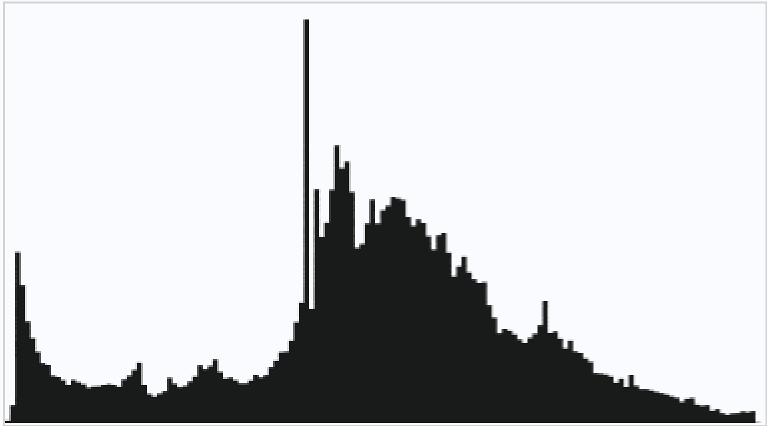
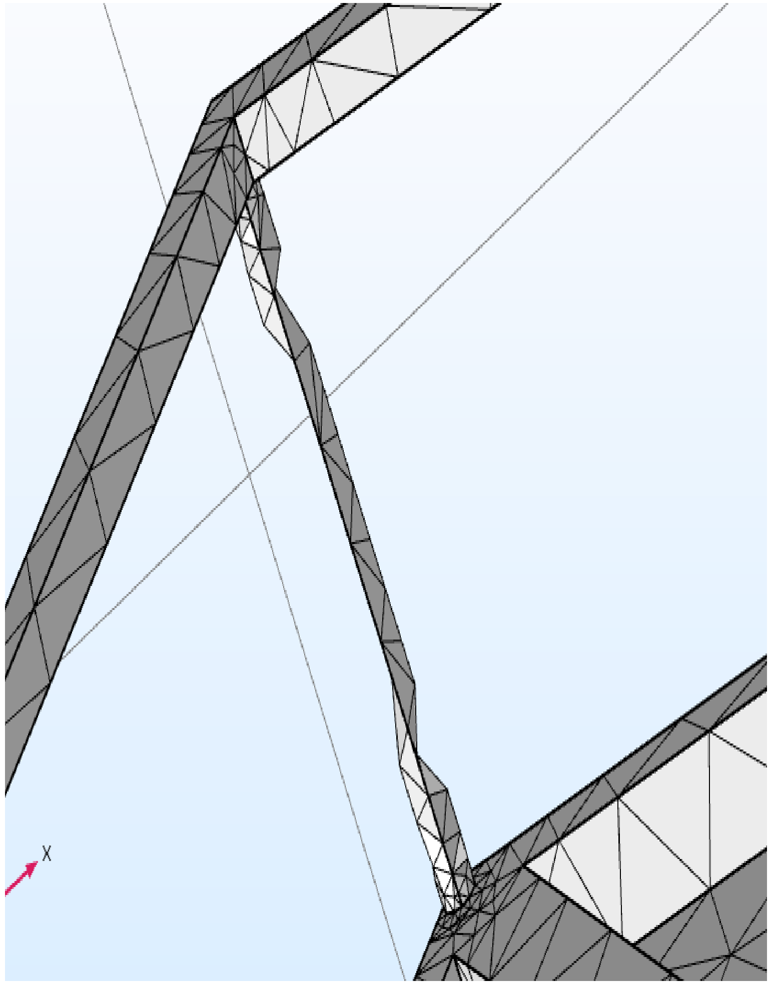
문제점

Domain element statistics

Number of elements:	138521
Minimum element quality:	2.722E-4
Average element quality:	0.4808
Element volume ratio:	1.58E-6
Mesh volume:	461.6 m³
Maximum growth rate:	5.893
Average growth rate:	2.082

