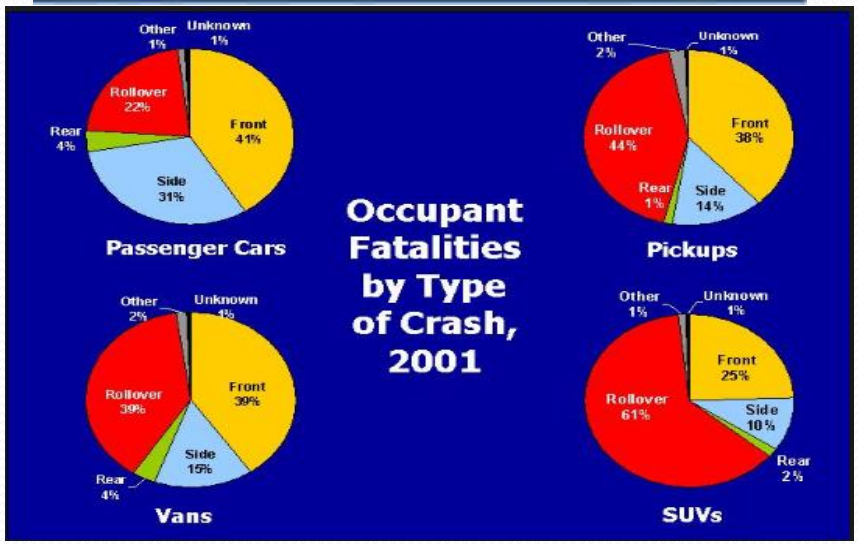
Roof crush test를 위한 B-pillar 보강재 최적설계

미래자동차공학과

2011004147

정규빈

주제선정배경: Rollover fatality

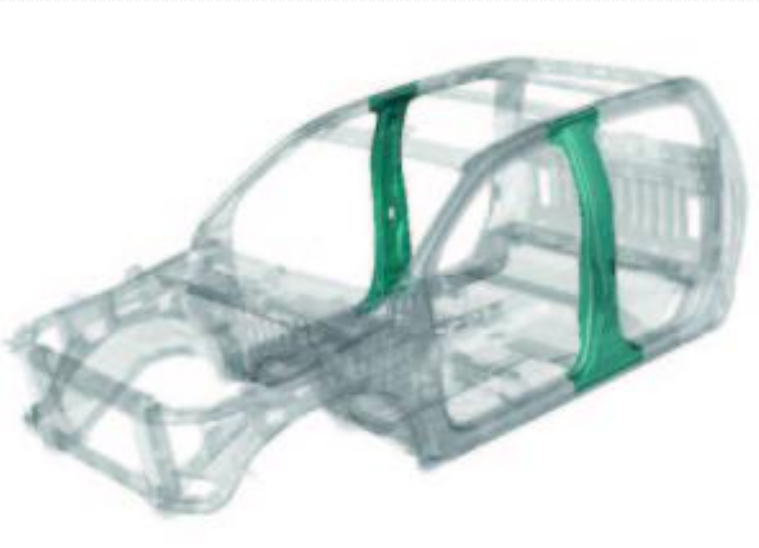


<Roof crush 보강에 대한 필요성>

차종에 따라 다르지만 픽업트럭이나 van 특히 SUV의 경우 롤오버 발생시 사망률이 다른 타입의 충돌(Front,side crash등)에 비해 높음

