

Body Structure Design

for Formula

GRAND PRIX

도종인, 김선우

2012. 12. 6 (Thur)

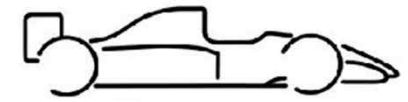


Contents



Grand Prix

1. Concept.
2. Basic frame.
3. Topology optimization.
4. Dimension optimization.
5. Result
6. Design of Crash damper



Grand Prix

Concept

Concept

2012 KSAE Formula



Grand Prix

√ Circumstance

총 주행 거리 : 22km

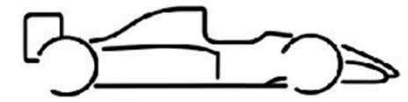
최고 속도 : 105km/h

평균 속도 : 48~57km/h

헤어핀, 슬라럼구간 포함

√ Objective

주어진 상황에서 최고의 퍼포먼스를 낼 수 있는 프레임의 설계.



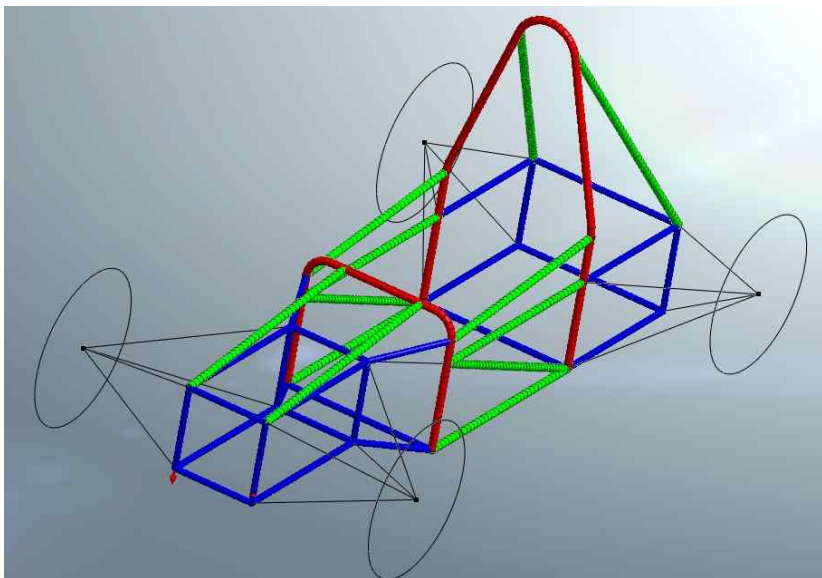
Grand Prix

Basic Frame

Basic frame



Grand Prix



√ Outline

Materials : Alloy steel

Size of section

roll hoop – 25/1.8(mm)

crash bracing – 25/1.6(mm)

etc – 20 /1.2 (mm)

Overall length : 2178mm

Overall width : 530mm

Overall height : 1220mm

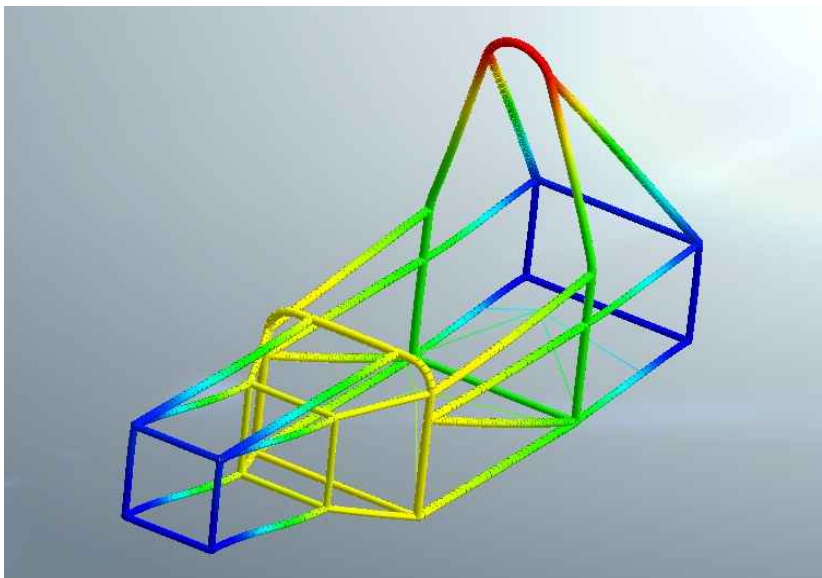
Wheel Base : 1915mm

Thread : 1220mm

Basic frame



Grand Prix



√ Features

Driving Type : Formula

Driving System : RR

Engine weight : 53Kg(건조중량)