Element Quality Histogram

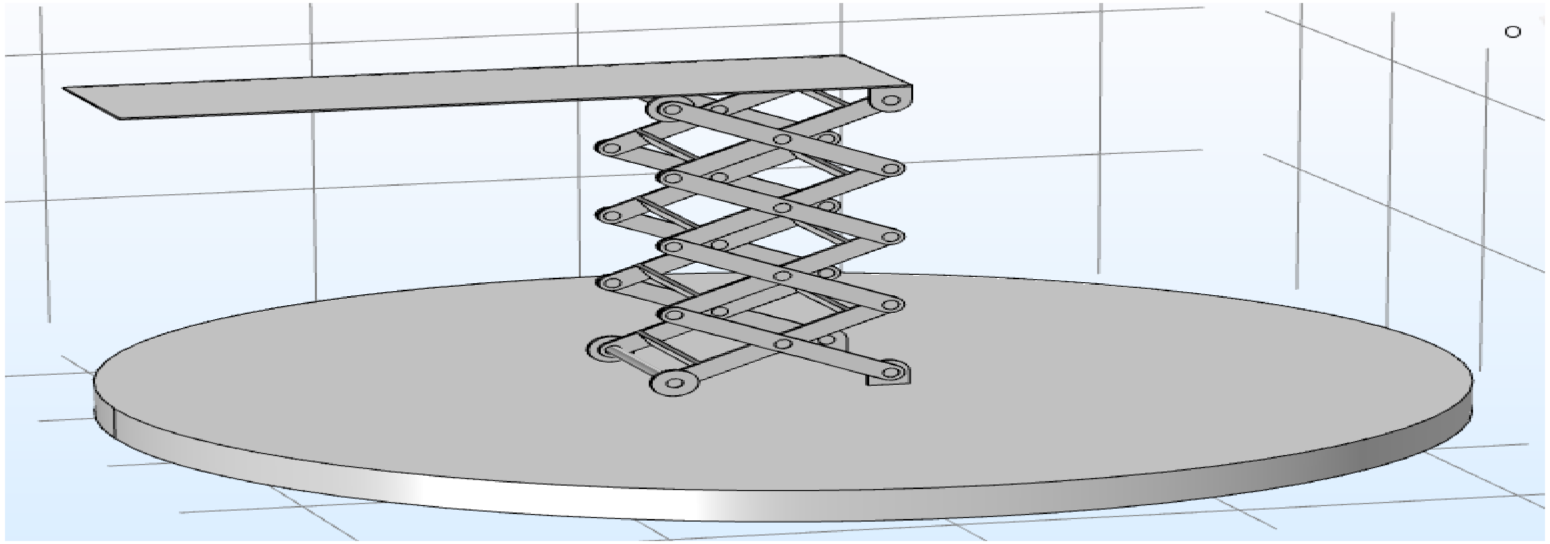




- CATIA를 이용하여 import

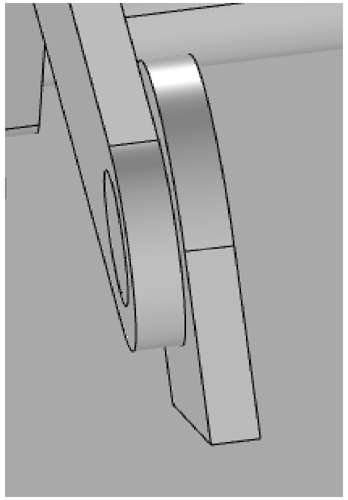
- 정확도(average element quality)가 떨어지는 문제점

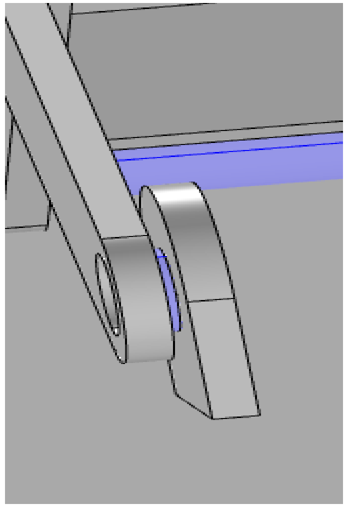
Simplified modeling for A point



-무대를 없애고 point load 로 변경

-철골구조를 같은 무게의 판으로 변경





a점 shaft의 응력을 정확하게 보기 위해서 모델링을 변경하였다.

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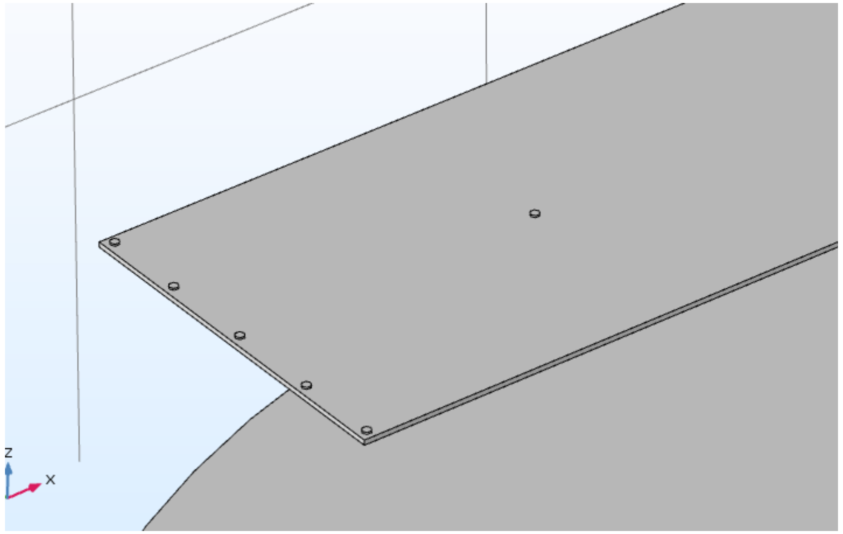
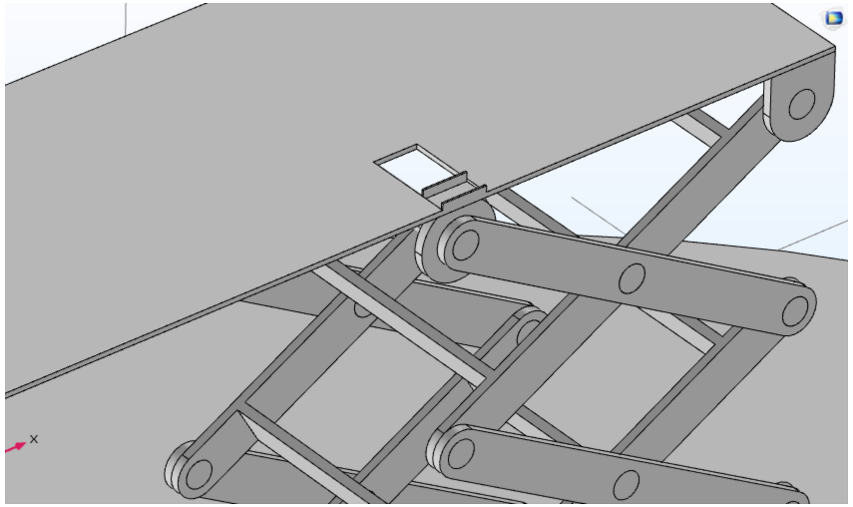
Simplified modeling for B point