B-pillar

- 자동차의 front door와 rear door 사이의 수직하중을 견디는 차체 기둥
- 롤오버시 탑승자의 안전과 직결



FMVSS 216 Roof crush test

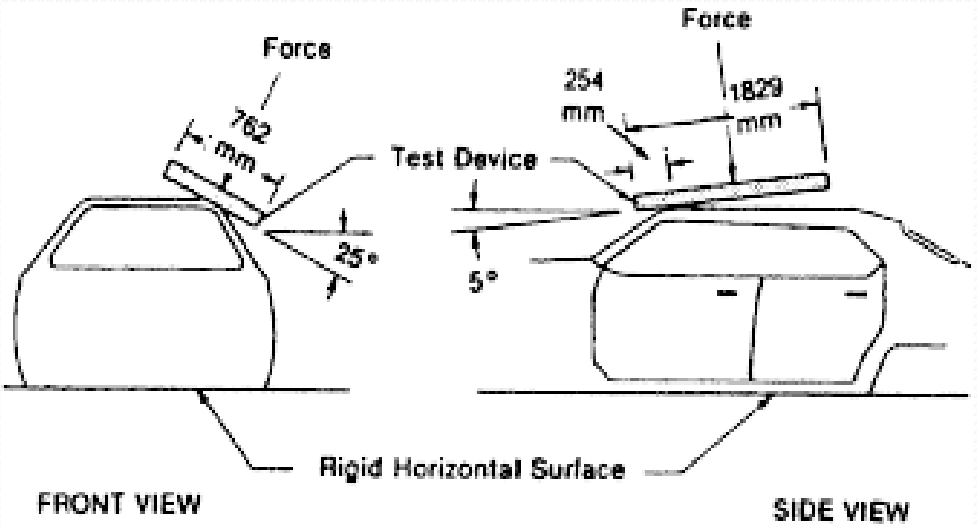


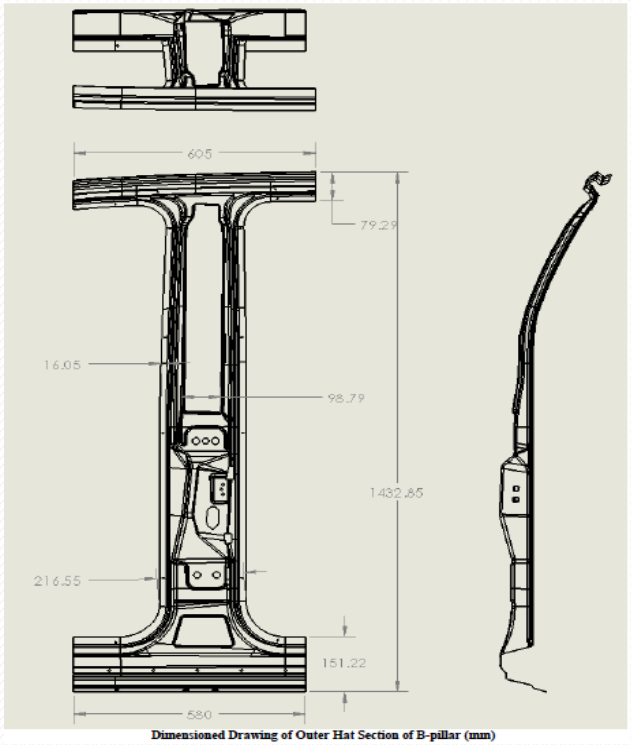
Figure 2.- Test Device Location And Application To The Roof

Force=1.5mg 또는 22240N중 작은 것으로

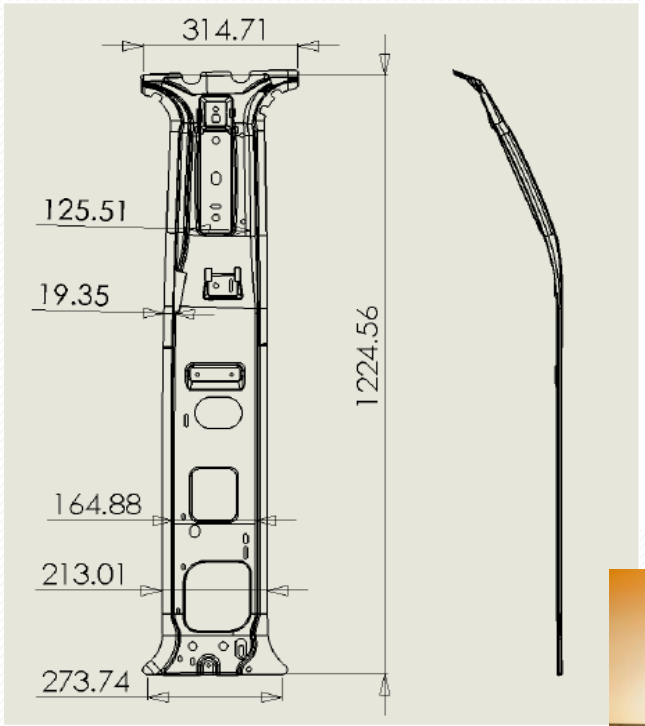
5in=127mm이상 displacement발생하면 안 됨. 최대허용변위

