Doc. No.	(주)금강씨에스

구 조 계 산 서

Structural Design Report
for

CPVC 배관연결구 구조검토

위 건축물(공작물)에 대하여 국토해양부 고시 건축구조기준(KBC)에 따라 책임구조기술자가 구조설계를 수행하여 구조안전을 확인하였으므로, 본 구조설계서에 표시된 구조형식, 사용재료 및 강도, 하중조건, 지반특성, 구조설계의 취지를 올바르게 파악하여 구조설계도에 표기하시기 바랍니다. 구조안전을 확인한 구조설계도서(구조설계도, 구조설계서, 구조체공사시방서)에는 사단법인 한국건축구조기술사회에 등록된 인장으로 날인합니다. 시공상세도서에 대한 구조안전확인, 시공 중 구조안전확인, 유지관리 중 구조안전 확인이 필요한 경우에는 미리 책임구조기술자에게 구조안전의 확인을 요청하시기 바랍니다.

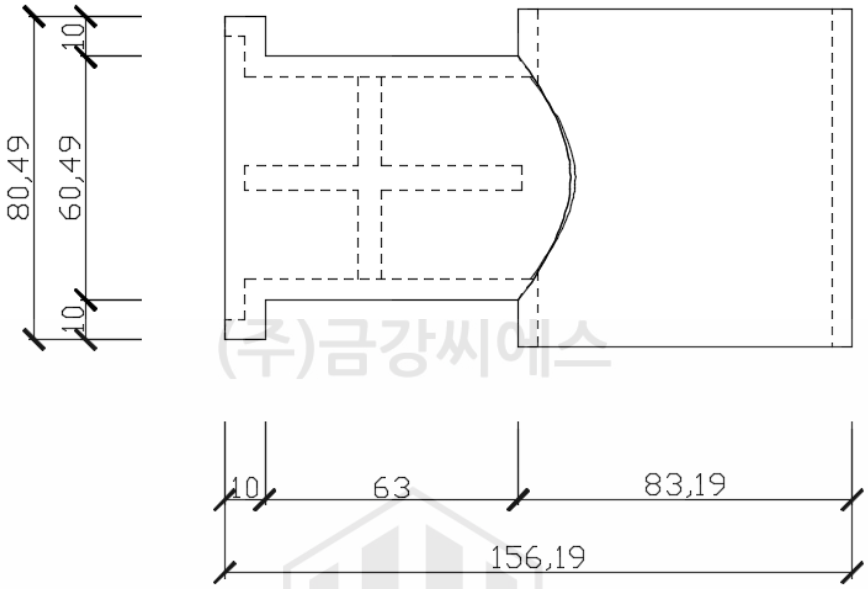
차 례	일 자	구 조 설 계 단 계	설 계 자	검 토 자	승 인 자
3					
2					
1					

KSEA 사단법인 한국건축구조기술사회 THE KOREAN STRUCTURAL ENGINEERS ASSOCIATION

회사CI	효성구조엔지니어링 HYOSUNG Structural Engineering	韓國技術士 登錄 No.161080102141 郭宜伸 技術士 建築構造 REGISTERED PROFESSIONAL ENGINEER
대 표 건축구조기술사	곽 의 신 (인)	
사업장주소	충남 천안시 동남구 병천면 충절로 1600 한국기술교육대학교 K420호 (31253)	

1. 개 요

• 대　　상 : 배관 지지대



[그림 1] 배관 지지대 크기

2. 설계 근거 및 기준

1) 설계규준

• 건축 구조설계 기준 (2016, 대한건축학회)

2) 참고 문헌

• ASTM D 638

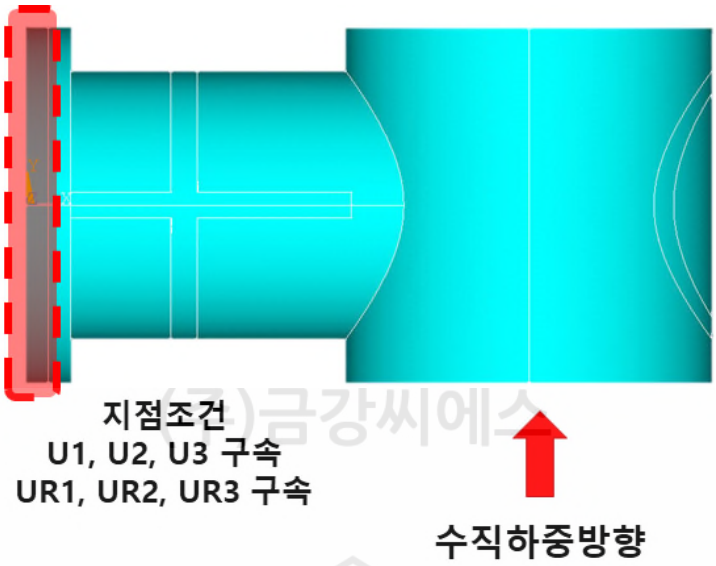
3. 구조해석용 프로그램

• 부재 해석 : ANSYS/CAE 13.0

4. 사용재료의 강도 및 규격

구 분	강 도	비 고
CPVC	항복강도 Fy = 550kgf/㎟ [55MPa] 탄성계수 E = 2.5GPa [2,500MPa]	ASTM D 638

5. 배관 지지대 지점조건 및 하중방향



[그림 2] 배관 지지대 지점조건 및 하중방향

6. 배관 지지대 하중 검토

하 중 (N)	항복강도 (MPa)	탄성계수 (MPa)	소요강도 (MPa)	Design Ratio	하 중 검 토
500	55	2,500	6.109	0.109	안전
1,000			12.039	0.219	안전
1,500			18.058	0.328	안전
2,000			24.007	0.436	안전
2,500			30.097	0.547	안전
3,000			36.131	0.657	안전
3,500			42.150	0.766	안전
4,000			48.170	0.876	안전
4,500			54.199	0.985	안전
5,000			60.208	1.095	파괴

※ Design Ratio 계산 예시

Design Ratio = 소요강도 / 항복강도

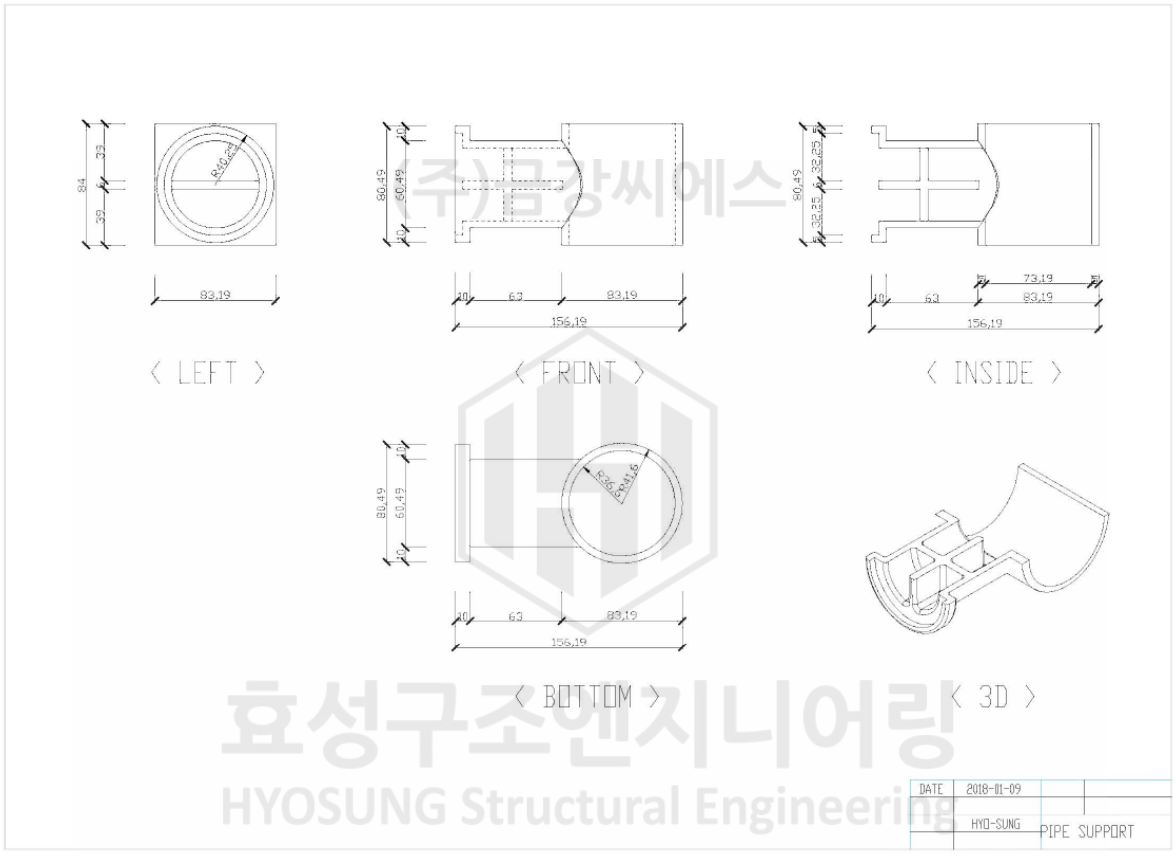
만약, Design Ratio < 1 : 안전

Design Ratio > 1 : 파괴

Design Ratio = 1 : 한계상태

7. 해석 상세 과정

1) 유한요소해석프로그램을 이용한 해석의 효율성을 높이기 위한 [그림 3]과 같은 해석모델 단순화 및 도면화 작업.
   - 해석결과에 큰 영향을 미치지 않는 ROUND 부분 삭제.
   - 모델링 간편화를 위한 BOLT와 BOLT 체결부 삭제.



[그림 3] 배관 지지대 도면

2) 유한요소해석프로그램에 배관 지지대의 물성치 입력.

항복강도 (MPa)	탄성계수 (MPa)	포아송비
55	2,500	0.3

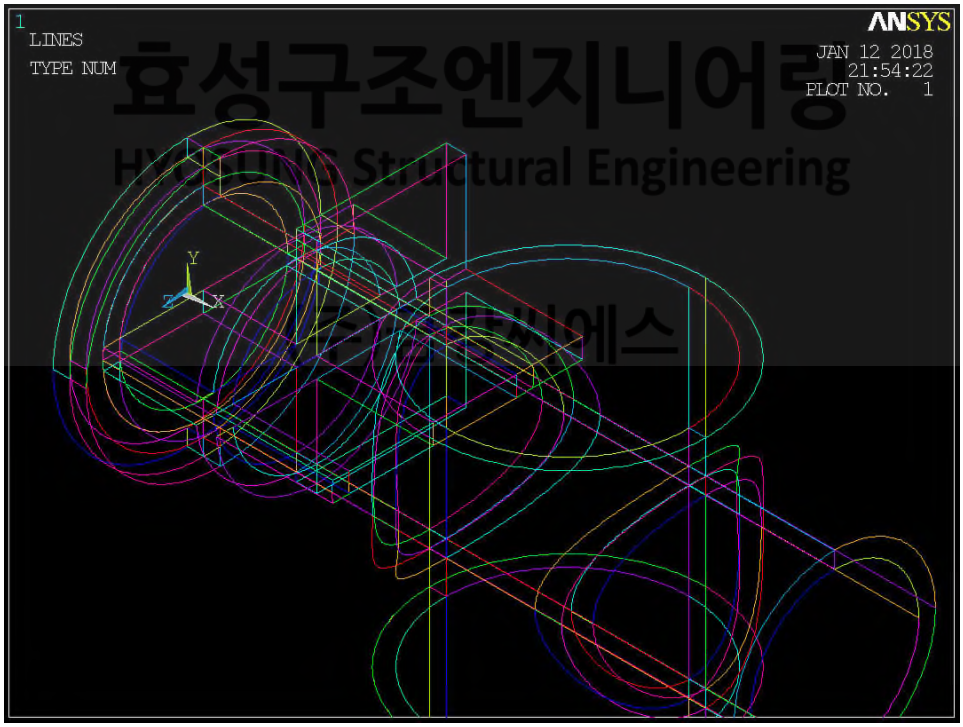
* Polymer 의 포아송비는 0.25 ~ 0.5 (한국고분자시험연구소(주))

3) 유한요소해석프로그램을 이용한 MODELING 작업.