-마찬가지로 무대를 없애고 point
load 로 변경

-ㄷ beam 의 응력 해석을 위해 modeling

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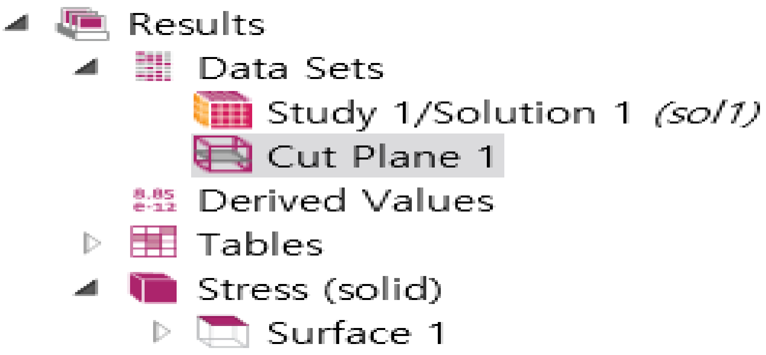
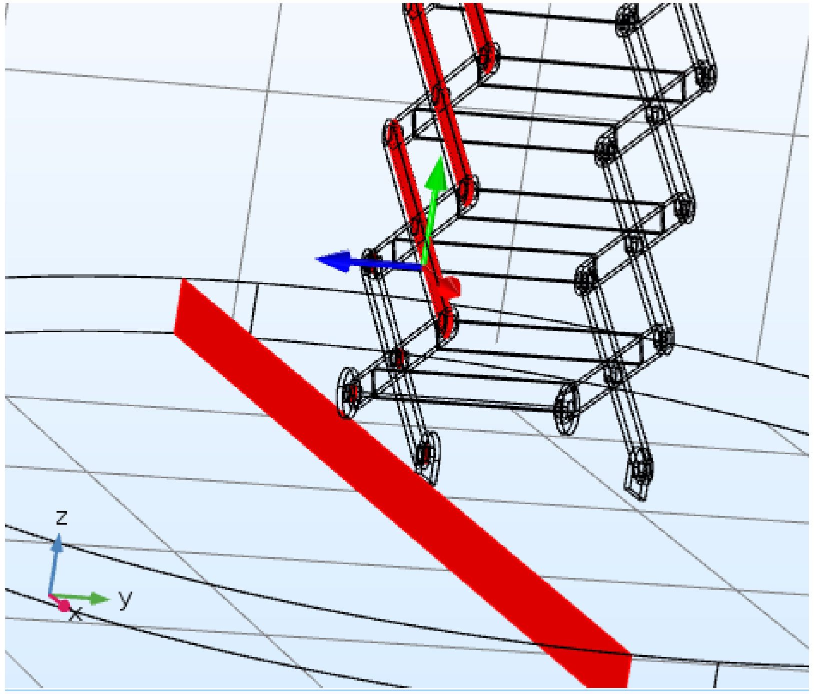
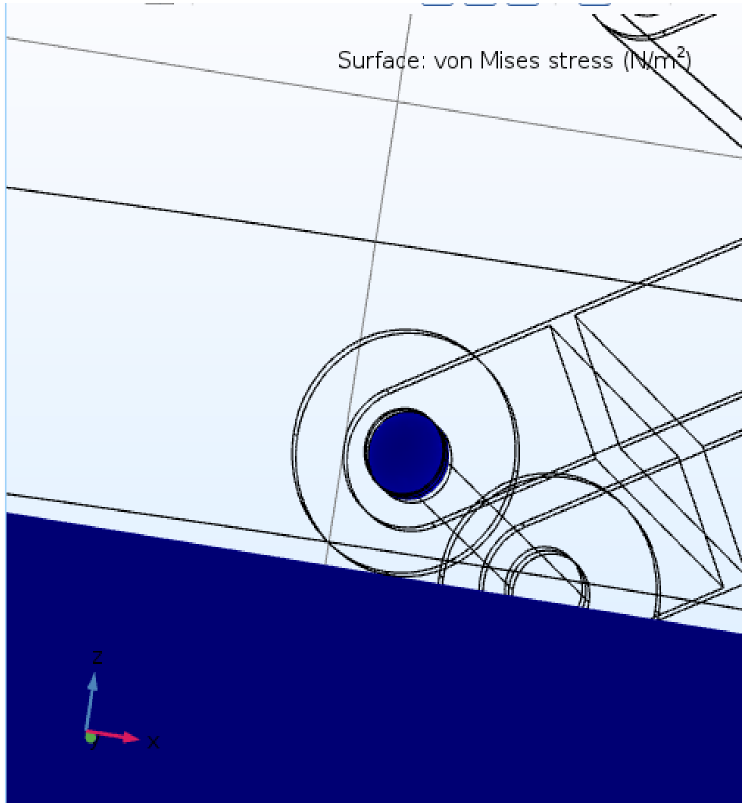
목표 1. mesh 변화를 통한 A점의 응력 해석