Driver weight : 55kg

ETC weight : 17Kg

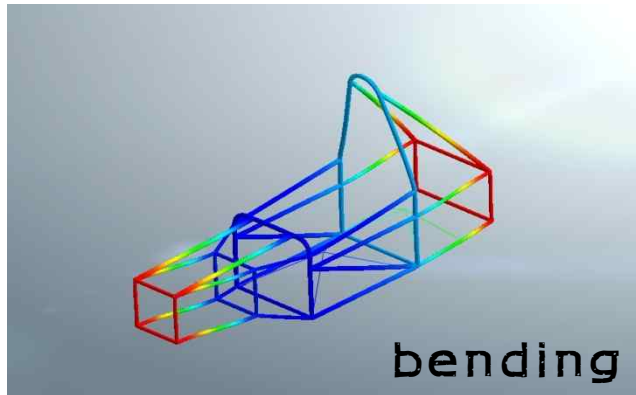
(Fuel, Cooling water, Engine Oil)

Total weight : 125kg(1225.75N)

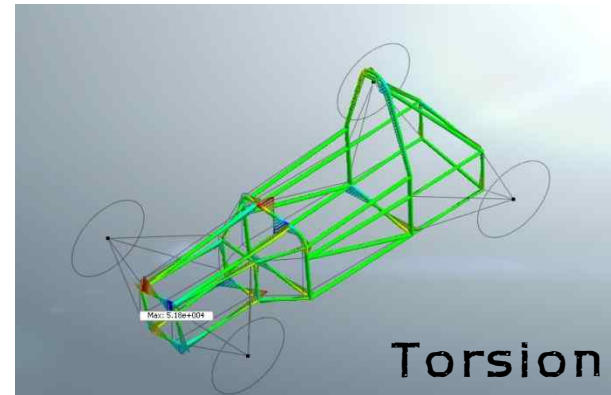
Basic frame



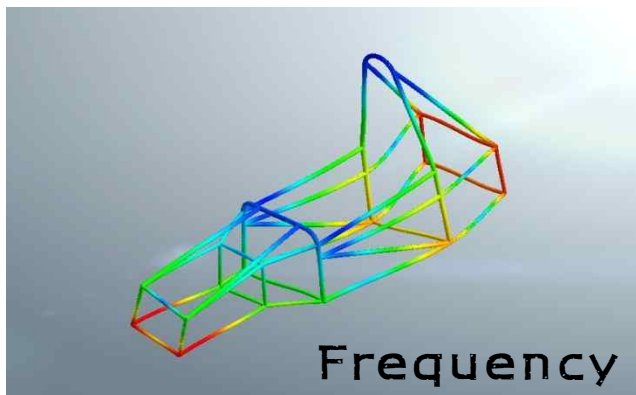
Grand Prix



bending



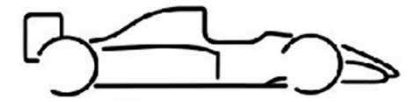
Torsion



Frequency

√ Result

Mass : 18.406kg
Bending Stiffness : 562.95N/mm
Torsion Stiffness : 35,728Nm/rad
Natural Frequency : 39.541 Hz