대상 모델

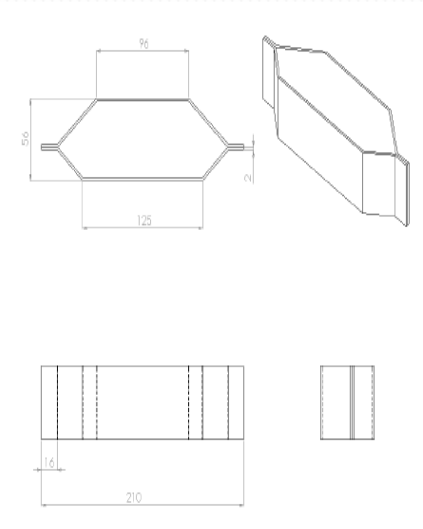
- **Ford F-150 B-pillar 모델 이용**



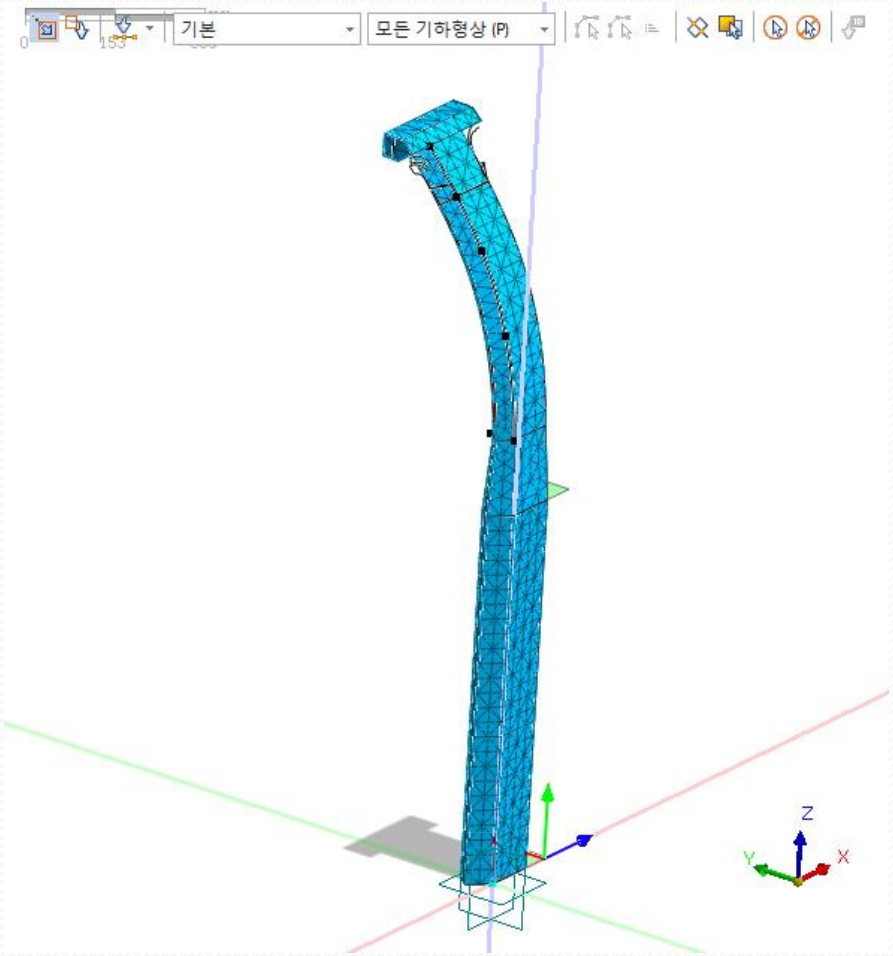
Dimensioned Drawing of Outer Hat Section of B-pillar (mm)



Dimensioned Drawing of Inner Hat Section of B-pillar (mm)

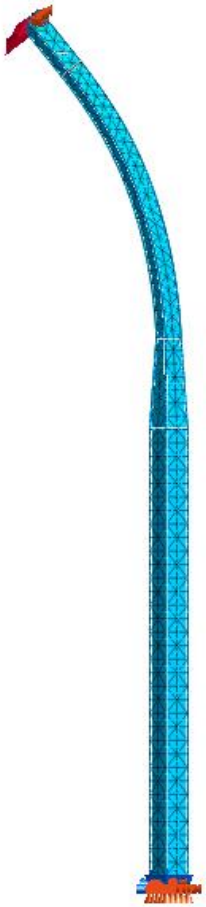


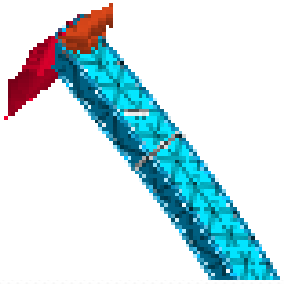
초기 모델링



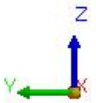
윗부분의 3차원fillet이 들어가는등 복잡한 형상의 정확한 모델링 구현 어려움-> b-pillar 윗부분 형상 제거 단순화