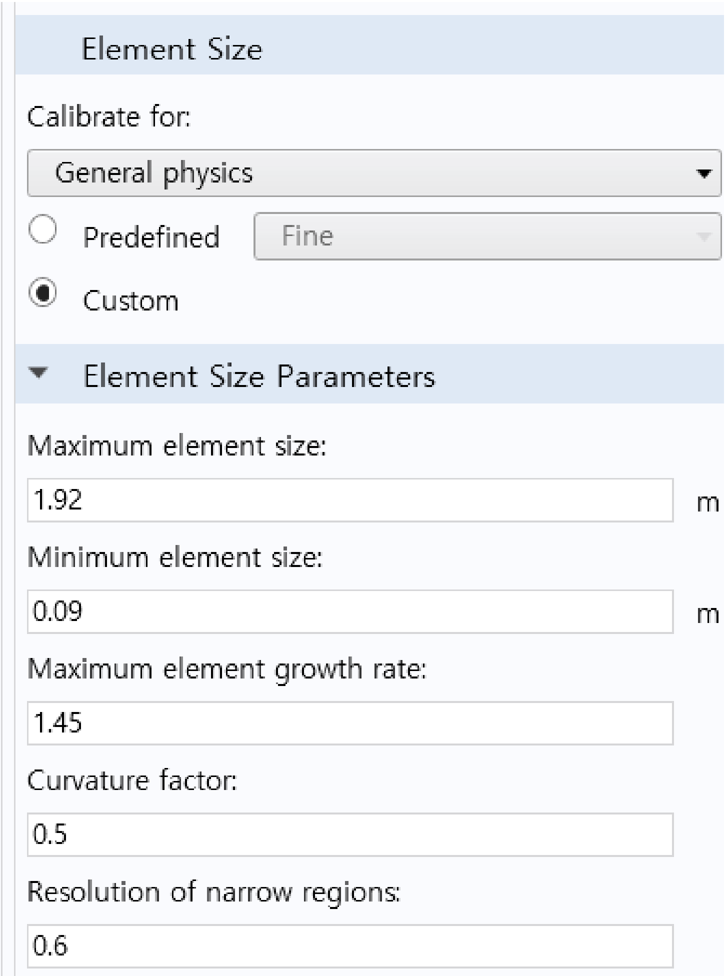


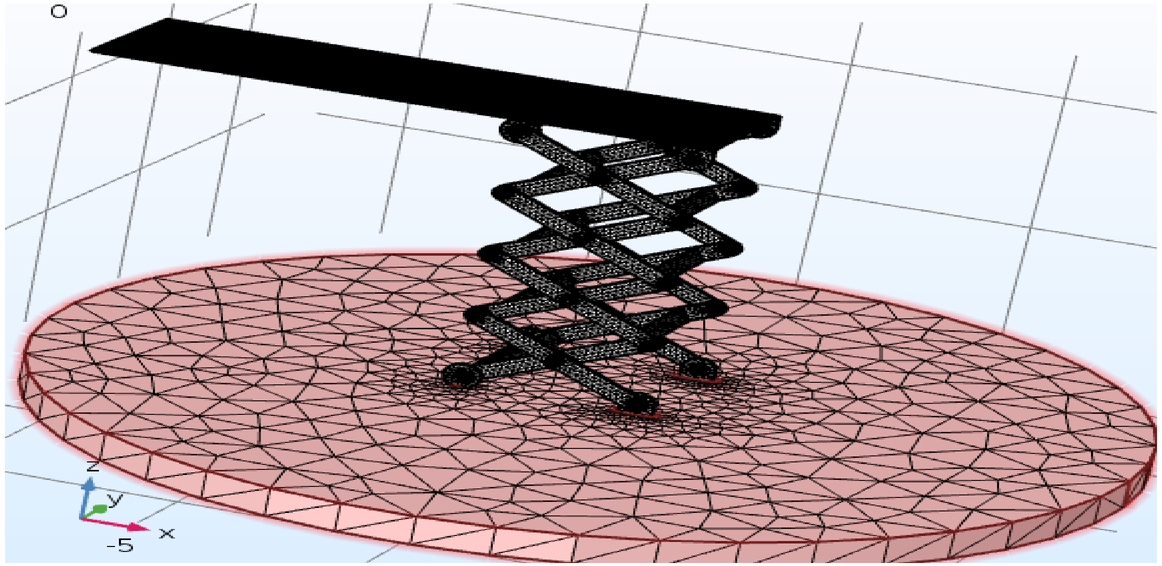
- A점 해석을 위해 cut plane을 사용





Mesh (1)