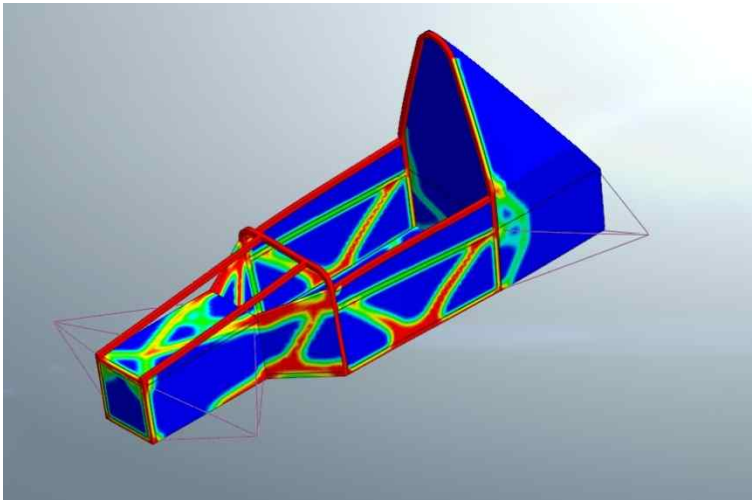
Grand Prix

Topology optimization

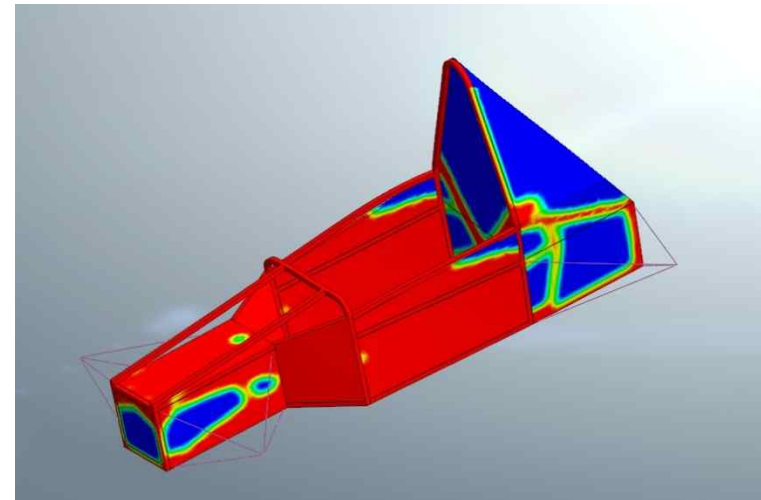
Topology optimization



Topology in torsion



Objective volume : 5%

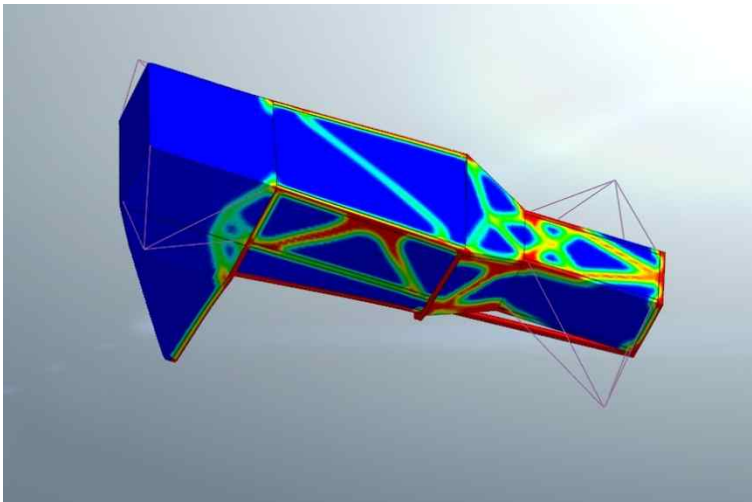


Objective Volume : 20%

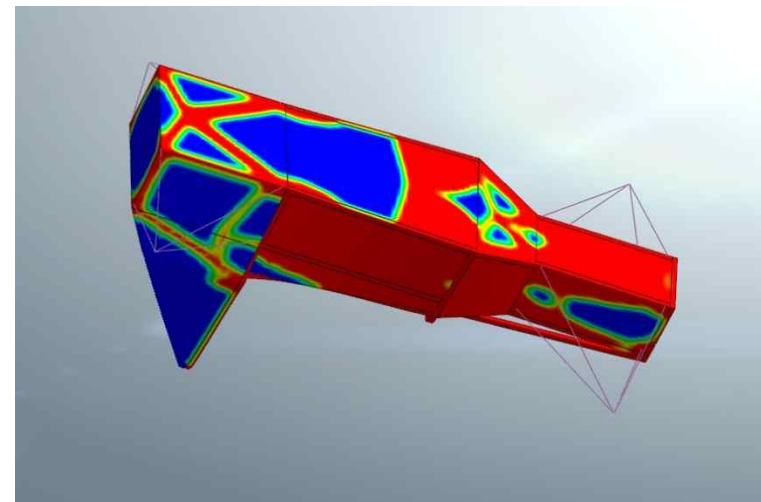
Topology optimization



Topology in torsion



Objective volume : 5%