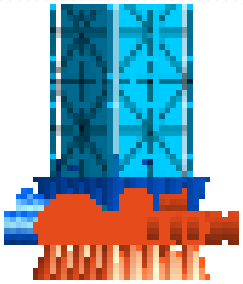
구속 조건





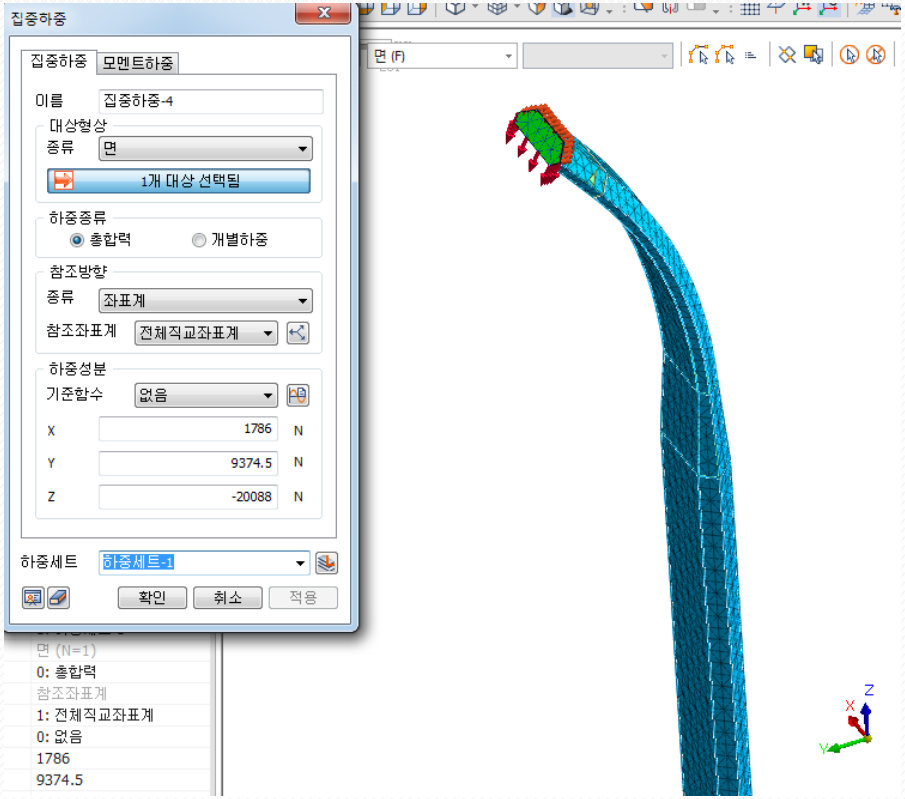
윗단:Roof와 고정되어 있으므로 y축방향 구속





아랫단: 고정 구속

하중 조건



윗 단면에 집중 하중

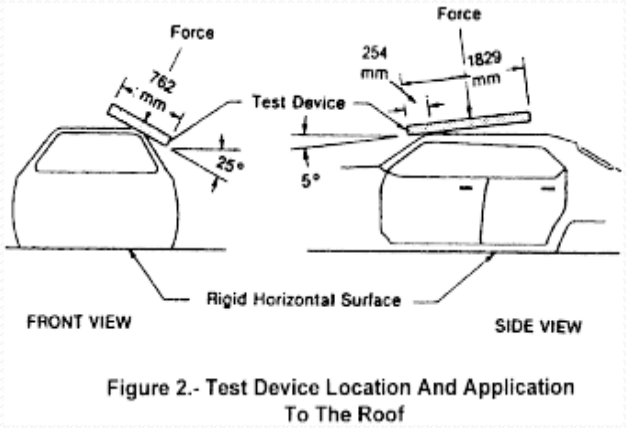
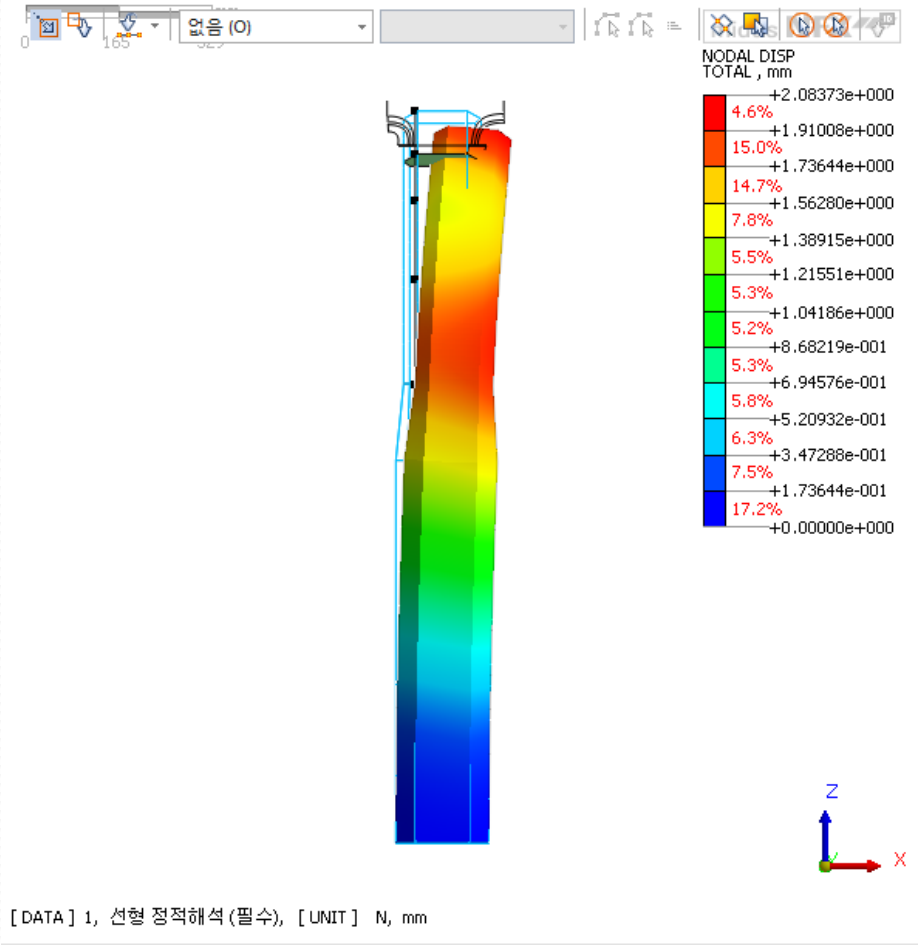