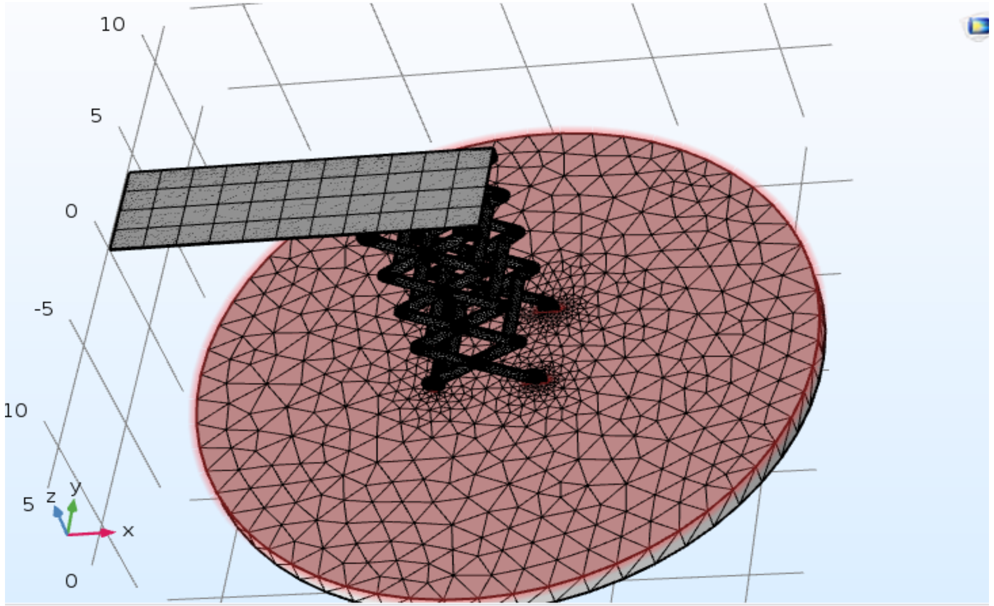


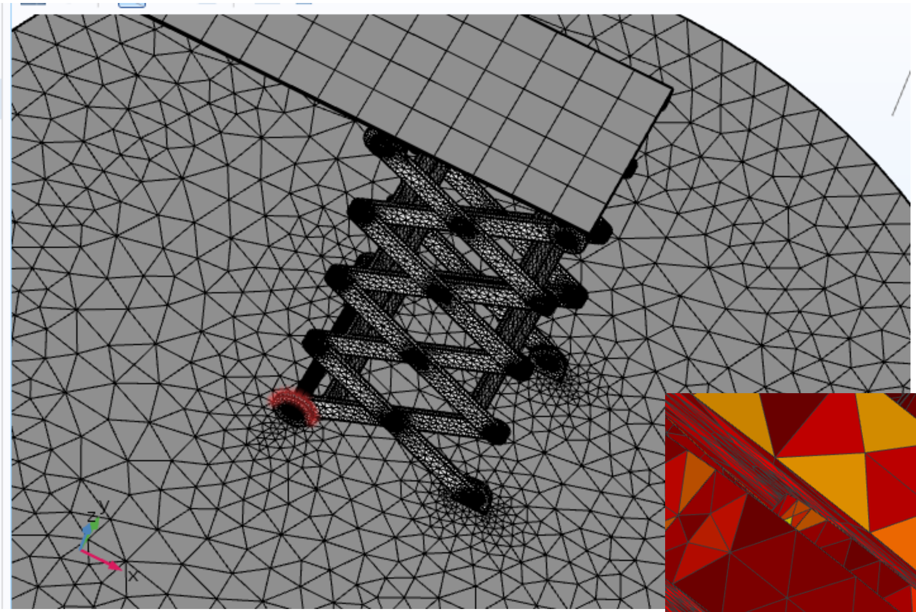


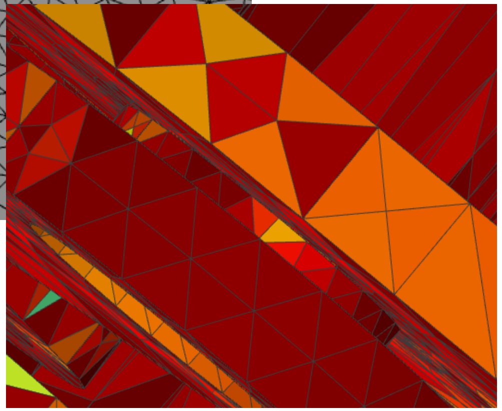
-Free tetrahedral mesh 로 사이즈 fine 으로 mesh 를 형성

-이 경우 해석이 필요치 않은 위쪽 부분에 과도한 mesh가 형성됨을 알 수 있다.

Mesh (2) ,(3)







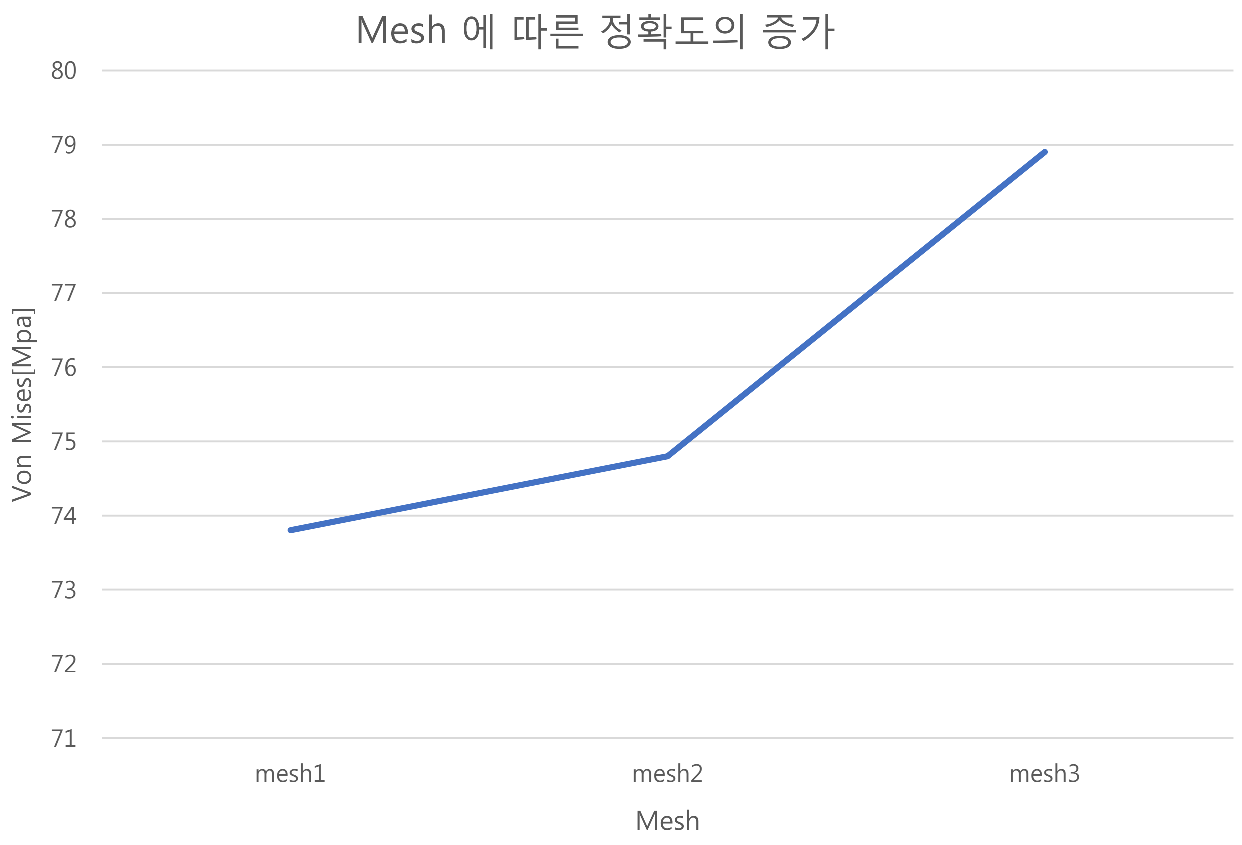
- 위 부분 mapped를 이용

- 나머지 부분 finer

- Point A 만 extra fine

픽

결과값



Matlab 값 = 80.6Mpa (analytic)

Mesh1. Comsol값 = 73.8Mpa

Mesh2. Comsol 값 = 74.8Mpa

Mech3. Comsol 값 = 78.9Mpa

- Mesh 를 정교하게 구성할 수 록 이론값에 가까워짐을 확인할 수 있다.