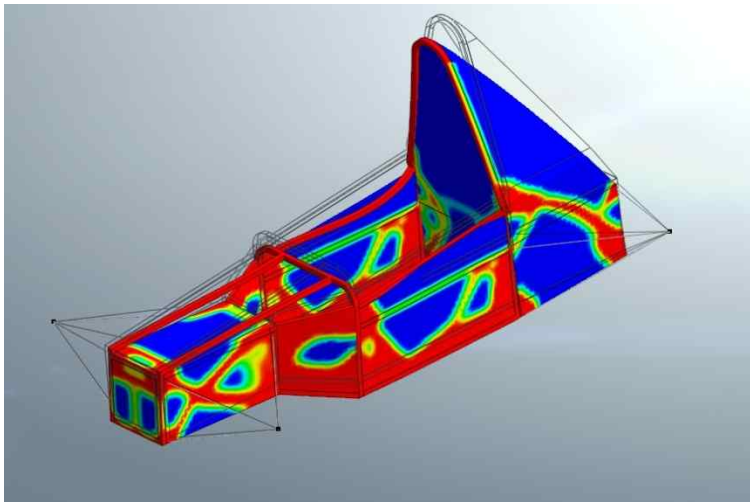


Objective Volume : 20%

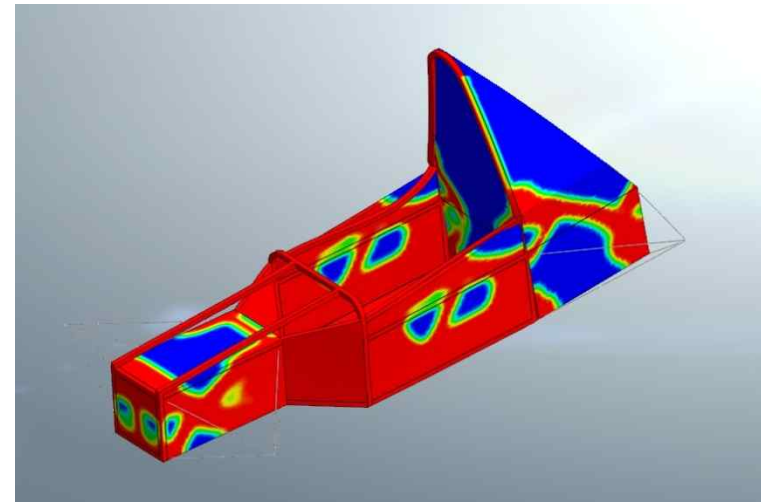
Topology optimization



Topology in Bending



Objective volume : 20%

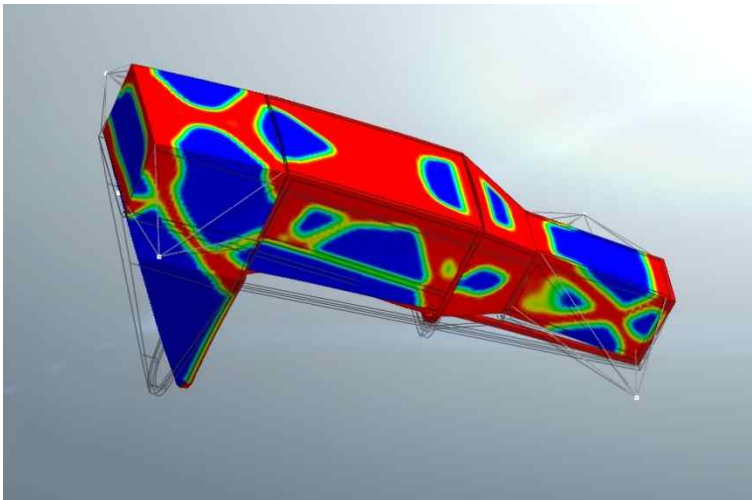


Objective Volume : 30%

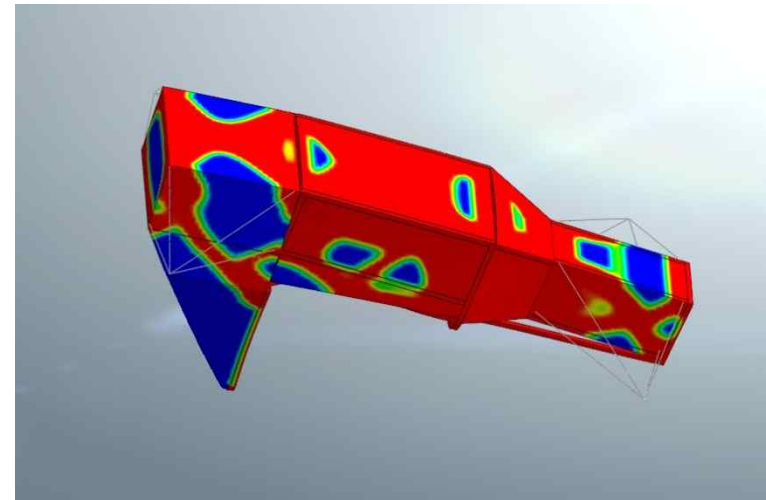
Topology optimization



Topology in Bending



Objective volume : 20%

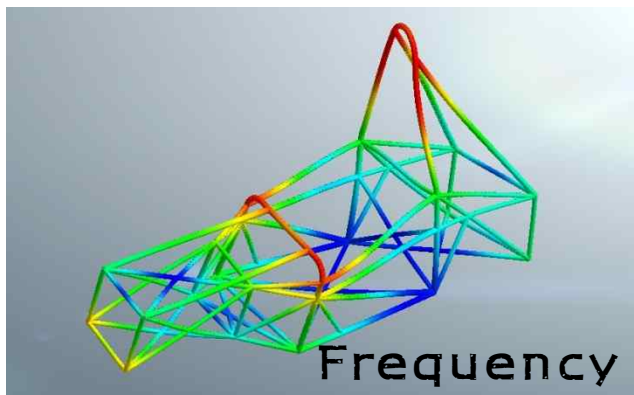