Figure 2.- Test Device Location And Application To The Roof

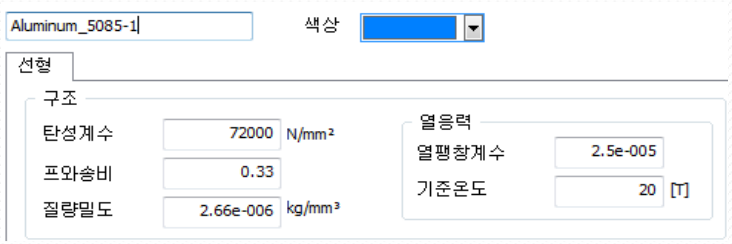
총 합력 22240N에서
Y축방향 회전 -25도
X축방향 회전 +5도 이므로
계산 결과
X방향: 1786N
Y방향: 9374.5N
Z방향: -20088N

위상 최적화(컴플라이언스 최소화)

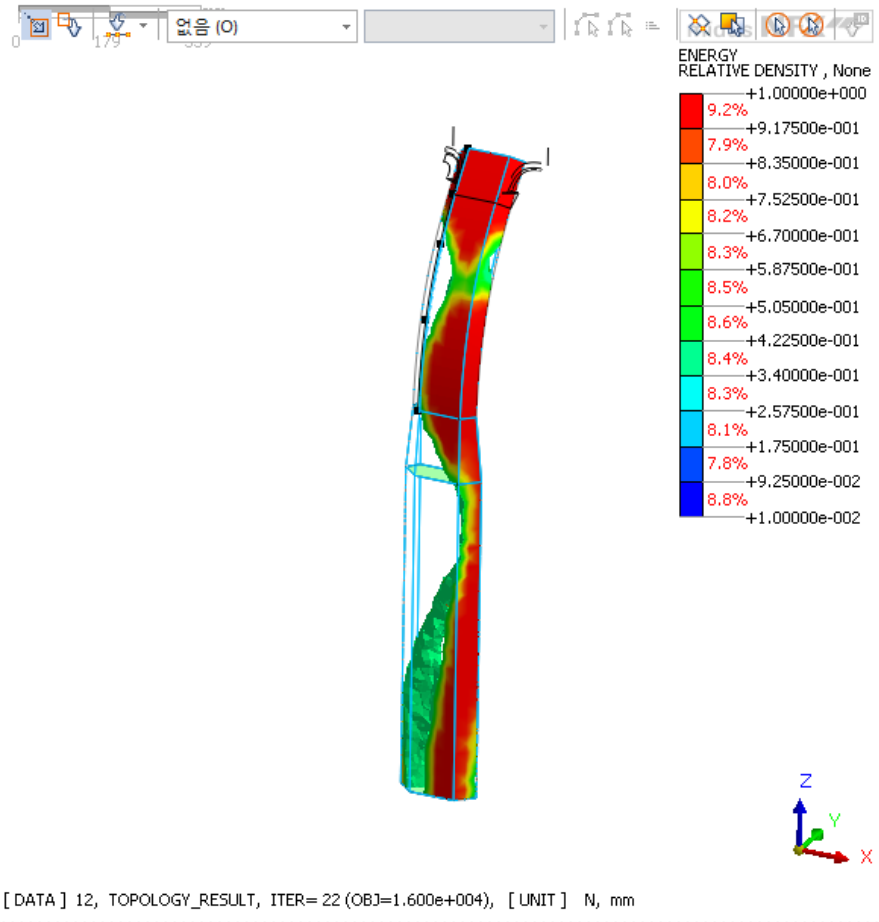


변위

보강재 재료: 알루미늄

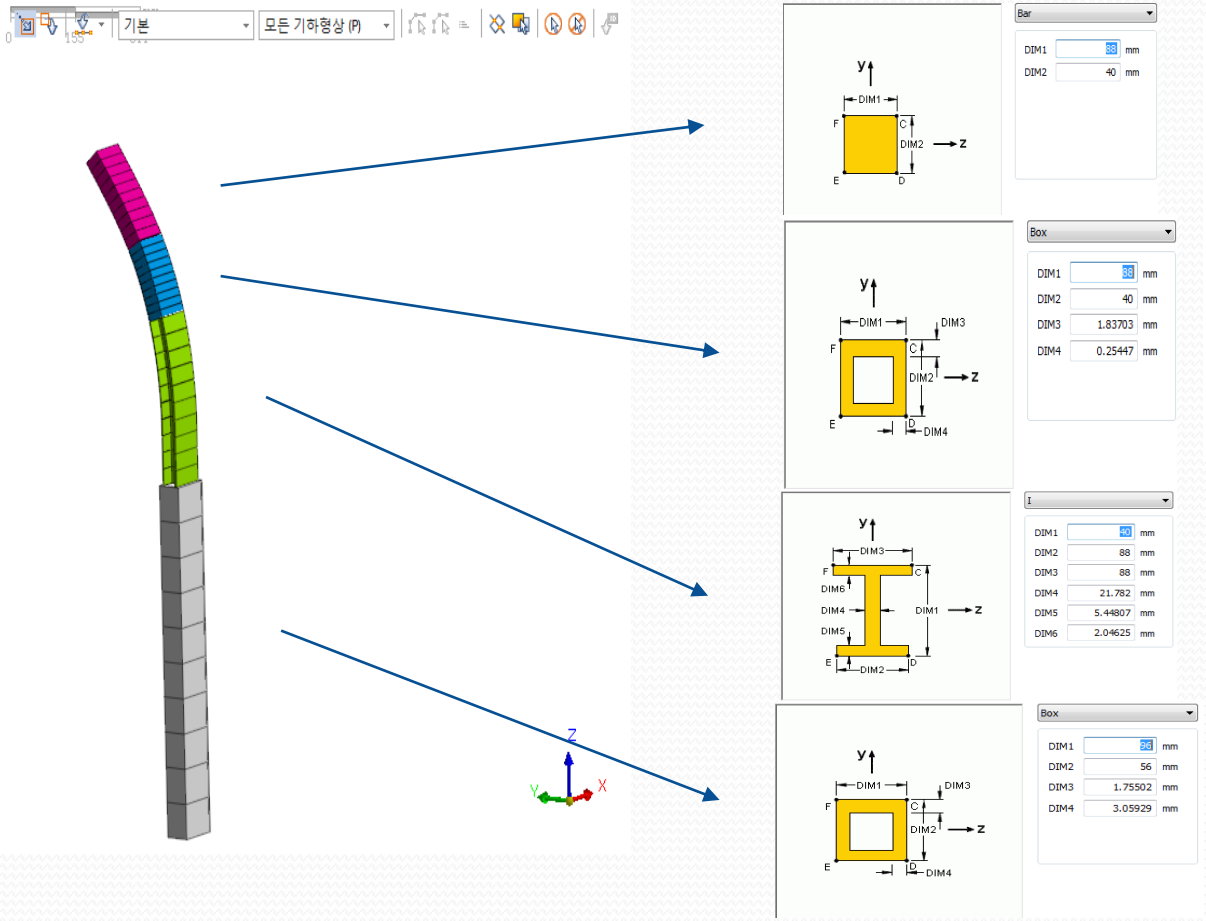


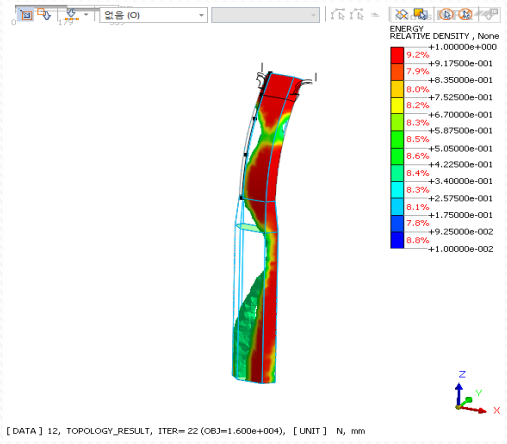