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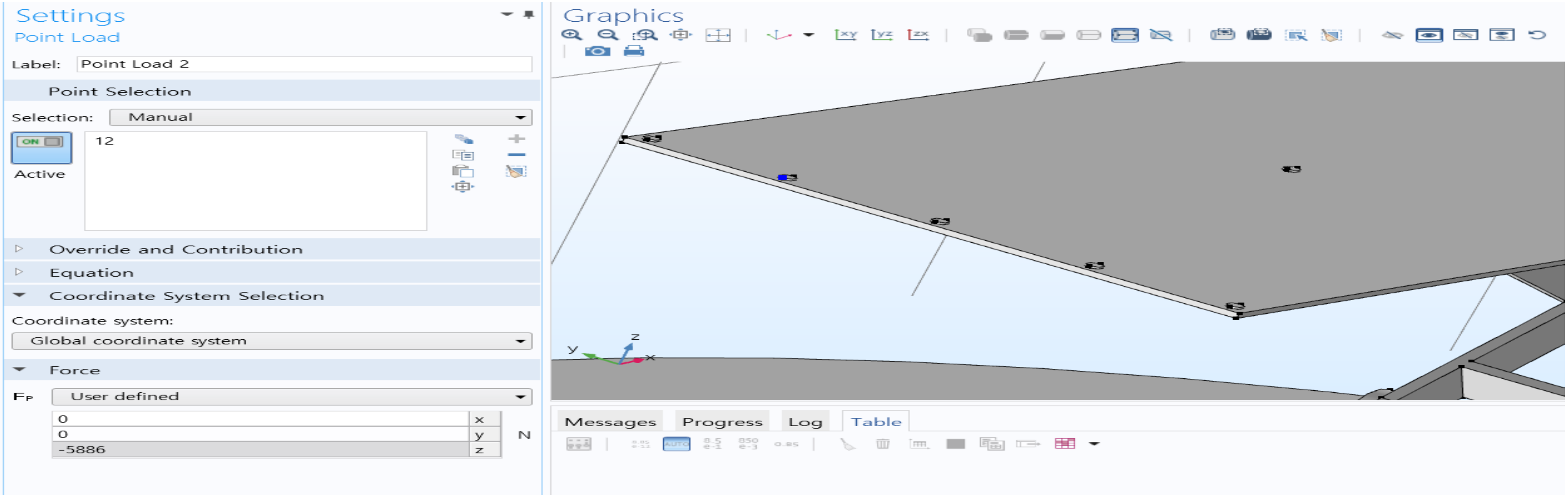
목표2. load의 X축 변화에 따른 응력 해석



무대의 무게 Fs(=15098N) 과 공연 가수들의 무게 Fp(=5886N) 을 해당하는 점에 point load 로 주었다.

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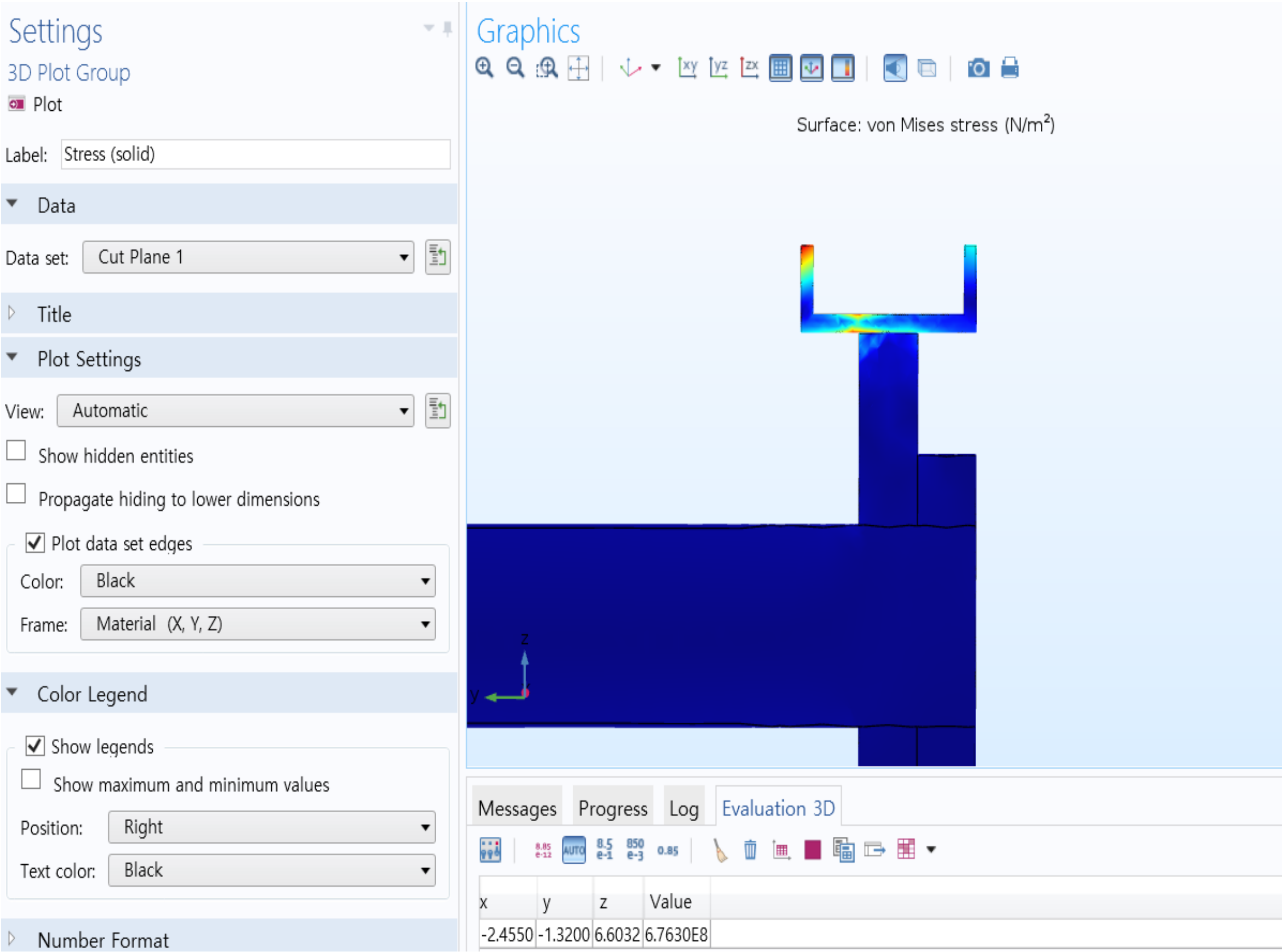
X=0