• KEYPOINT 생성

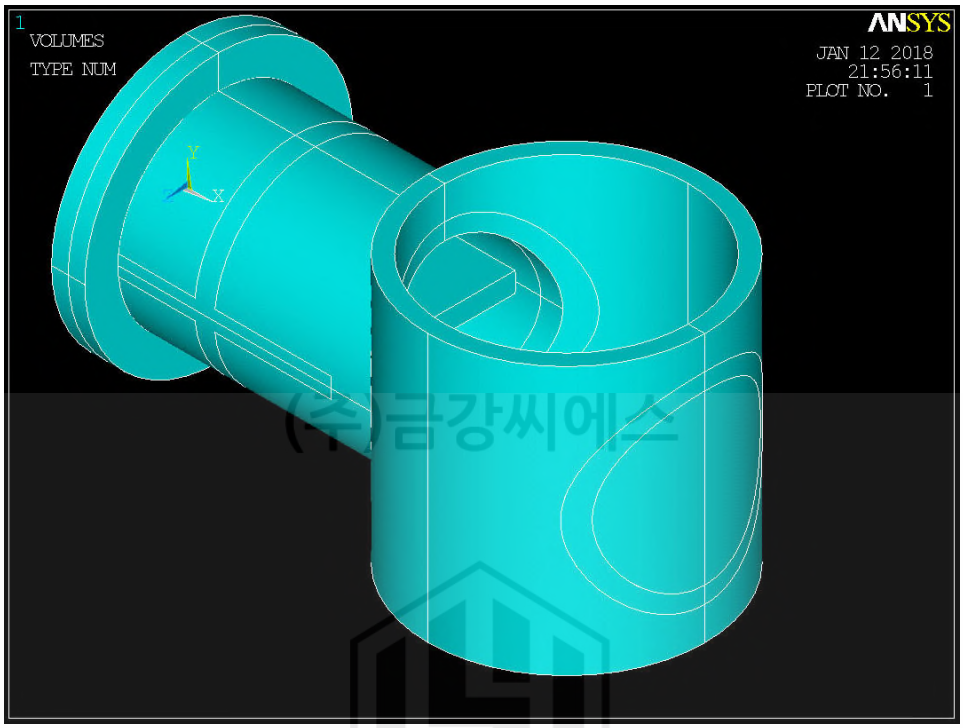
[그림 4] 생성된 KEYPOINT

• LINE 생성



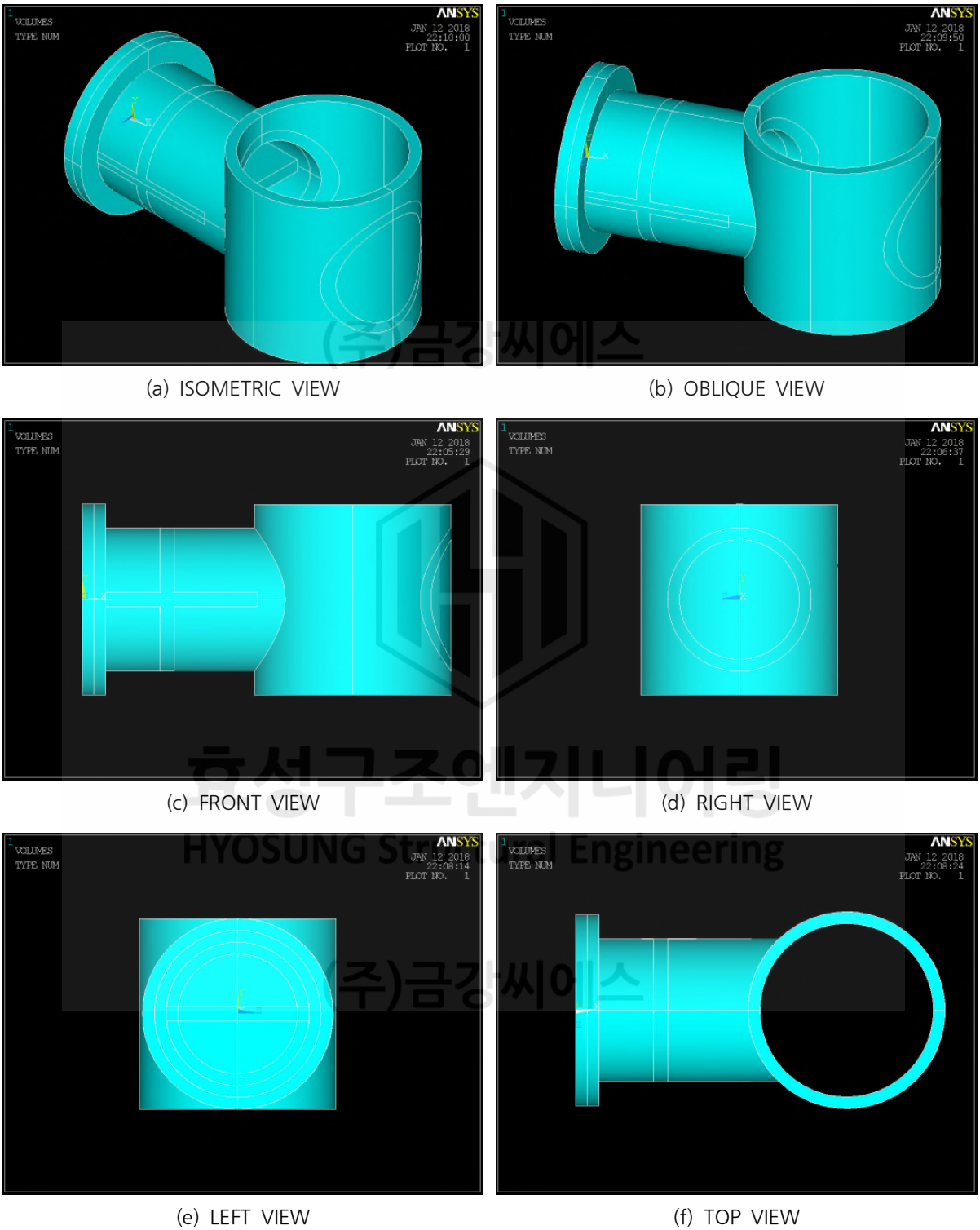
[그림 5] 생성된 LINE

• VOLUME 생성



[그림 6] 생성된 VOLUME

• 최종 해석모델



(a) ISOMETRIC VIEW (b) OBLIQUE VIEW

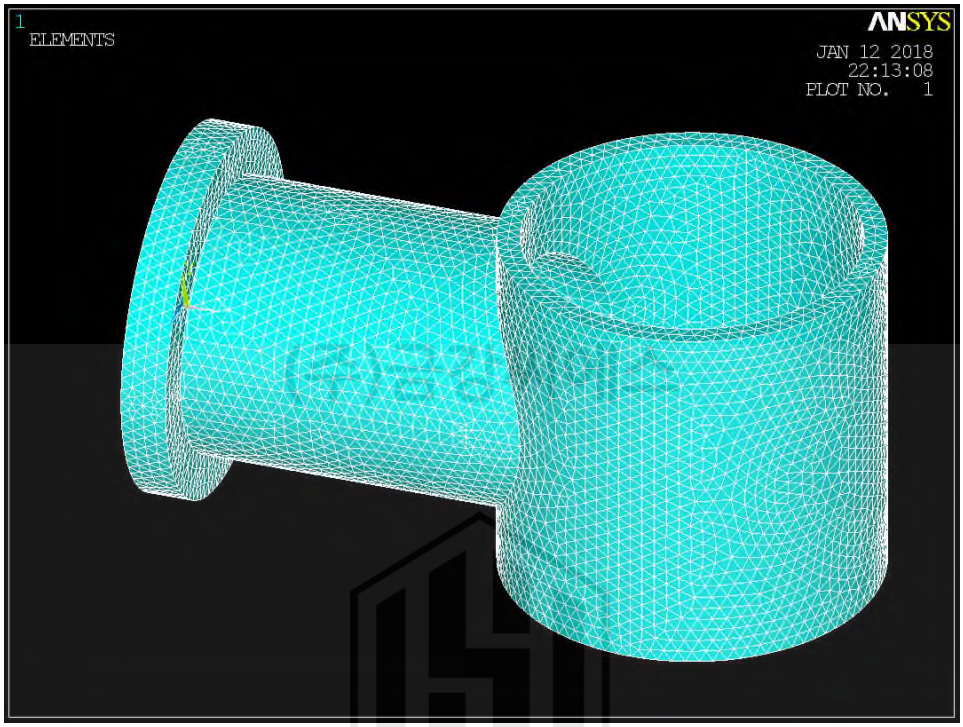
(c) FRONT VIEW (d) RIGHT VIEW

(e) LEFT VIEW (f) TOP VIEW

[그림 7] 최종 해석모델

4) 해석모델의 MESHING 작업.

- 해석의 효율성을 높이기 위해 MESH의 크기를 3으로 지정.



[그림 8] MESHING 작업된 해석모델

5) 해석모델의 LOADING 작업.

- 해석모델의 하중을 주기 위해 PRESSURE 기능사용.
- PRESSURE 기능을 사용하기 위해 단위면적당 하중 계산.

  - 단위면적 계산

$$A_1 = \pi \times \left(\frac{83.19^2}{4}\right) = 5{,}435.41mm^2,\ A_2 = \pi \times \left(\frac{73.19^2}{4}\right) = 4{,}207.20mm^2$$

$$\Rightarrow A = A_1 - A_2 = 5{,}435.41 - 4{,}207.20 = 1{,}228.21mm^2$$

  - 단위면적당 하중 계산

  < if 50kg >

  $50\,kgf = 500N$ (중력가속도 $g = 10m/\sec^2$)

  단위면적당 하중 $= 500N/1{,}228.21mm^2 = 0.407N/mm^2$

하 중		단위면적당 하중 (N/mm^2)	하 중		단위면적당 하중 (N/mm^2)
kgf	N		kgf	N	
50	500	0.407	50	500	0.407
`150	1,500	1.221	150	1,500	1.221
250	2,500	2.035	250	2,500	2.035
350	3,500	2.850	350	3,500	2.850
450	4,500	3.664	450	4,500	3.664

6. 해석모델의 BOUNDARY CONDITION 작업.

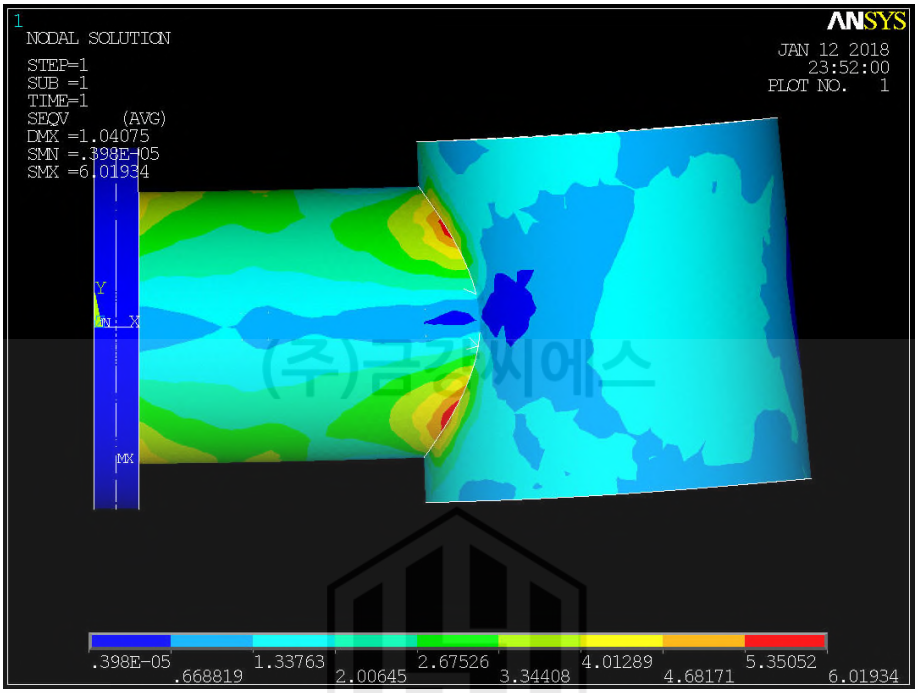
- 해석모델의 고정부에 DISPLACEMENT_ALL DOF = 0 으로 입력.

7. 해석모델의 해석 작업.

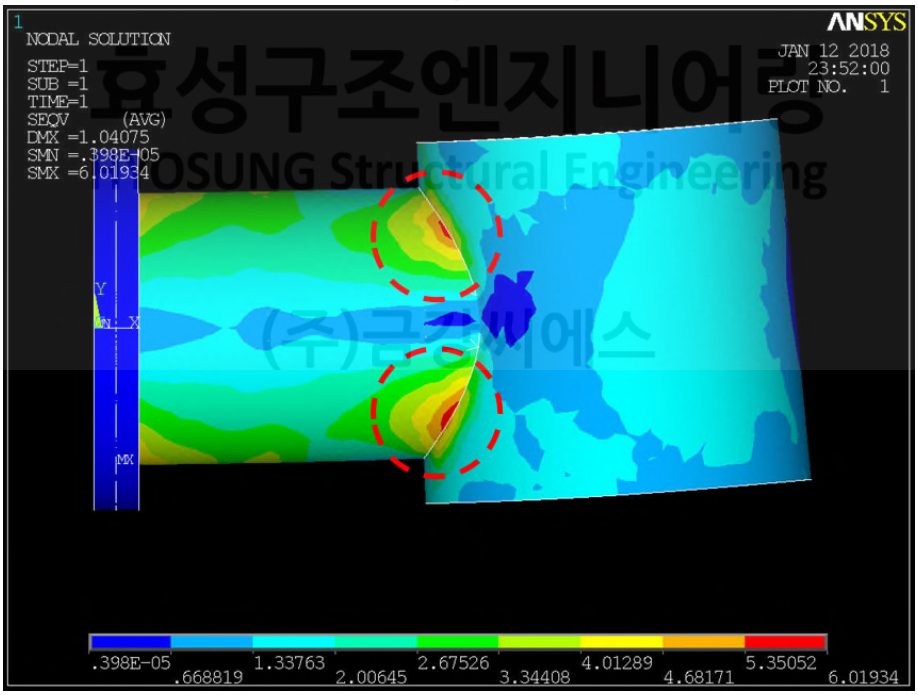
- Von-Mises Stress 응력값 확인.

[별첨 1-Shape Deformation]

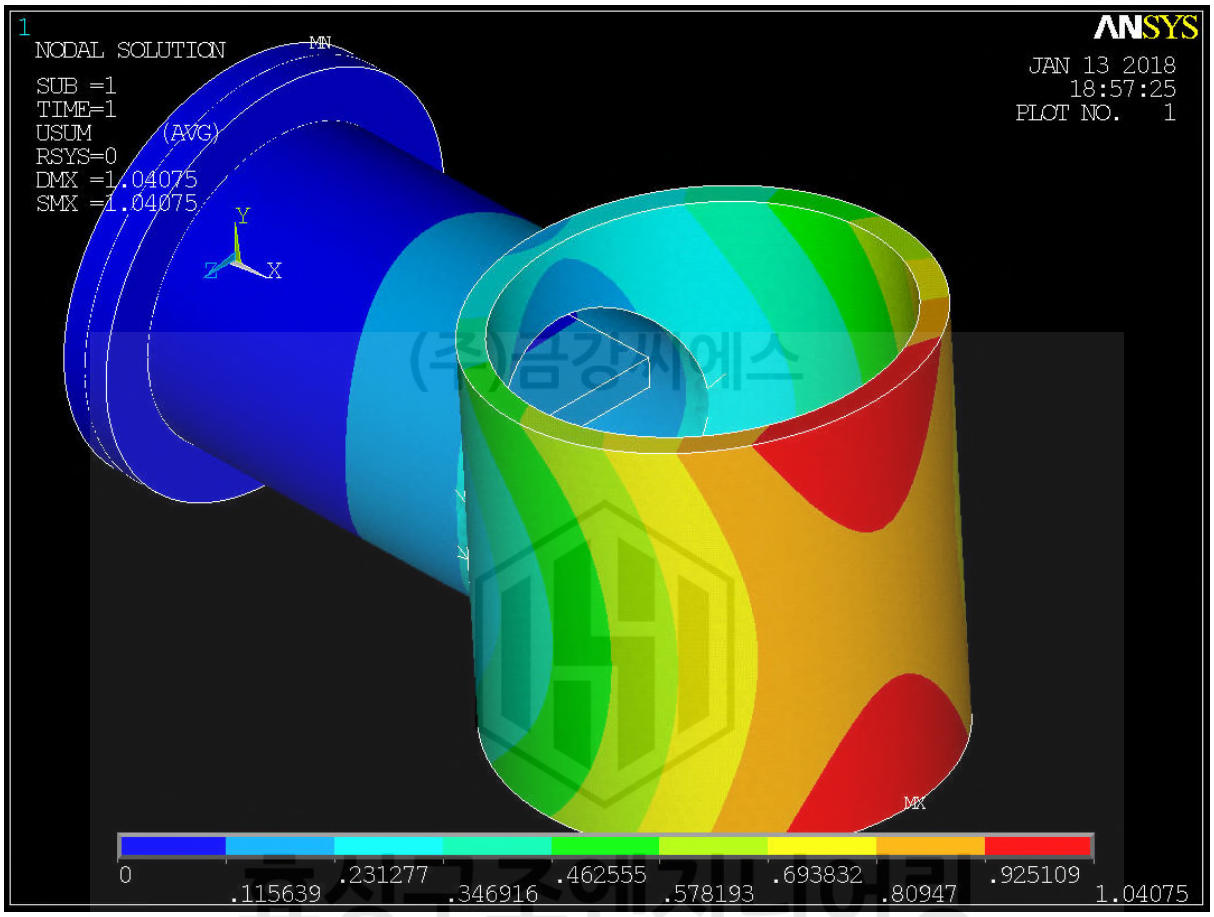
- 해석모델은 모든 하중에 동일한 형상으로 변형.