위상 최적화(컴플라이언스 최소화)



치수 최적

- 위상 최적화 결과를 바탕으로 1d요소를 파트 별로 나누고 단면 형상 결정





Inner, outer와 assembly가 되어야 하므로 바깥부분 size는 고정, 내부 두께치수들을 설계변수로 지정

치수 최적

- 목적 함수: 부피 최소화
- 제약 조건: 응력,변위

$$S_{max} \leq \frac{S_{ultimate,aluminum}}{safety\ \ factor} = 120MPa$$

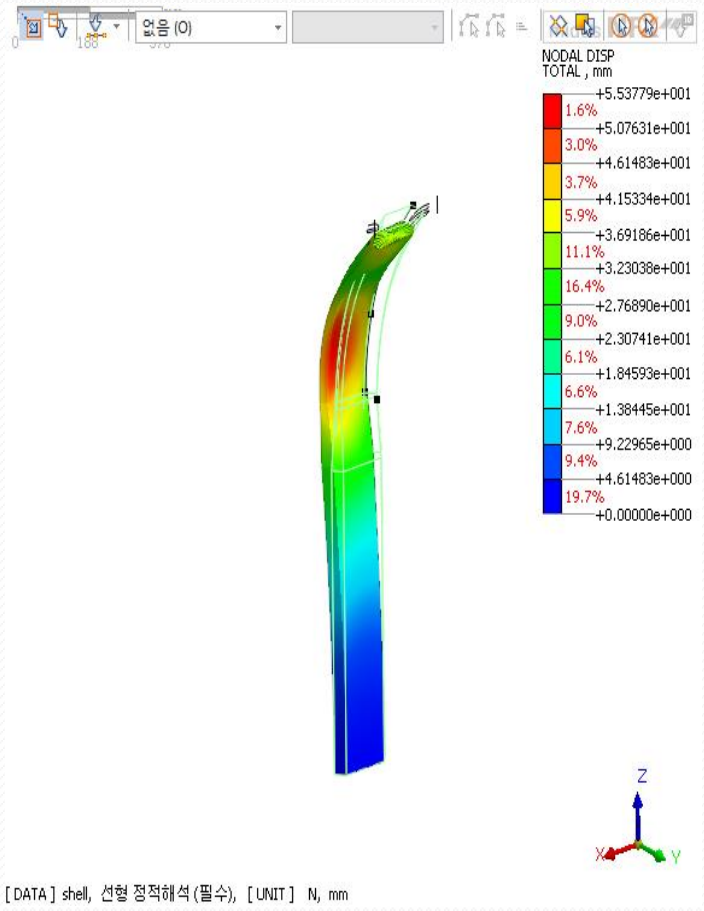
$$\text{Displacement} \leq 121.1\text{mm}$$