Matlab 값 : 65.7Mpa

Comsol 값 : 67.6Mpa

von_e 6.5785e+08

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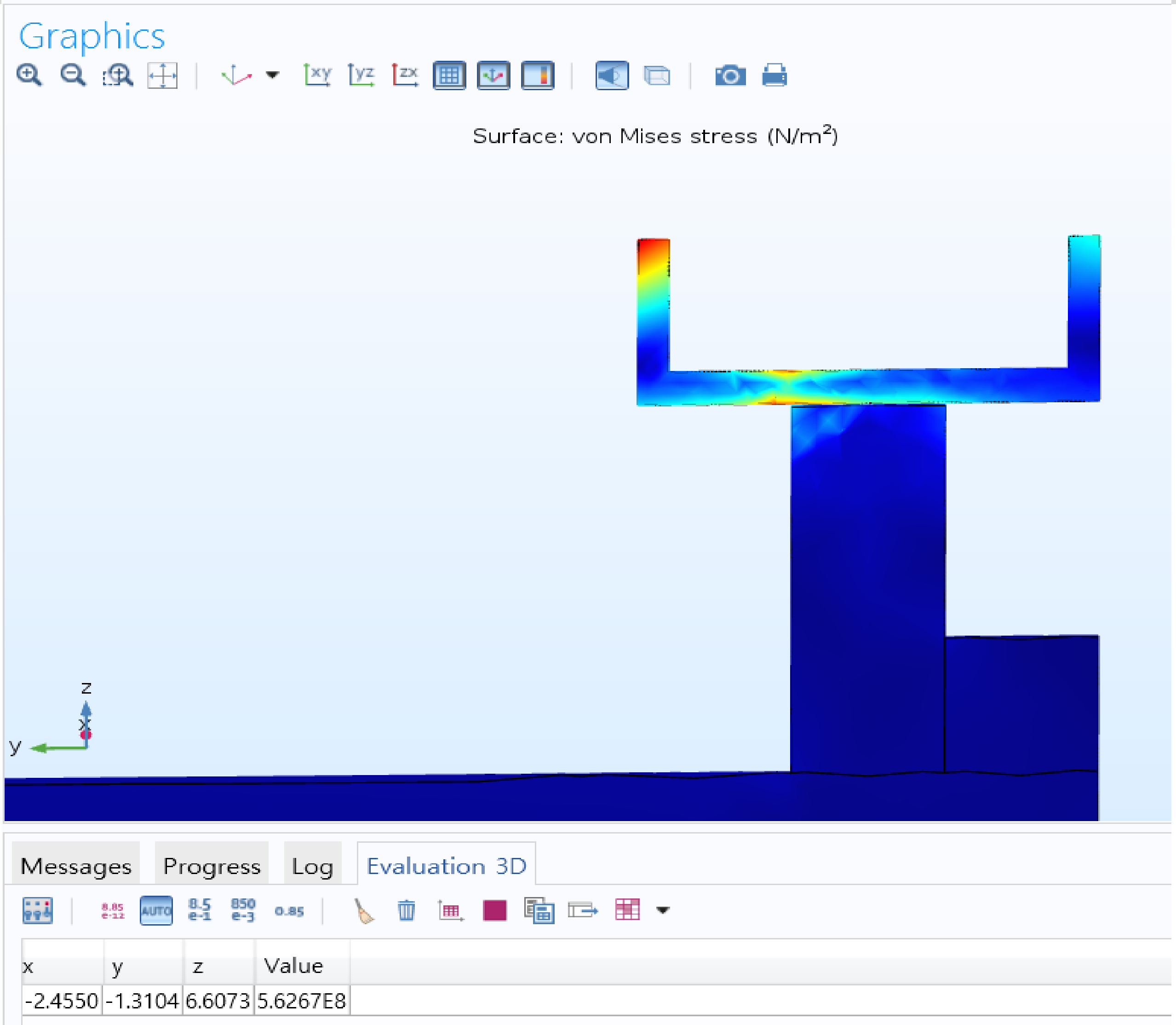
X=2



Matlab 값 : 59.8Mpa

Comsol 값 : 56.2Mpa

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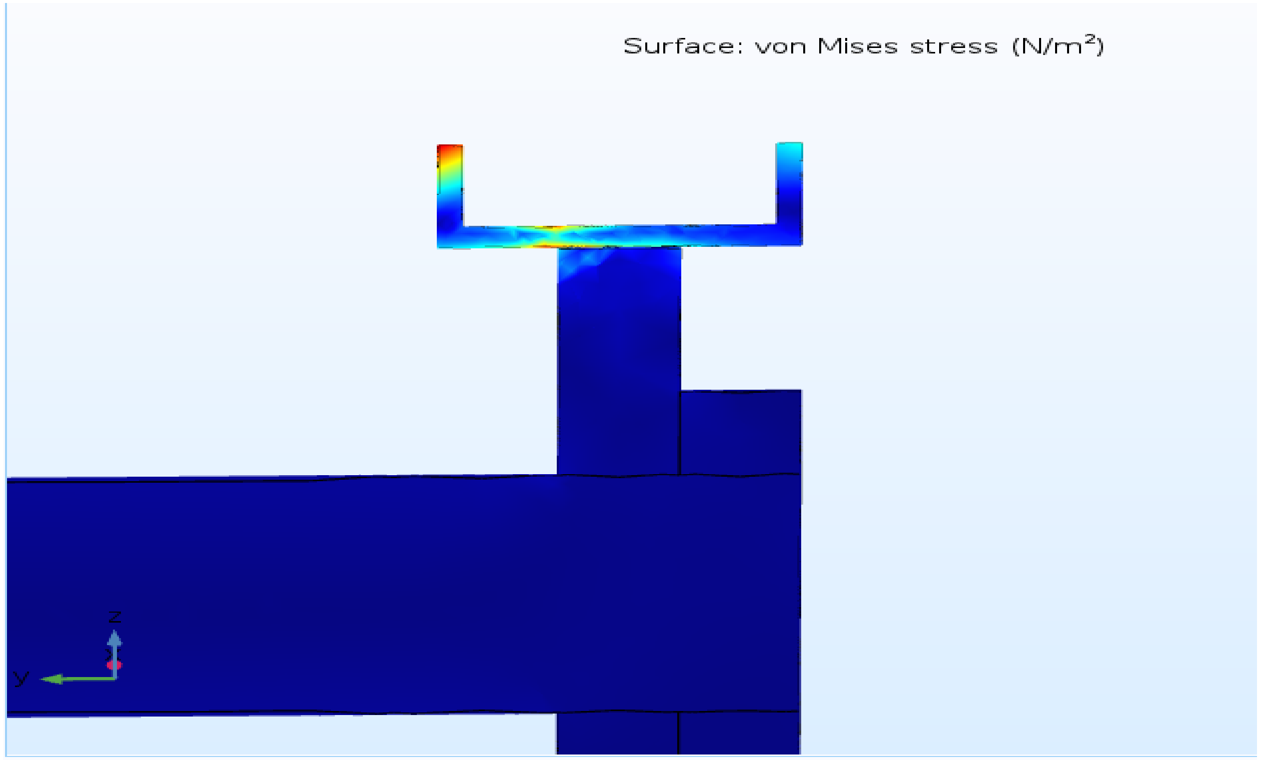
X=-2