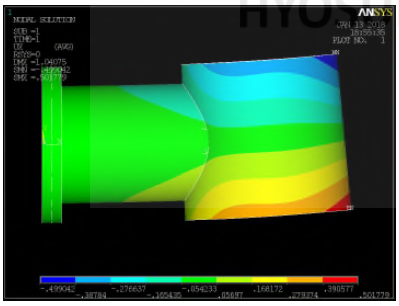
- 해석모델의 최대응력 작용 부분 동일.



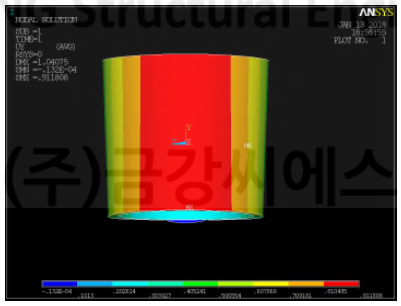
1. $50kfg = 500N$



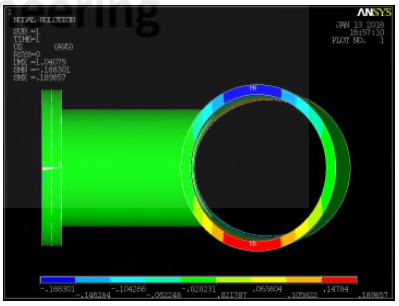
(a) Vector SUM



(b) X-Component



(c) Y-Component

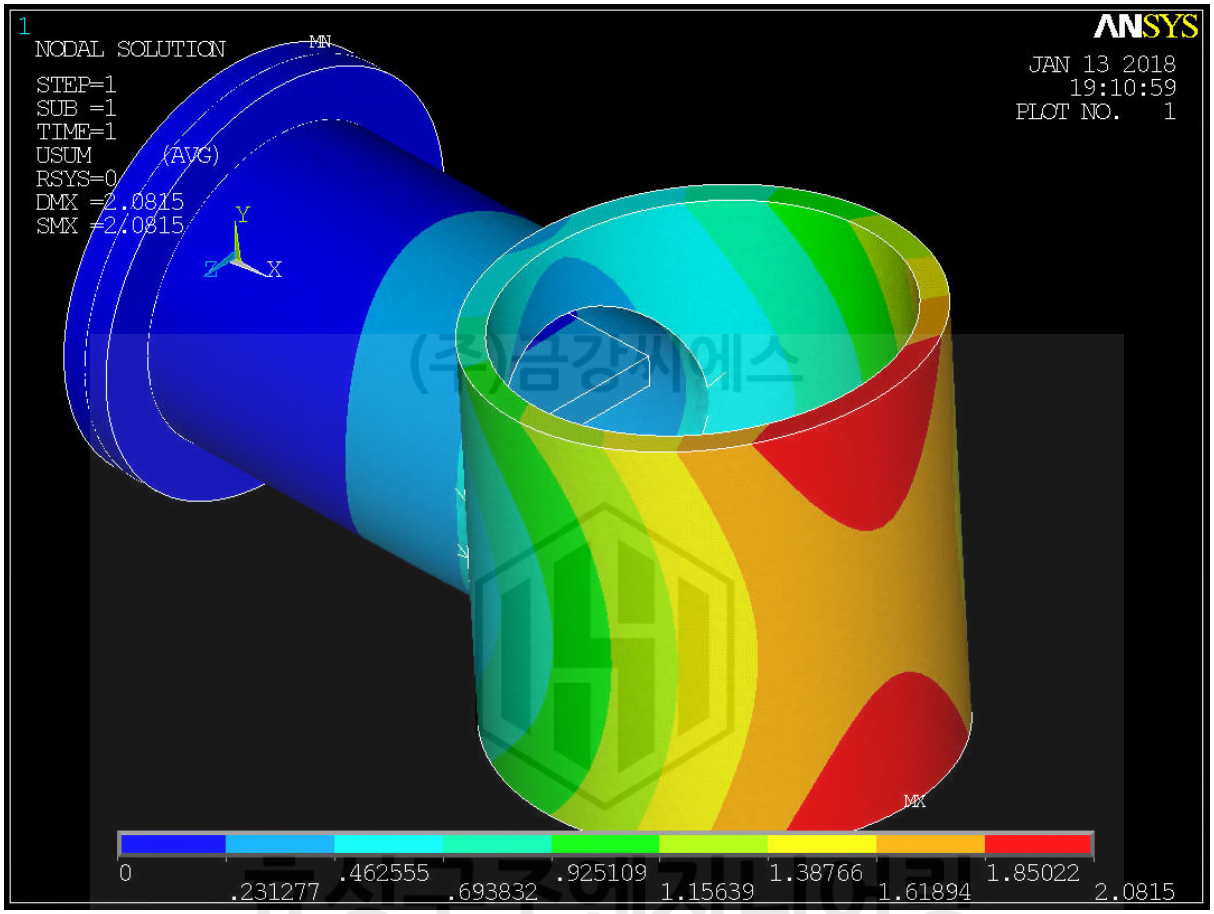


(d) Z-Component

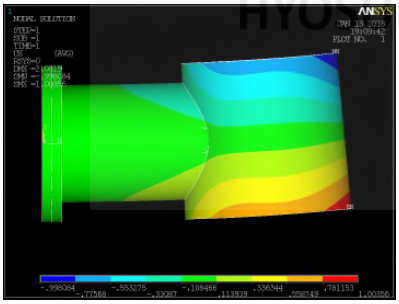
RESULT

- Displacement Vector Sum = 1.041mm
- Displacement of Y-Component = 0.912mm

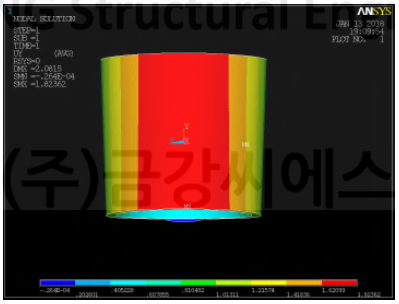
2. $100kfg = 1{,}000N$



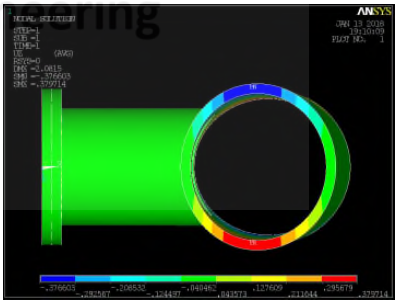
(a) Vector SUM



(b) X-Component



(c) Y-Component

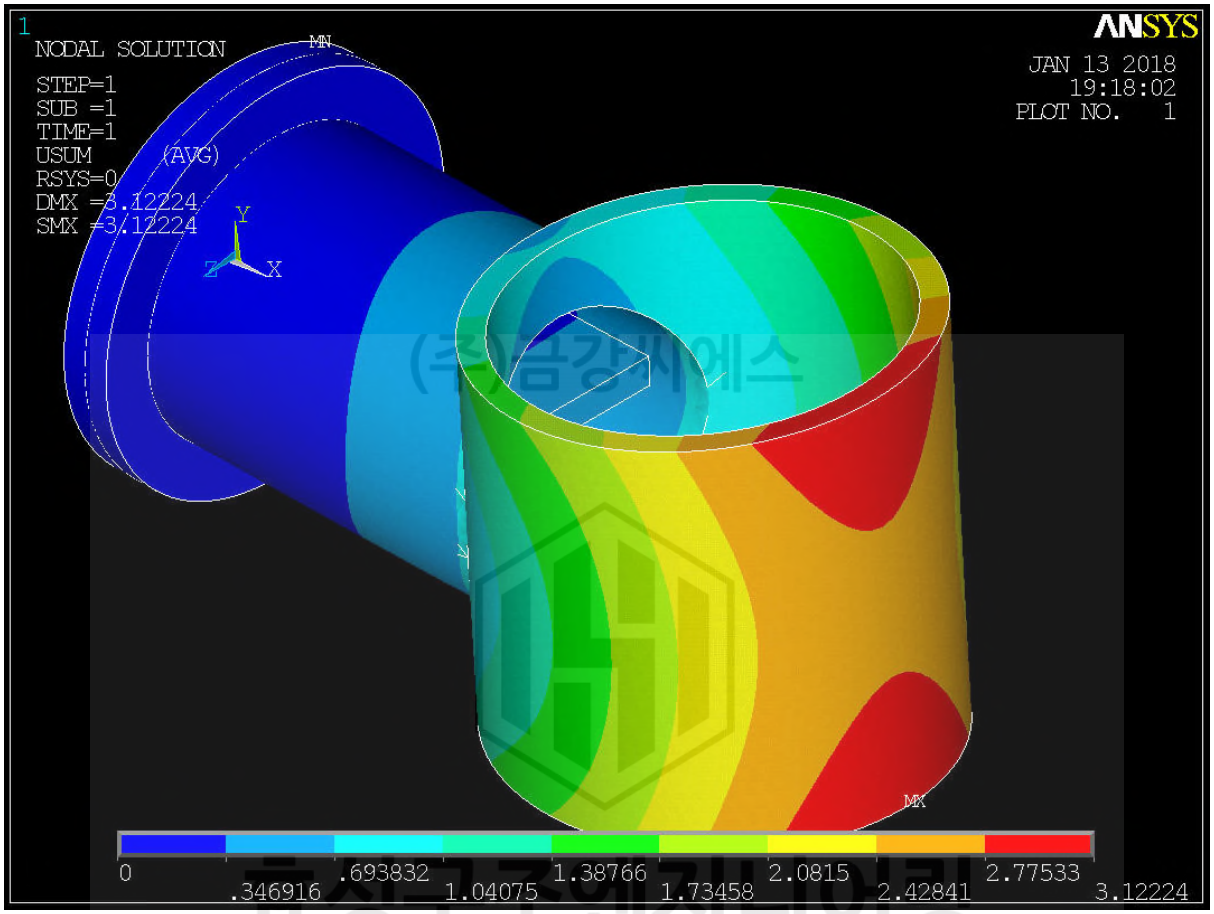


(d) Z-Component

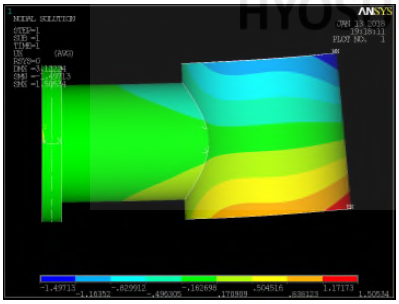
RESULT

- Displacement Vector Sum = 2.082mm
- Displacement of Y-Component = 1.823mm

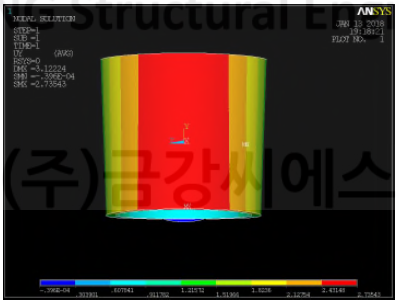
3. $150kfg = 1{,}500N$



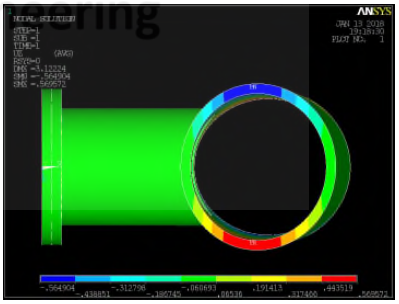
(a) Vector SUM



(b) X-Component



(c) Y-Component

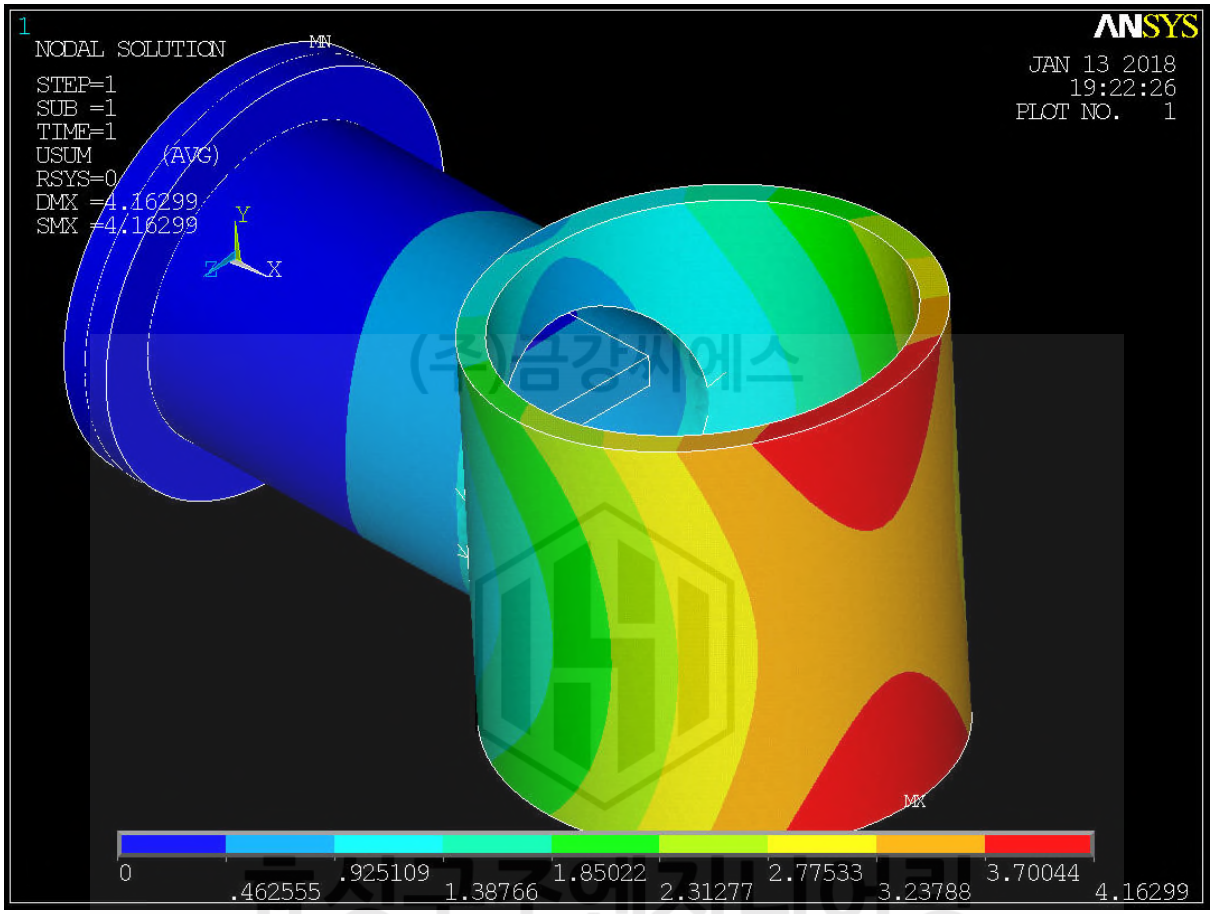


(d) Z-Component

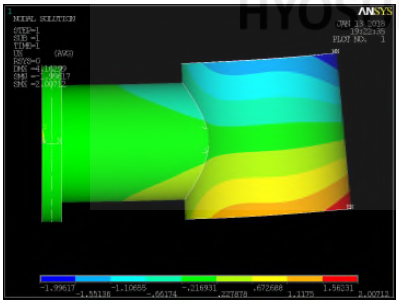
RESULT

- Displacement Vector Sum = 3.122mm
- Displacement of Y-Component = 2.735mm

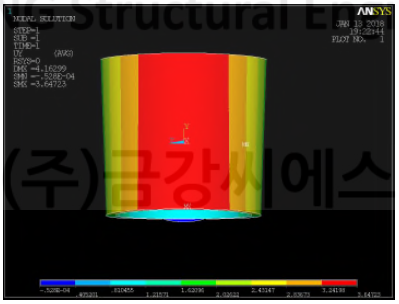
4. $200kfg = 2{,}000N$