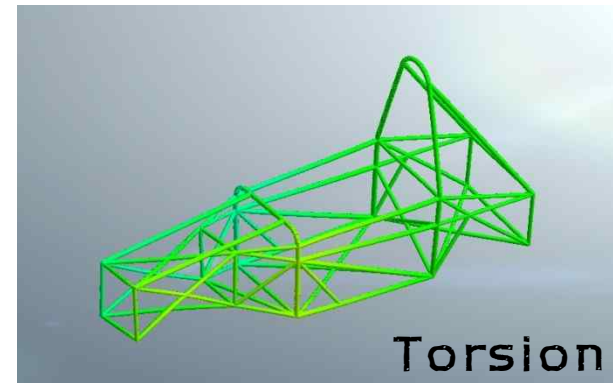
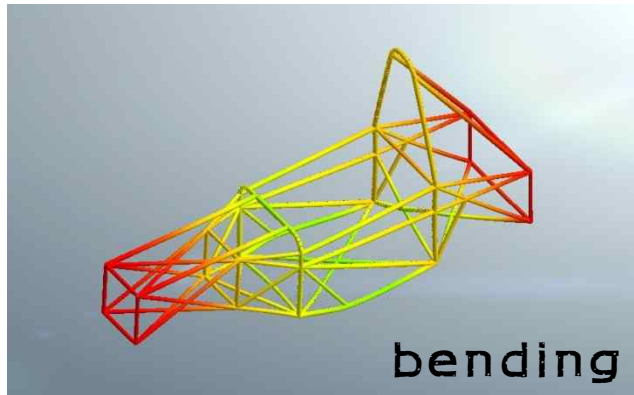


Objective Volume : 30%

Topology optimization



Grand Prix



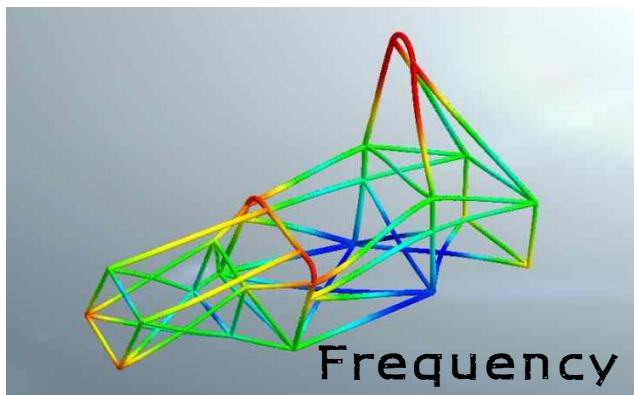
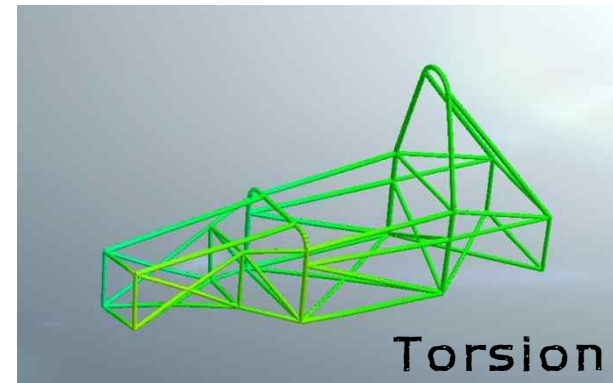
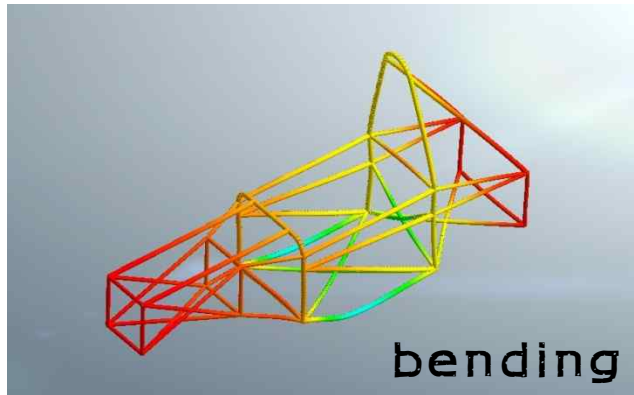
√ Result

Mass : 25.298kg
Bending Stiffness : 9,153.2N/mm
Torsion Stiffness : 94,915Nm/rad
Natural Frequency : 56.909 Hz