B-pillar구성: (inner,outer)+보강재

$$K_{objective} = \frac{22240N}{38mm} = 585.26N/mm$$

$$K_{objective} = K_{steel} + K_{aluminum}$$

Steel shell model 결과



Alloy steel inner+outer model displacement->55.7mm

$$K_{objective} = K_{steel} + K_{aluminum}$$

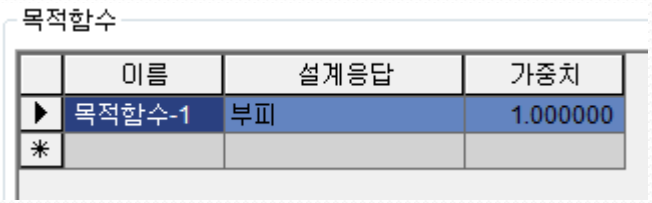
$$K_{objective} = \frac{22240N}{38mm} = 585.26N/mm$$

$$K_{steel} = \frac{22240N}{55.7mm} = 401.6N/mm$$

$$K_{alumnimum} = \frac{22240N}{xmm} = 183.66N/mm$$

=>목표 변위 값: 121.1mm

목적 함수/제약 조건


목적함수
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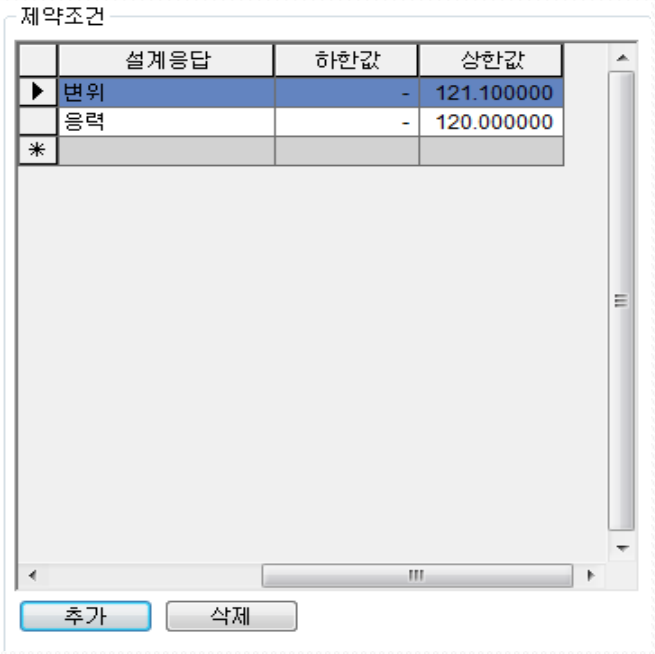
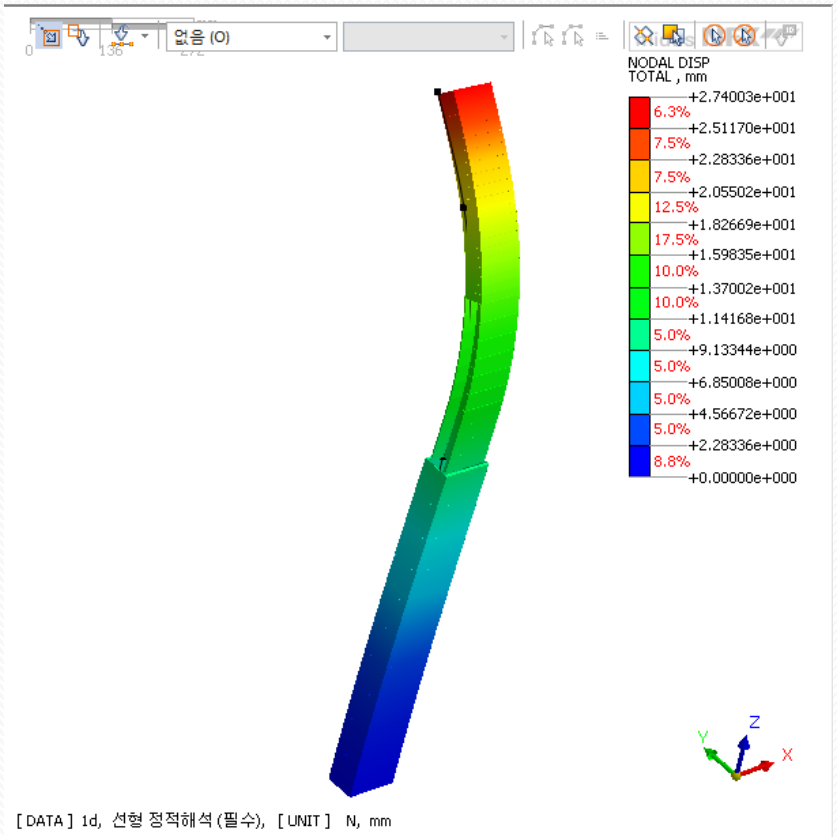
설계응답
가중치
목적함수-1
부피
1.000000