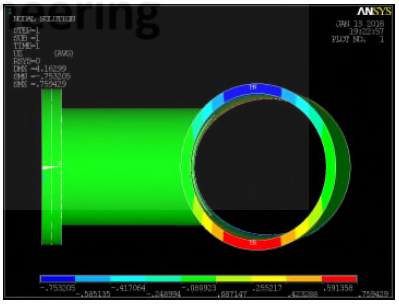
(a) Vector SUM



(b) X-Component



(c) Y-Component

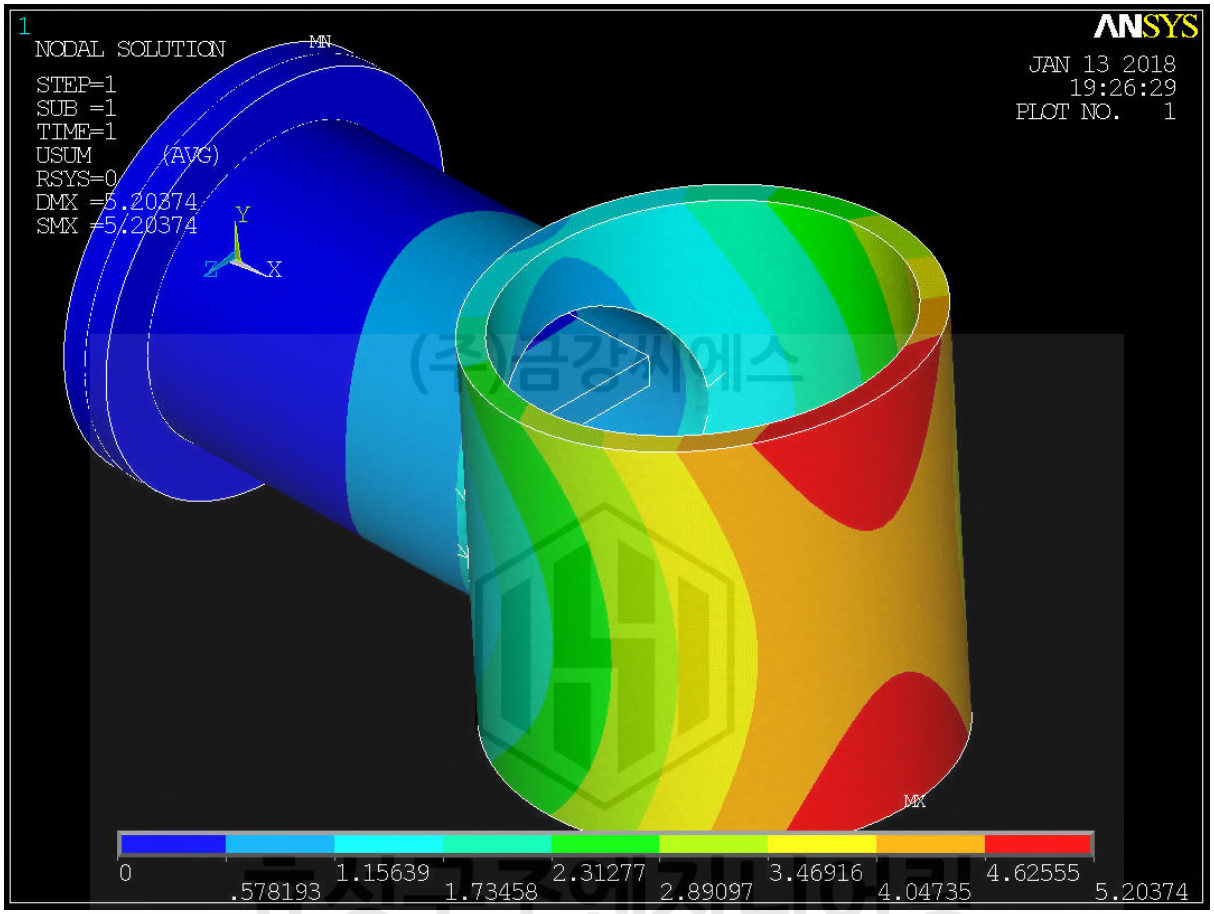


(d) Z-Component

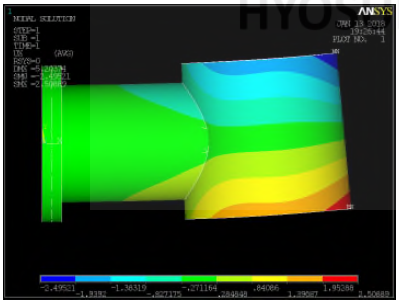
RESULT

- Displacement Vector Sum = 4.163mm
- Displacement of Y-Component = 3.647mm

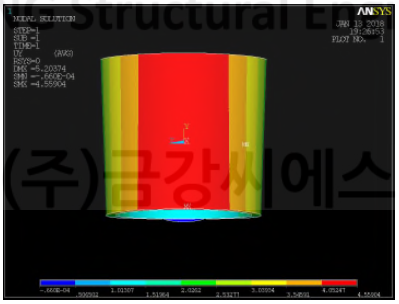
5. $250kfg = 2{,}500N$



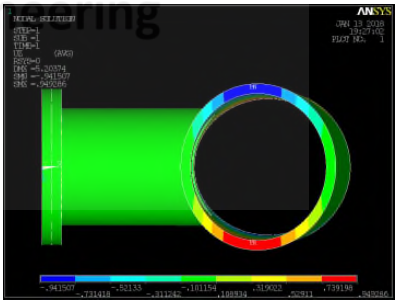
(a) Vector SUM



(b) X-Component



(c) Y-Component

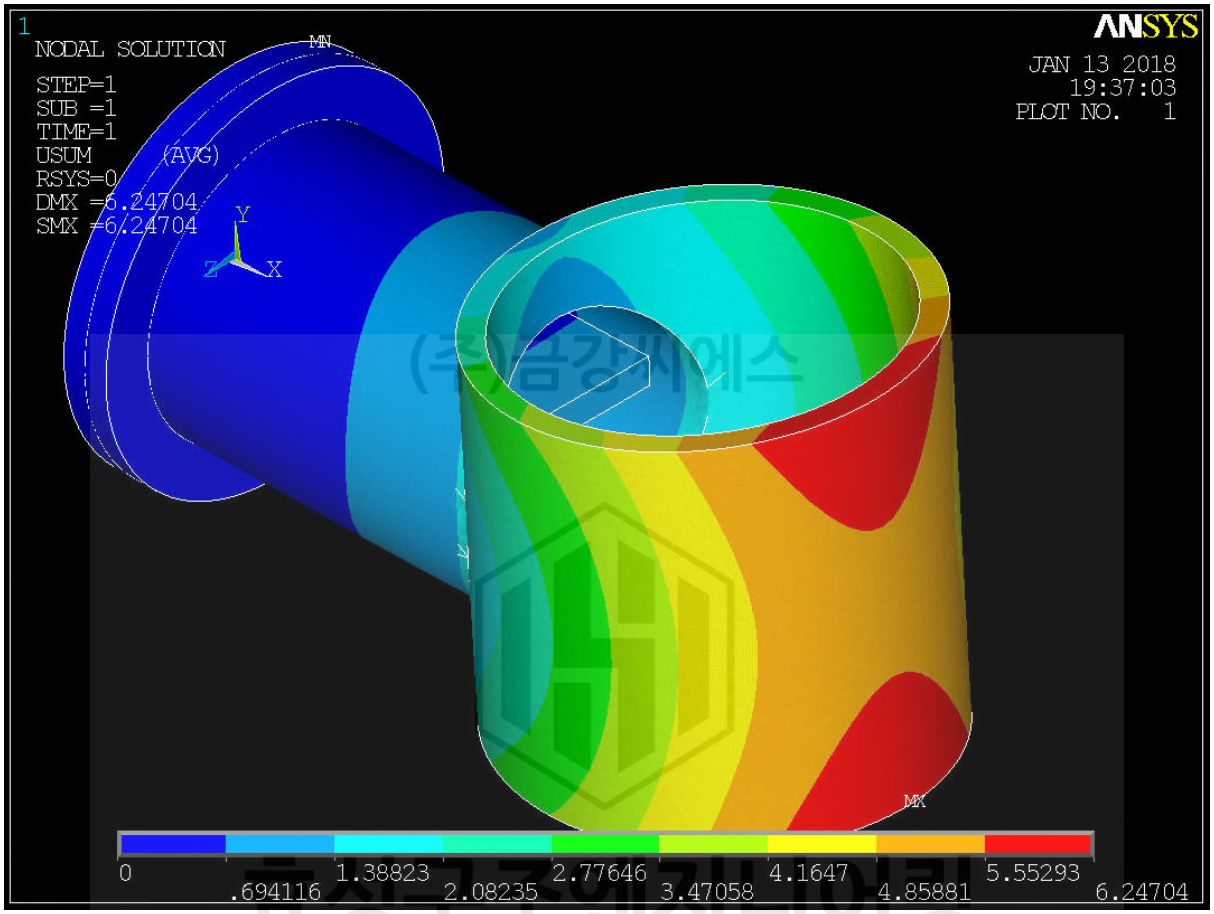


(d) Z-Component

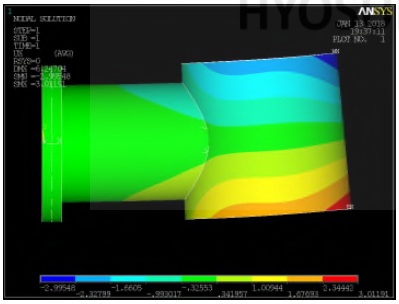
RESULT

- Displacement Vector Sum = 5.204mm
- Displacement of Y-Component = 4.559mm

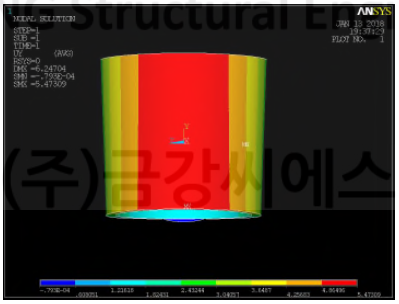
6. $300kfg = 3{,}000N$



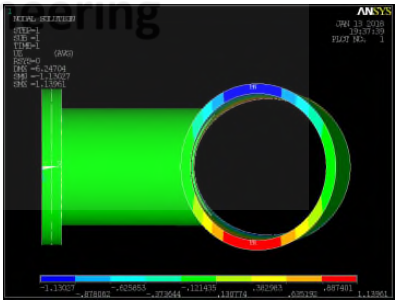
(a) Vector SUM



(b) X-Component



(c) Y-Component

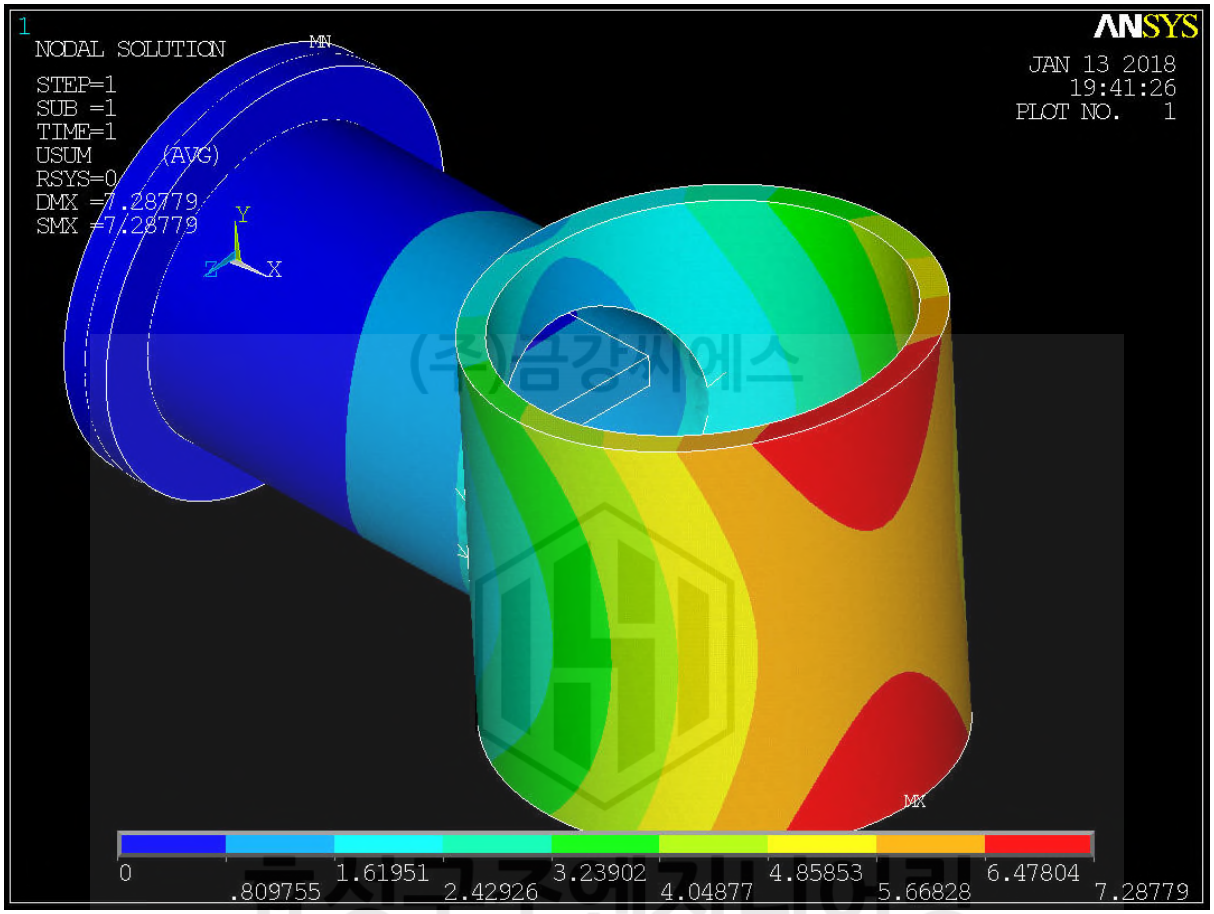


(d) Z-Component

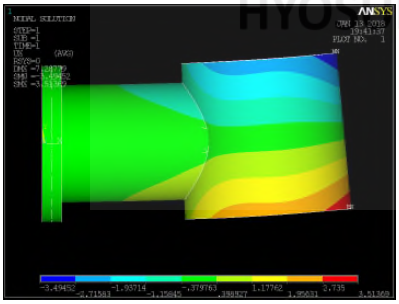
RESULT

- Displacement Vector Sum = 6.247mm
- Displacement of Y-Component = 5.473mm

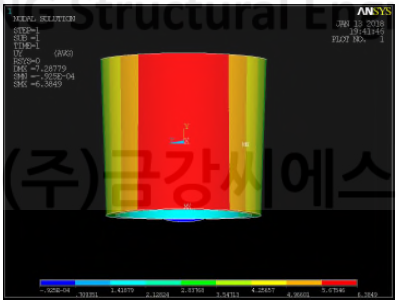
7. $350kfg = 3{,}500N$



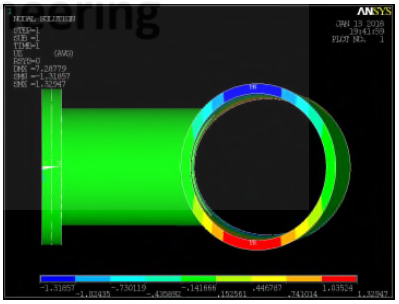
(a) Vector SUM



(b) X-Component



(c) Y-Component

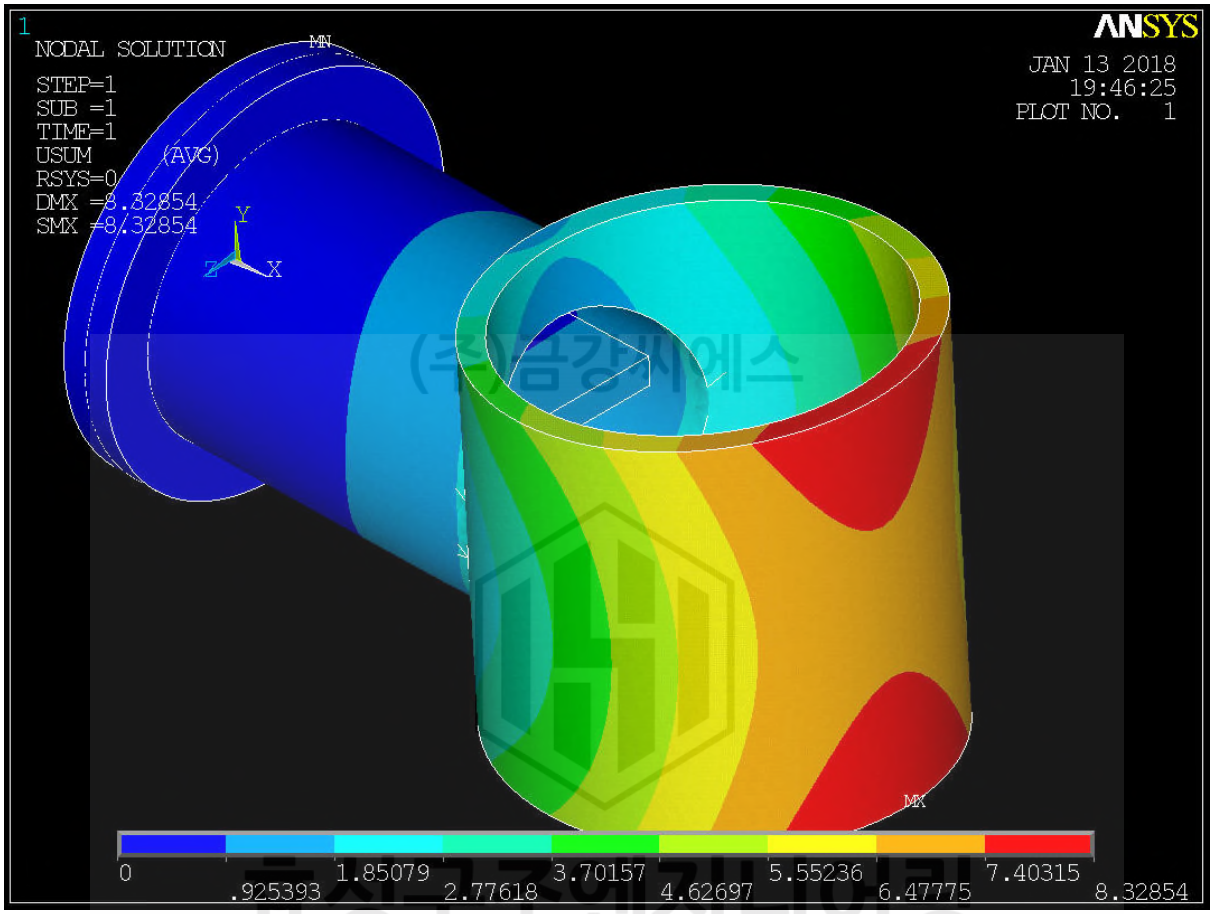