Messages Progress Log Evaluation 3D

x	y	z	Value
-2.4550	-1.3084	6.5998	7.1832E8

Matlab 값 : 72.6Mpa

Comsol 값 : 71.8Mpa

von_e 7.2060e+08

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04 실제 무대에 적용

가수의 공연을 설계한 무대에 적용

X= 0

X=-2

X = 2

평창동계올림픽 개.폐막식에서 가수가 공연을 할 때 cirtical point인 d 점의 von-mises 응력이 어떻게 작용하는지 살펴본다.

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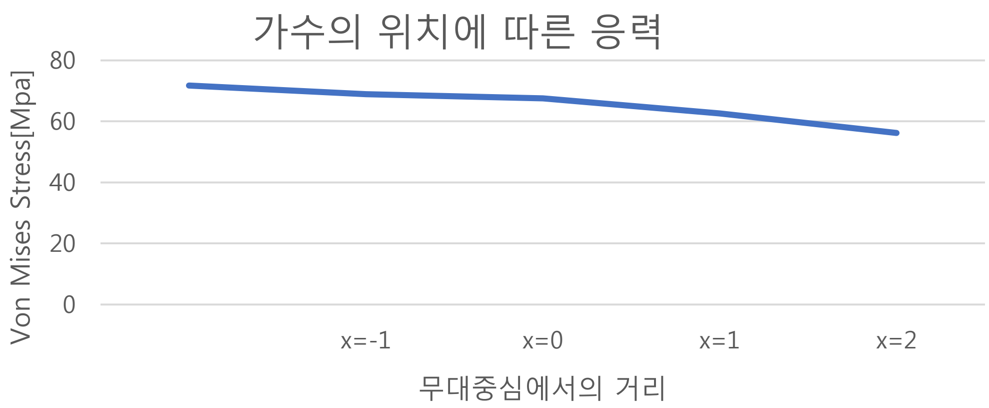
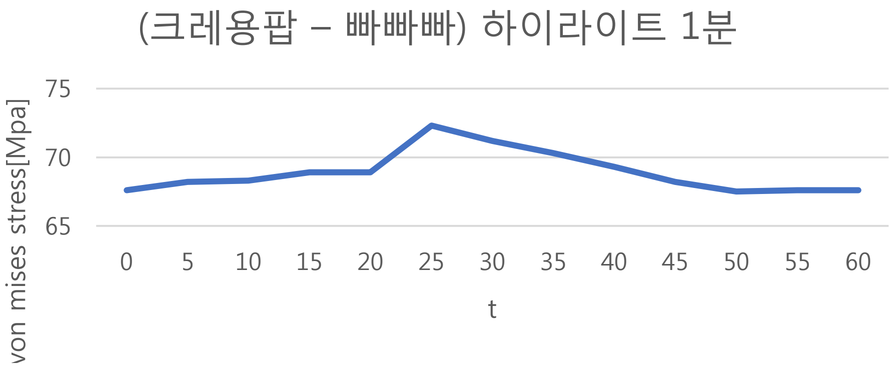
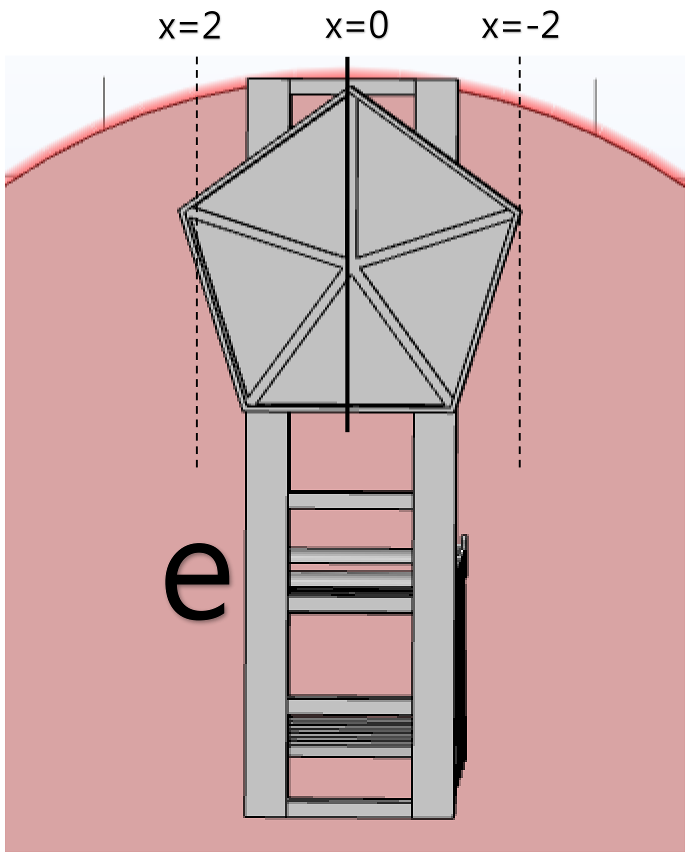
2018 평창동계올림픽

결과



E점에서 오른쪽으로 거리가 증가할 때 torsion이 증가하기 때문에 응력이 커짐을 알 수 있다.





하이라이트 1분의 데이터를 살펴보면 22~30 초 동안 무대 오른쪽에 가수들이 위치해있다고 볼 수 있다.

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감사합니다