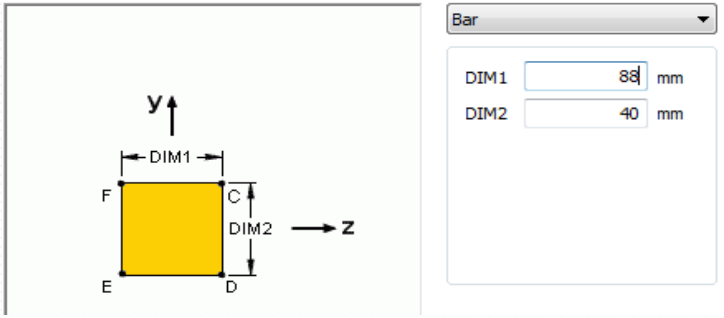

제약조건
설계응답
하한값
상한값
변위
-
121.100000
응력
-
120.000000
추가
삭제

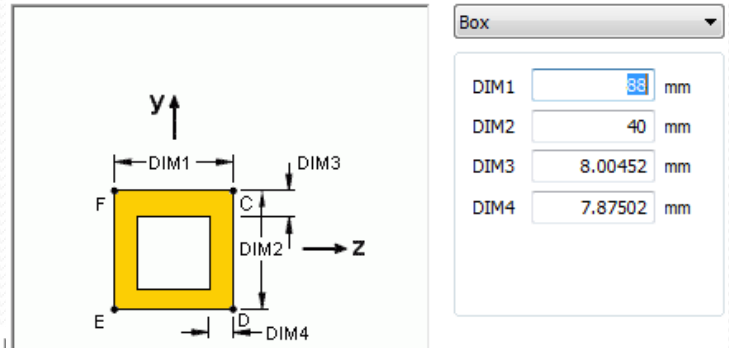
치수최적결과

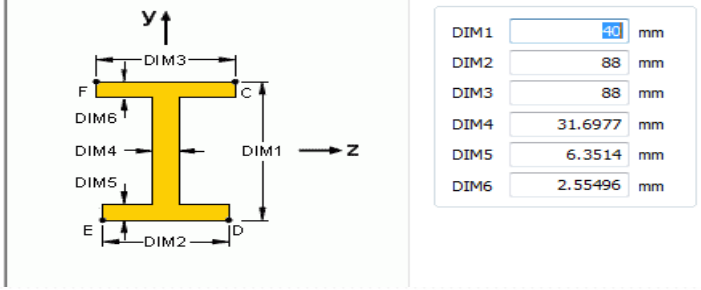
설계변수 이름	초기값	최소값	최대값	설계안 1	설계안 2	설계안 3	사용자 설계안
입 력							
middle1	50	20	55	32	30	32	32
middle2	5	2	15	6.4	9.2	12	6.4
middle3	5	2	15	2.6	5.5	4.3	2.6
lower1	1	0	10	5.7	5.5	5.4	5.7
lower2	1	0	10	1.1	1.1	1	1.1
upper1	1	0	10	8	8	7.6	8
upper2	1	0	10	7.9	8.1	7.5	7.9

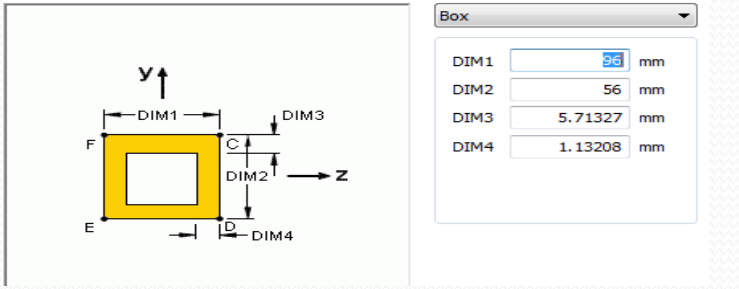
결과>











최적화 후 부피: 2178822mm^3

보강재에 필요한 알루미늄 질량: 5.8kg

결과 및 고찰

- 위상최적,치수최적결과 roof crush test를 만족시키는 b-pillar 보강재 예상
- Stress 조건이 dominant하게 영향 -> 1d로 접근하기 어려운 부분을 1d로 해석함에 따른 과정상의 문제점 작용
- 정확한 형상 구현과 3d 해석기반 진행시 보다 나은 결과 예상

Q&A