(d) Z-Component

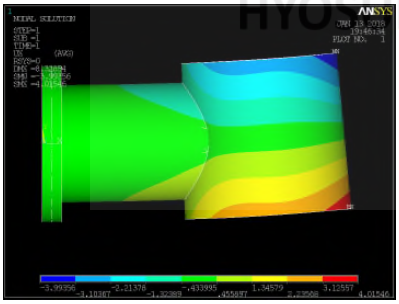
RESULT

- Displacement Vector Sum = 7.288mm
- Displacement of Y-Component = 6.385mm

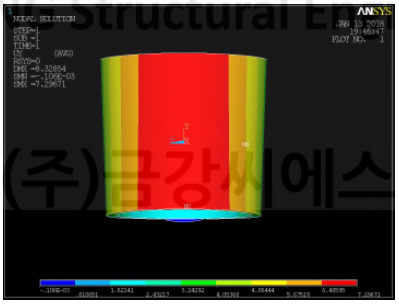
8. $400kfg = 4{,}000N$



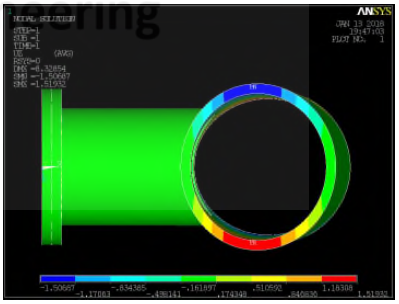
(a) Vector SUM



(b) X-Component



(c) Y-Component

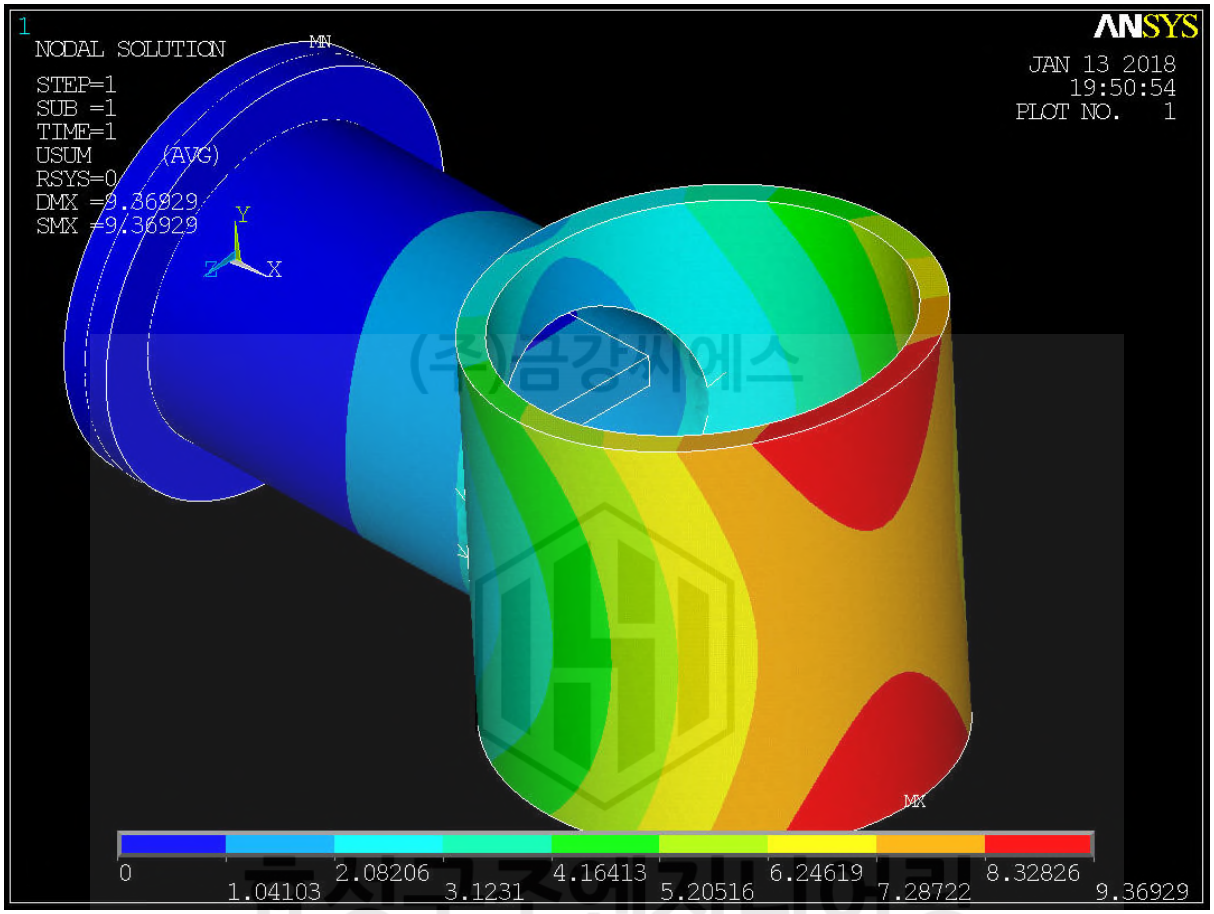


(d) Z-Component

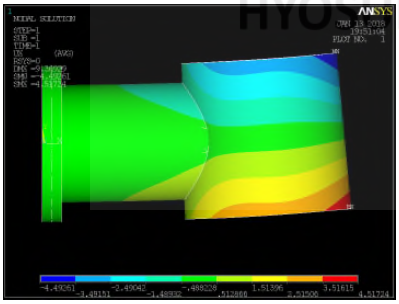
RESULT

- Displacement Vector Sum = 8.329mm
- Displacement of Y-Component = 7.297mm

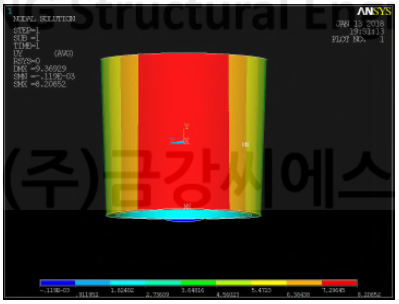
9. $450kfg = 4{,}500N$



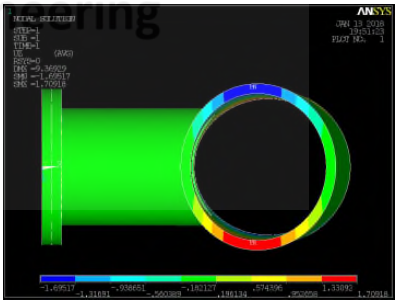
(a) Vector SUM



(b) X-Component



(c) Y-Component

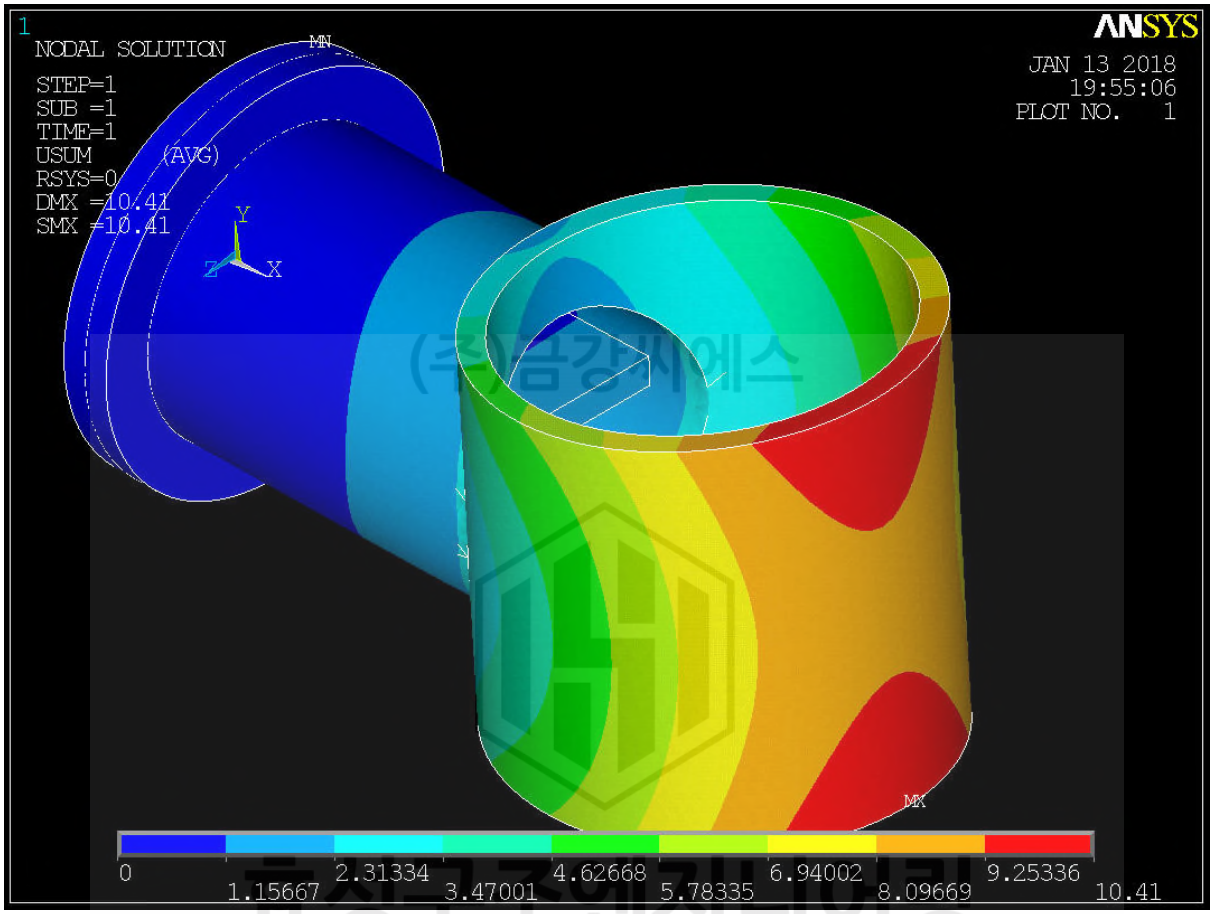


(d) Z-Component

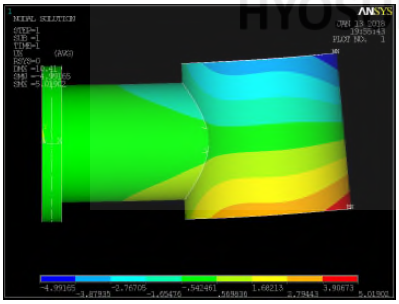
RESULT

- Displacement Vector Sum = 9.370mm
- Displacement of Y-Component = 8.209mm

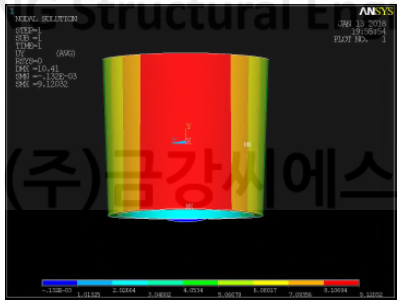
10. $500kfg = 5{,}000N$



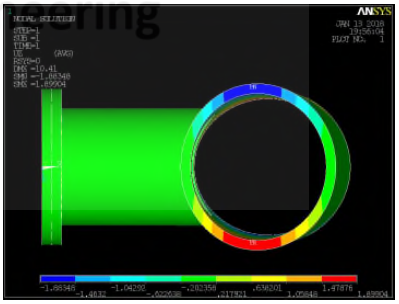
(a) Vector SUM



(b) X-Component



(c) Y-Component



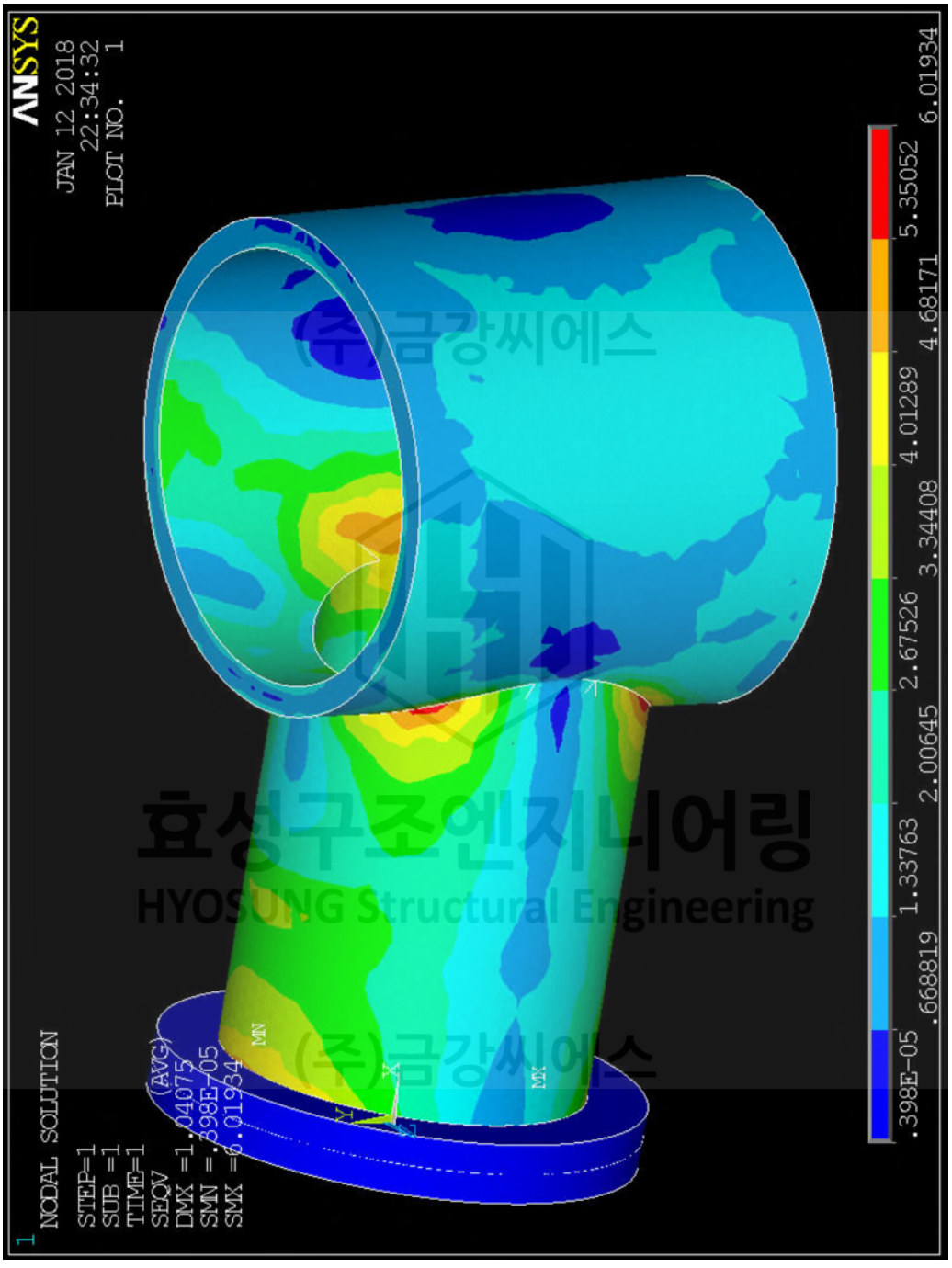
(d) Z-Component

RESULT

- Displacement Vector Sum = 10.410mm
- Displacement of Y-Component = 9.120mm

[별첨 2-Design Ratio]