Topology optimization

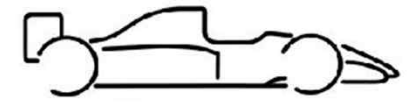


Grand Prix



√ Result

Mass : 22.269kg
Bending Stiffness : 4,434.6N/mm
Torsion Stiffness : 39,958Nm/rad
Natural Frequency : 51.150 Hz



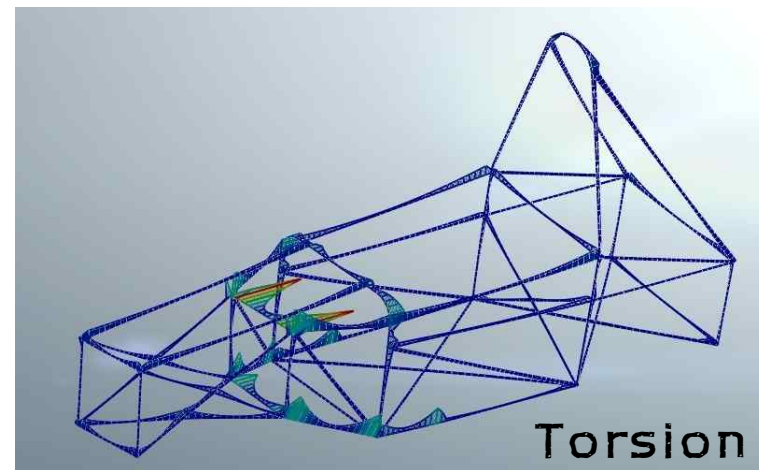
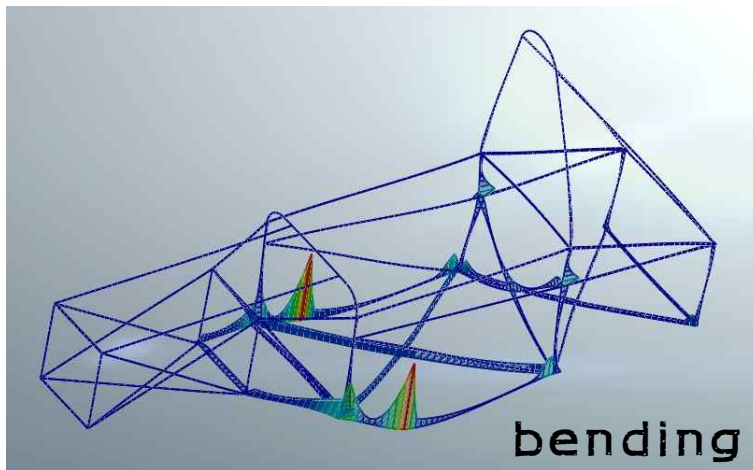
Grand Prix