1. $50kfg = 500N$



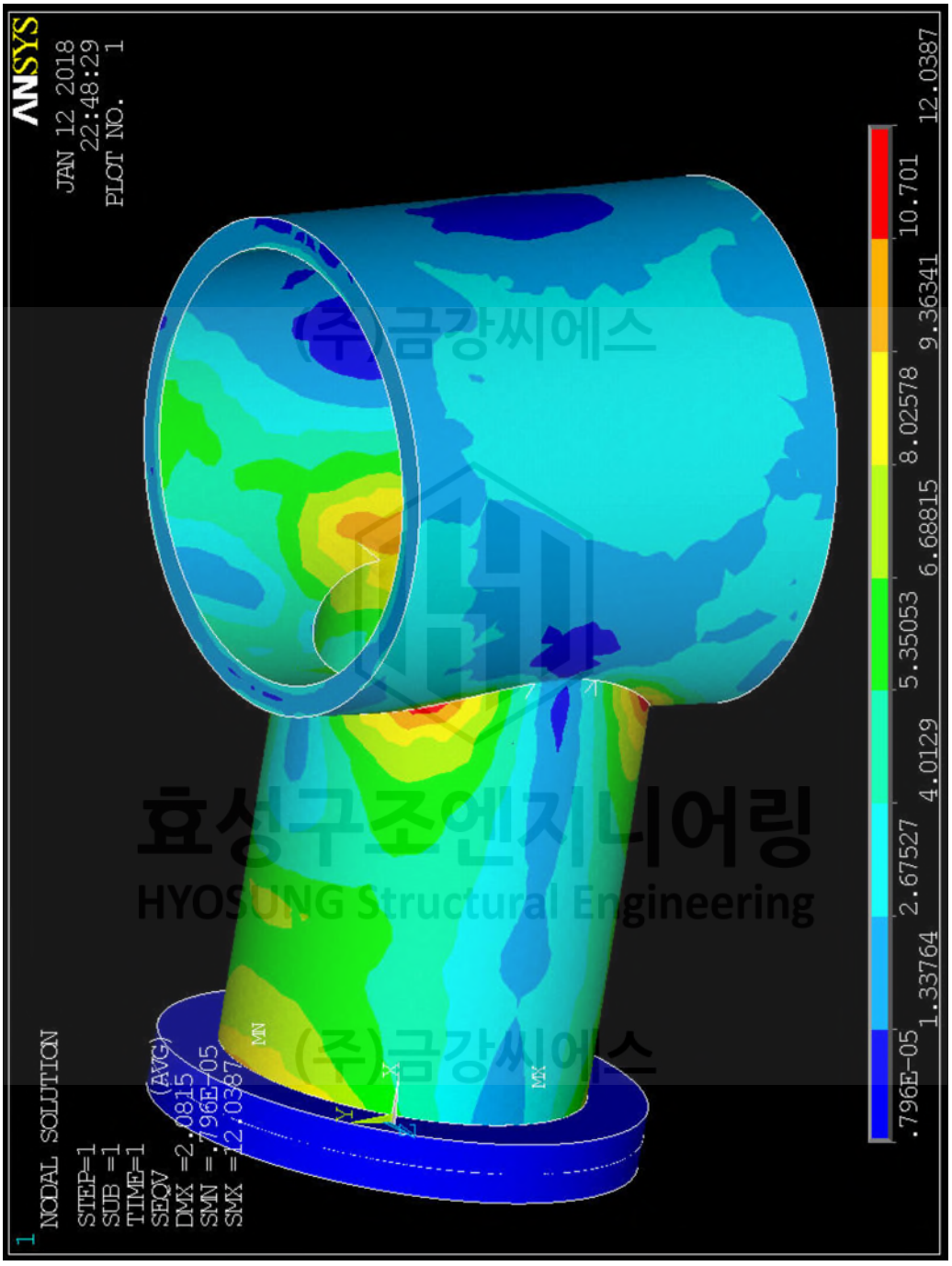
RESULT

Design Ratio = 소요강도 / 항복강도

= 6.019N / 55N

= 0.109 > **안전**

2. $100kfg = 1{,}000N$



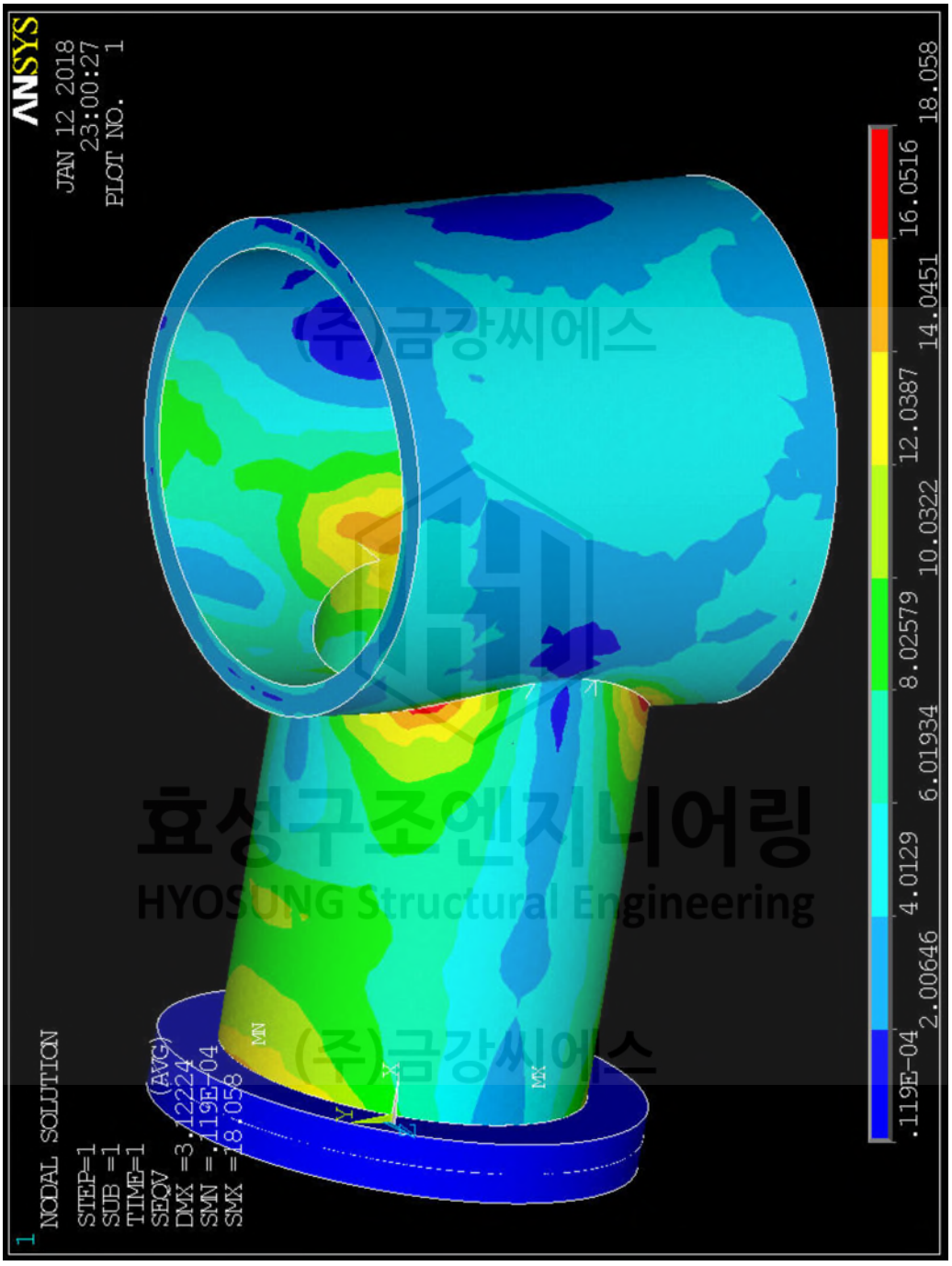
RESULT

Design Ratio = 소요강도 / 항복강도

= 12.039N / 55N

= 0.219 > **안전**

3. $150kfg = 1{,}500N$



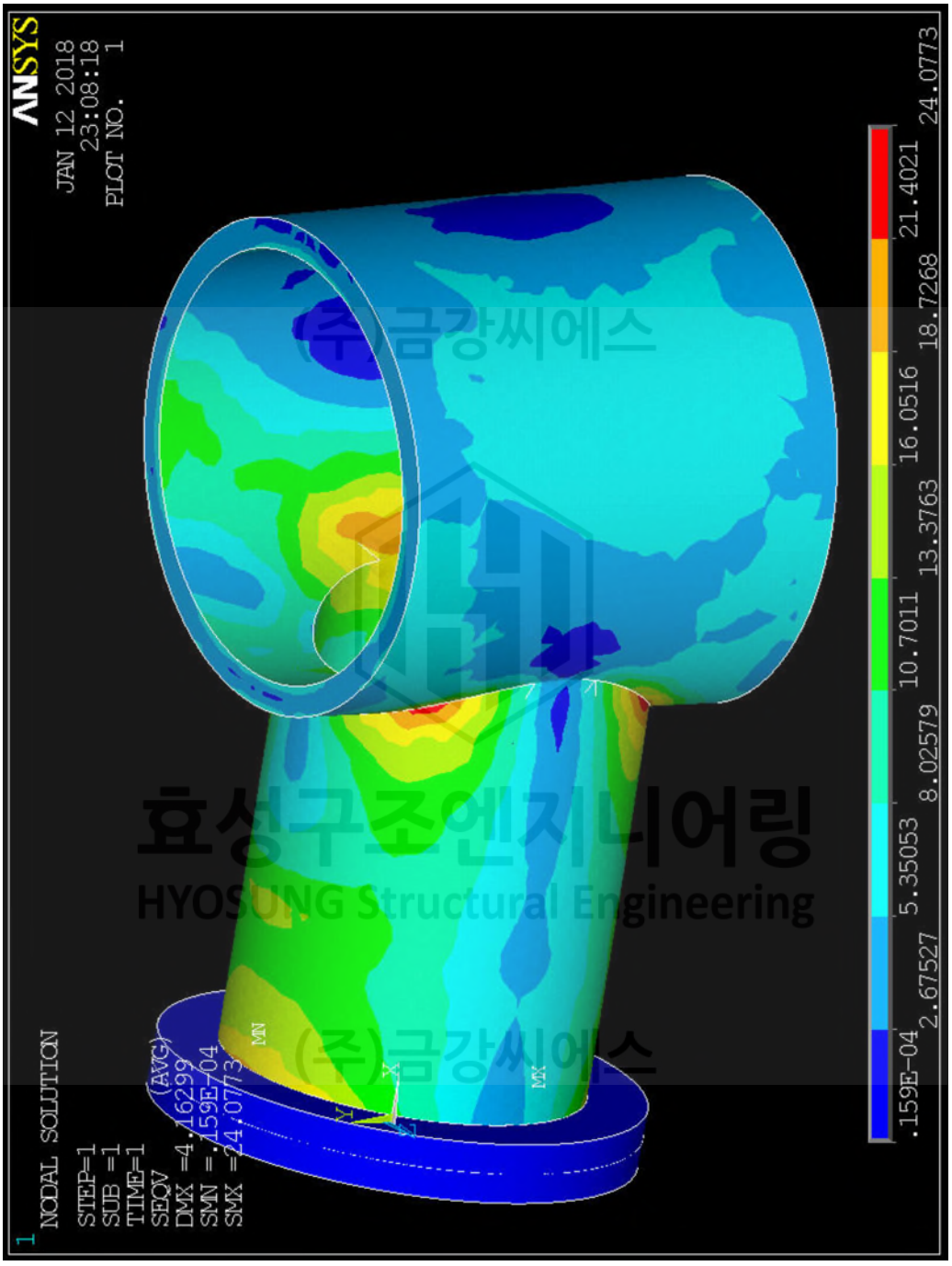
RESULT

Design Ratio = 소요강도 / 항복강도

= 18.058N / 55N

= 0.328 > **안전**

4. $200kfg = 2{,}000N$