Dimension optimization

Dimension optimization



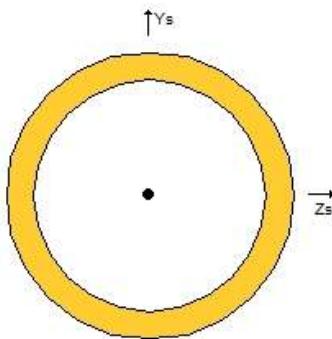
Energy density



Dimension optimization



Optimize dimension

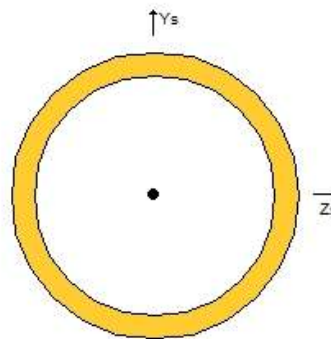


√ Roll hoop

D = 25mm, t=1.8mm



D = 29mm, t=3mm

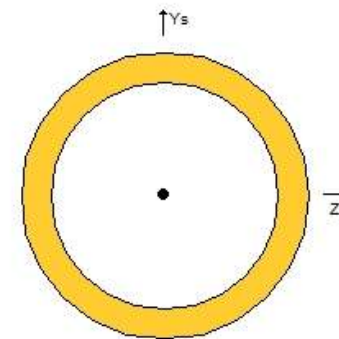


√ Side & Bracing

D = 25mm, t=1.6mm



D = 26mm, t=2.1mm



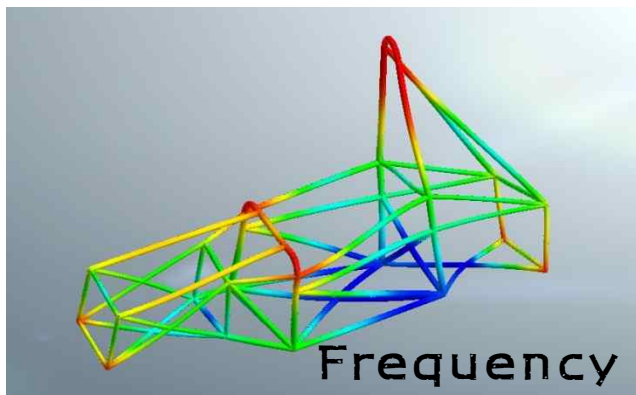
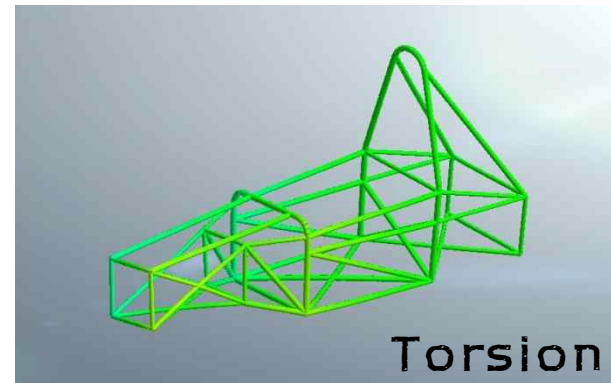
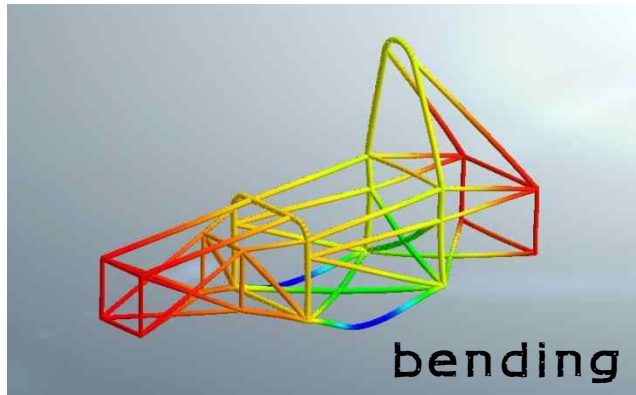
√ Etc

D = 20mm, t=1.2mm



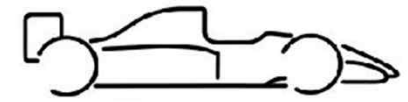
D = 27mm, t=2.6mm

Dimension optimization



√ Result

Mass : 38.236kg
Bending Stiffness : 7,221.27N/mm
Torsion Stiffness : 69,560Nm/rad
Natural Frequency : 54.764 Hz



Grand Prix

Result

Result



	Basic Frame	Topology Optimization	Dimension Optimization
Mass	18.406 kg	22.269 kg 20.99% 증가	38.236 kg 107.74% 증가
Bending Stiffness	562.95 N/mm	4434.6 N/mm 687.74% 증가	7221.3 N/mm 1182.76% 증가
Torsion Stiffness	35,728 Nm/rad	39,958 Nm/rad 11.84% 증가	69,560 Nm/rad 94.69% 증가
1 st Frequency	39.541 Hz	51.150 Hz	54.764 Hz