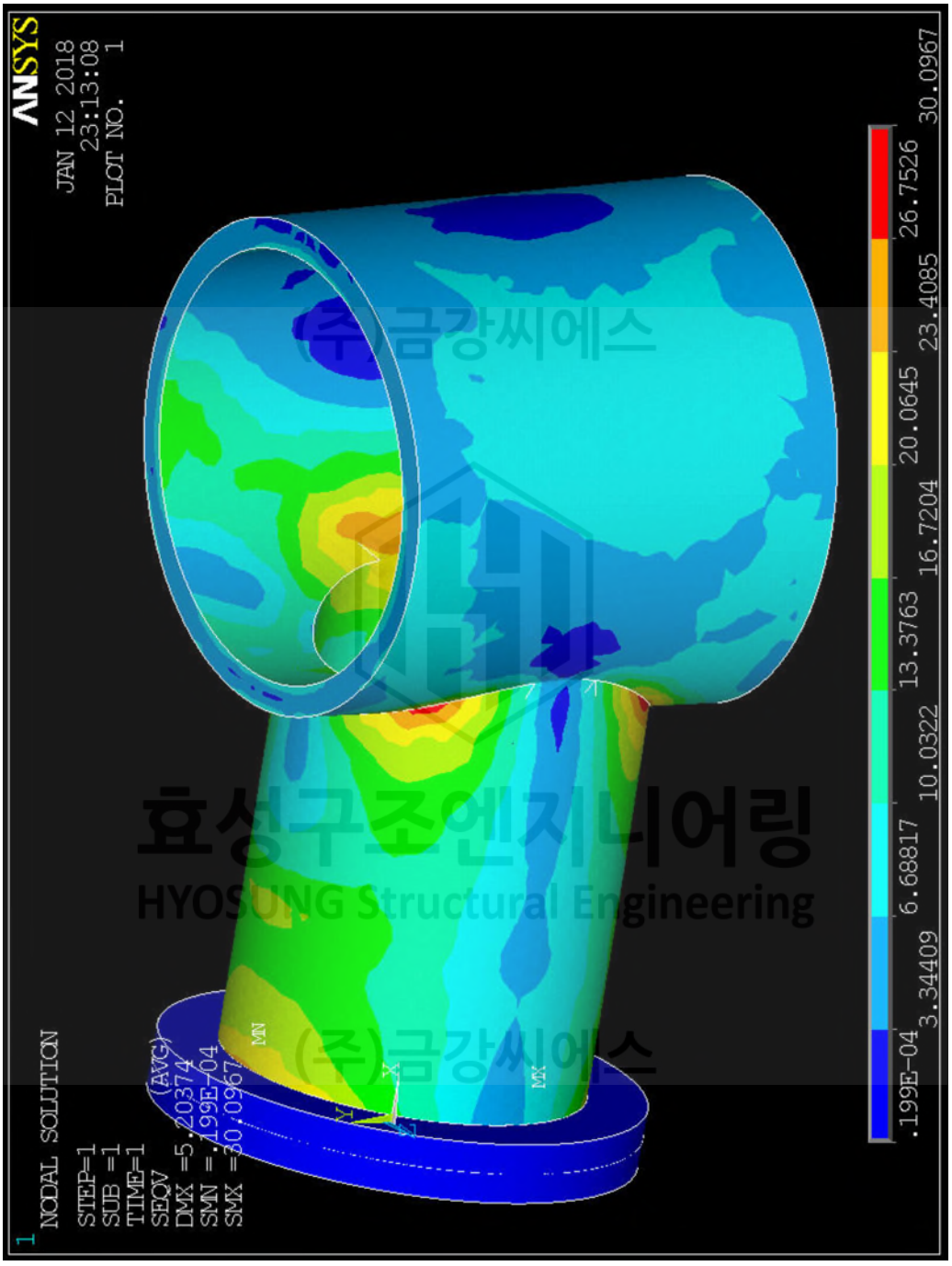
RESULT

Design Ratio = 소요강도 / 항복강도

= 24.007N / 55N

= 0.436 > **안전**

5. $250kfg = 2{,}500N$



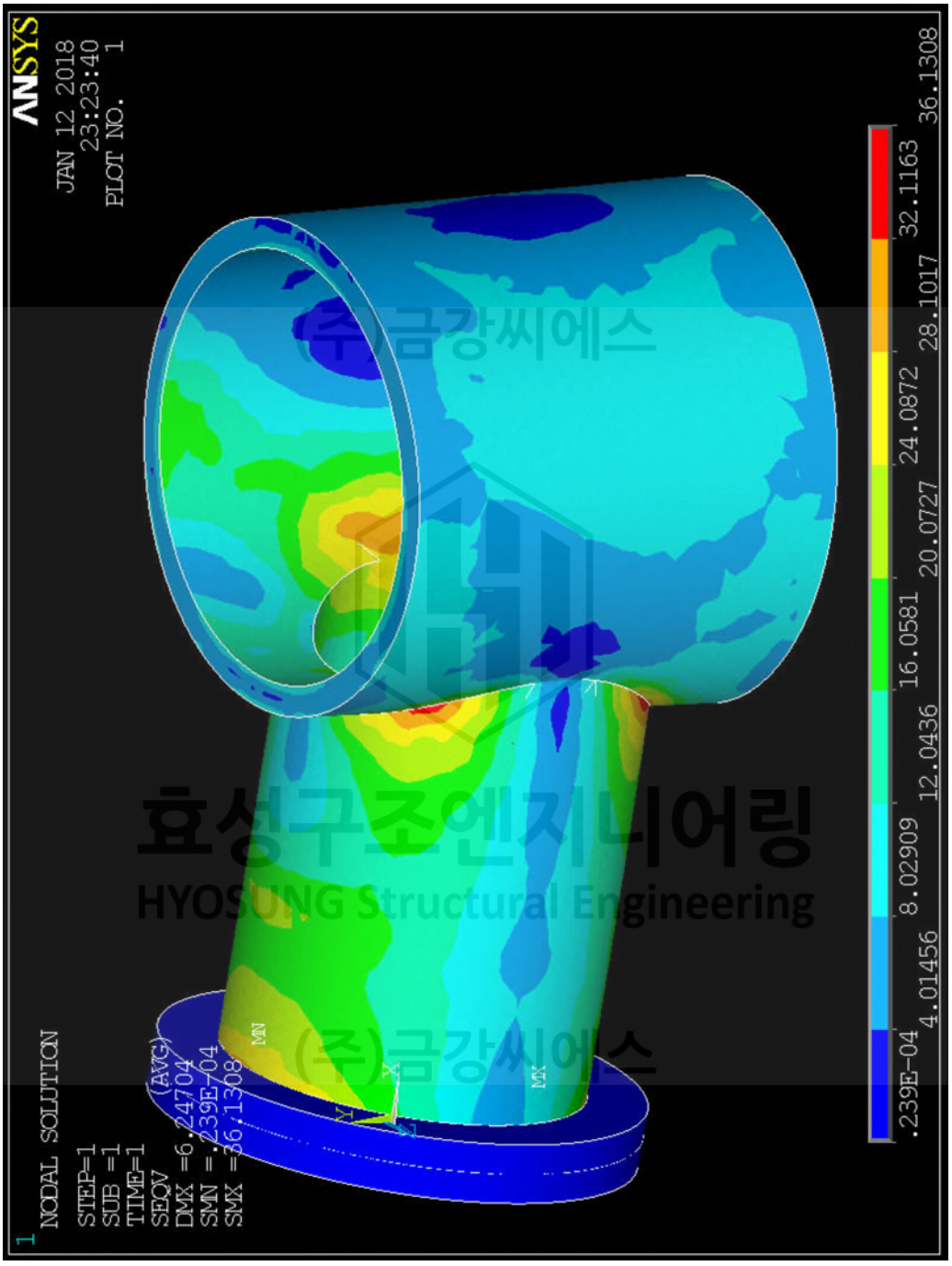
RESULT

Design Ratio = 소요강도 / 항복강도

= 30.097N / 55N

= 0.547 > **안전**

6. $300kfg = 3{,}000N$



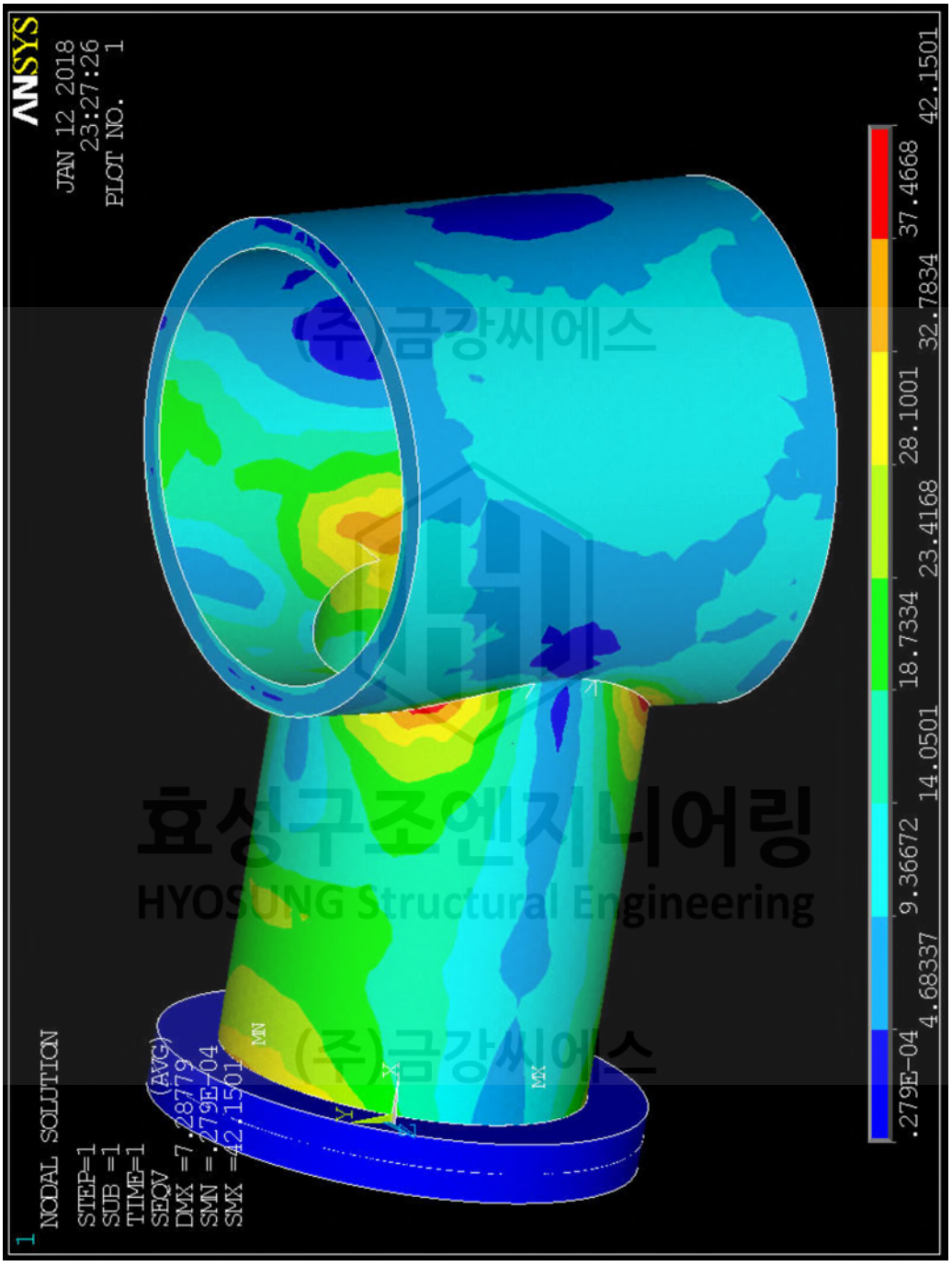
RESULT

Design Ratio = 소요강도 / 항복강도

= 36.131N / 55N

= 0.657 > **안전**

7. $350kfg = 3{,}500N$



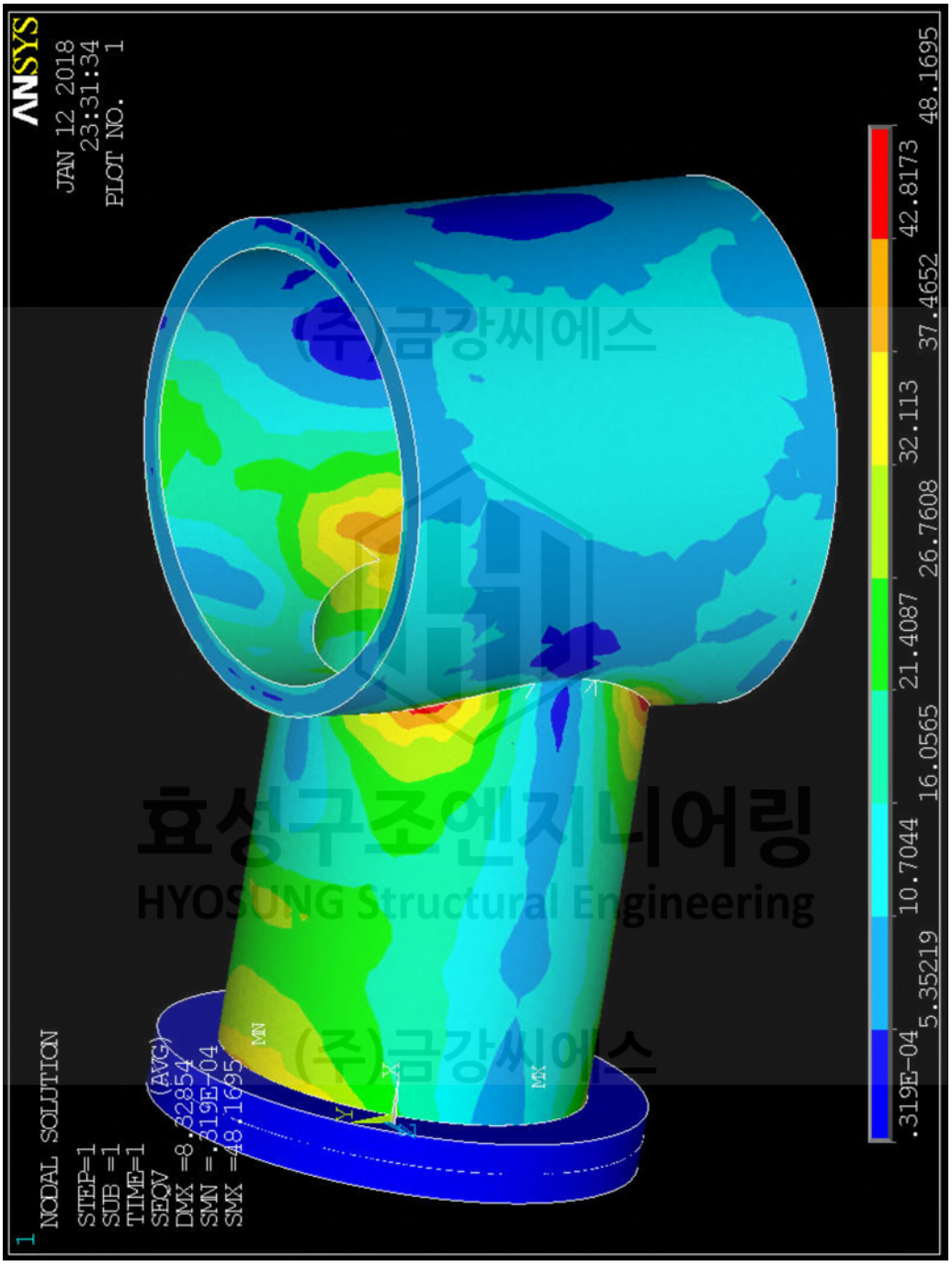
RESULT

Design Ratio = 소요강도 / 항복강도

= 42.150N / 55N

= 0.766 > **안전**

8. $400kfg = 4{,}000N$



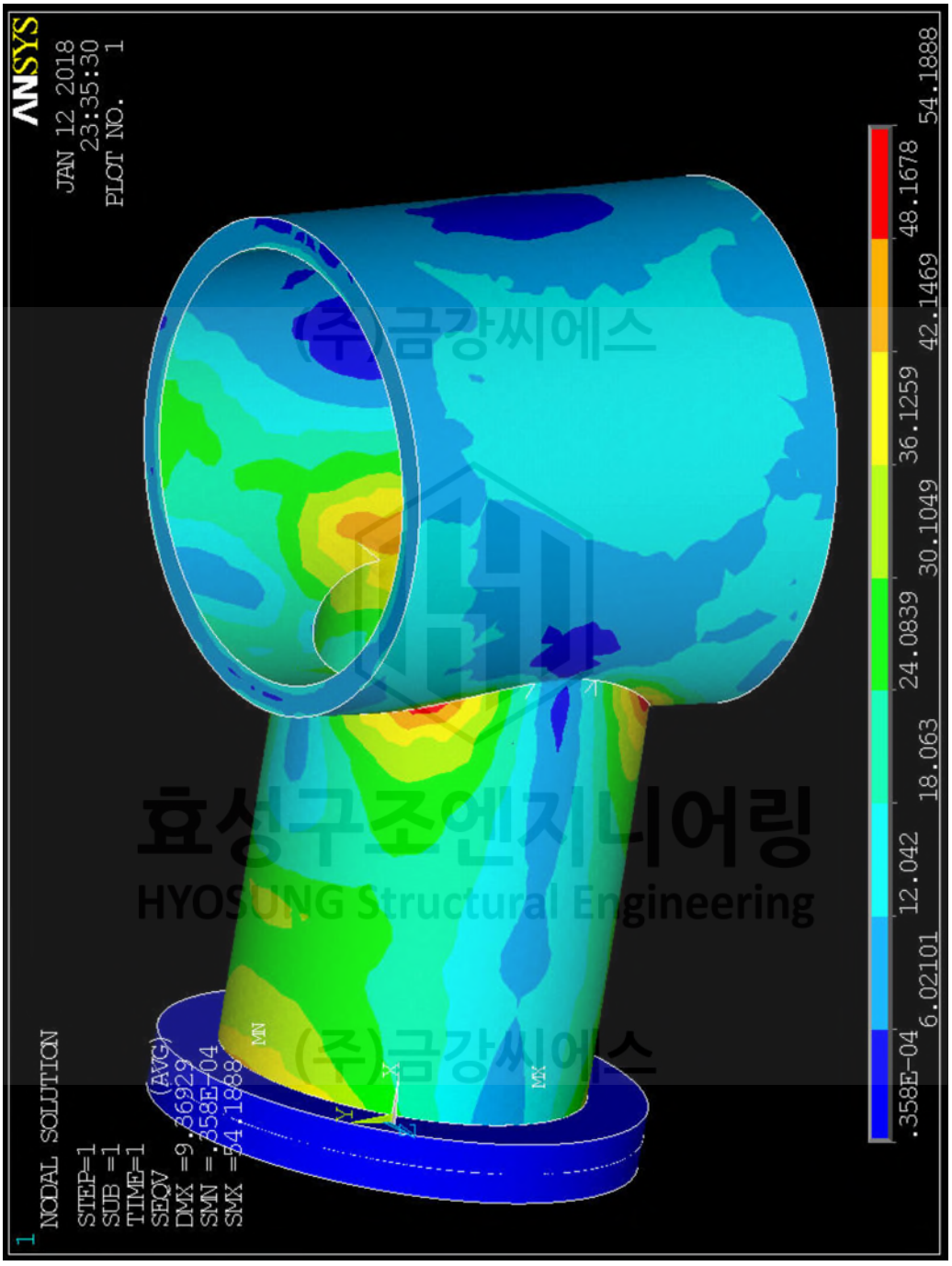
RESULT

Design Ratio = 소요강도 / 항복강도

= 48.170N / 55N

= 0.876 > **안전**

9. $450kfg = 4{,}500N$



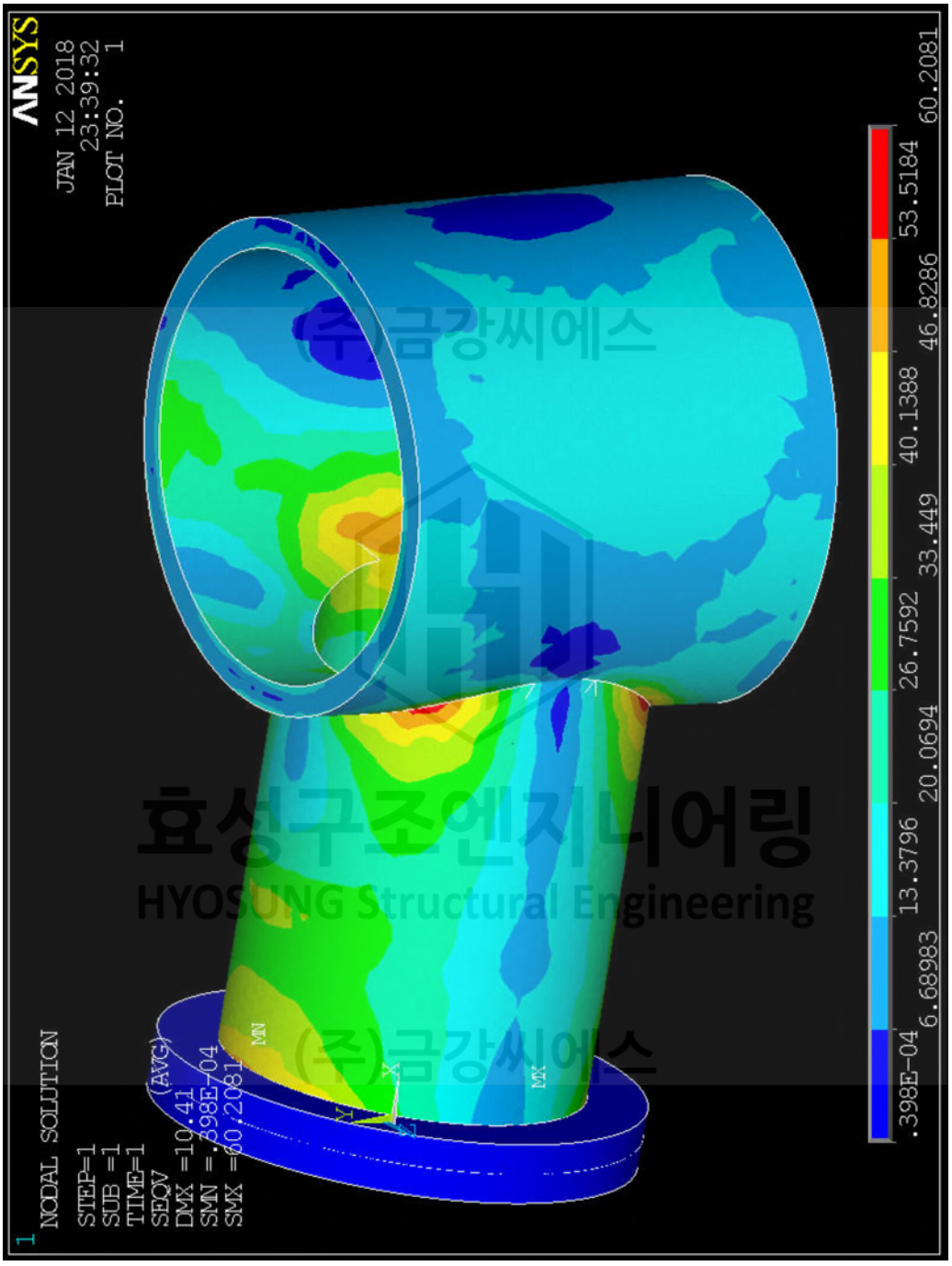
RESULT

Design Ratio = 소요강도 / 항복강도

= 54.199N / 55N

= 0.985 > **안전**

10. $500kfg = 5{,}000N$



RESULT

Design Ratio = 소요강도 / 항복강도

= 60.208N / 55N

= 1.095 > **파괴**