Result

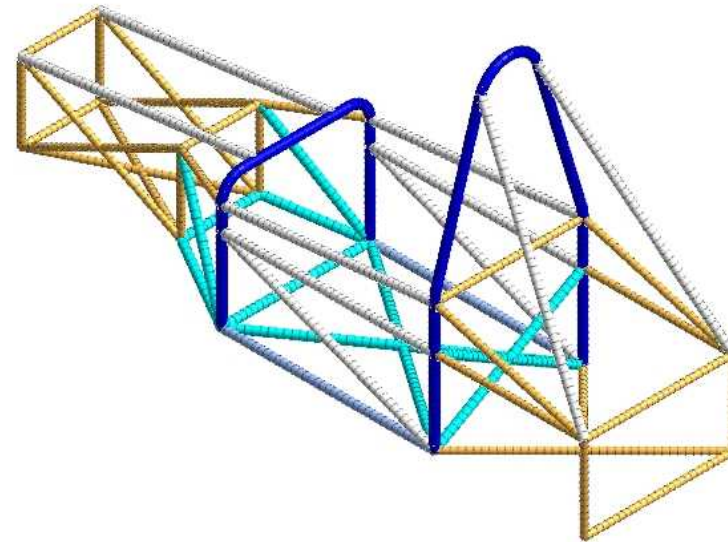


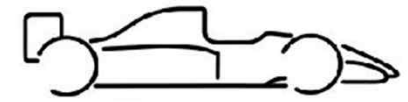
√ Topology Optimization

- 굽힘강성 증가 월등
- 비틀림강성 증가 미미

√ Dimension Optimization

- 무게 증가비율만큼 강성 증가





Grand Prix

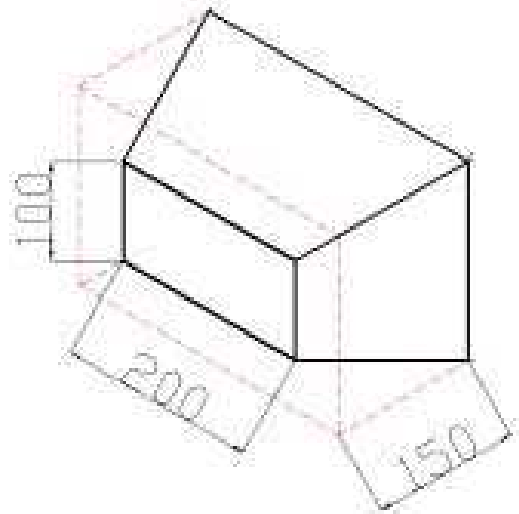
Design of Crash Damper

What is Crash Damper



√ Objective

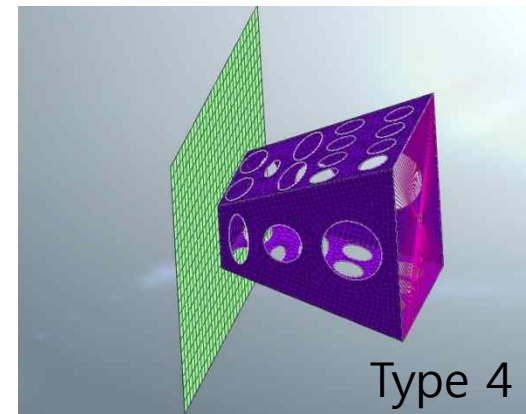
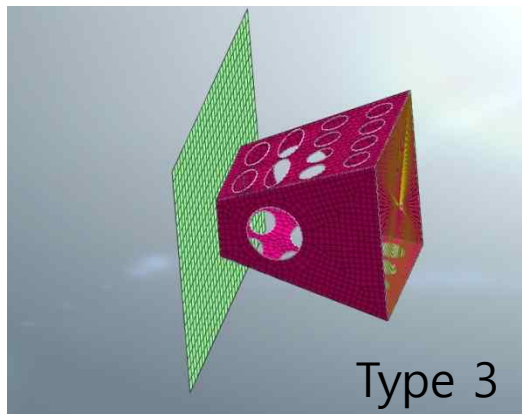
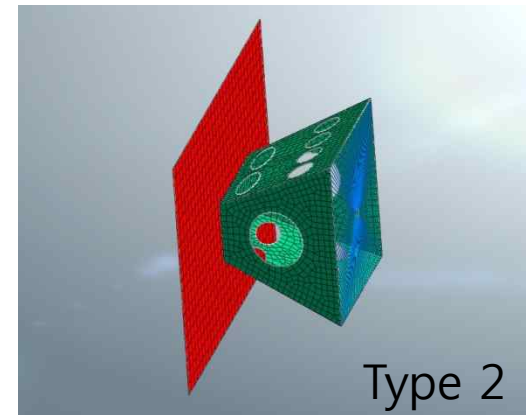
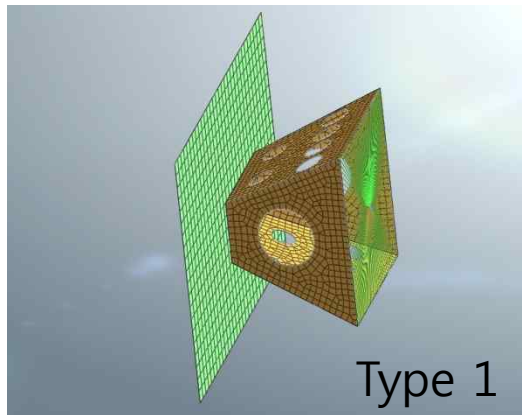
- 차량 가장 앞부분의 변형 가능한 공간/충돌 에너지를 흡수할 수 있는 구조물



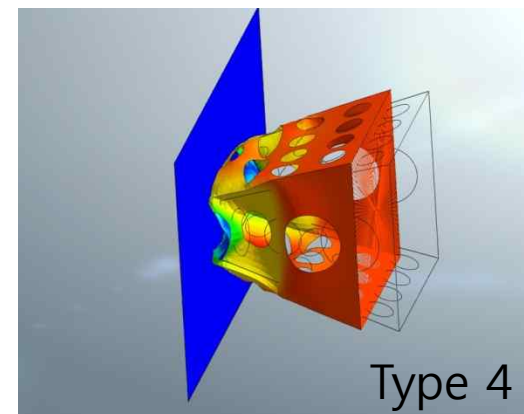
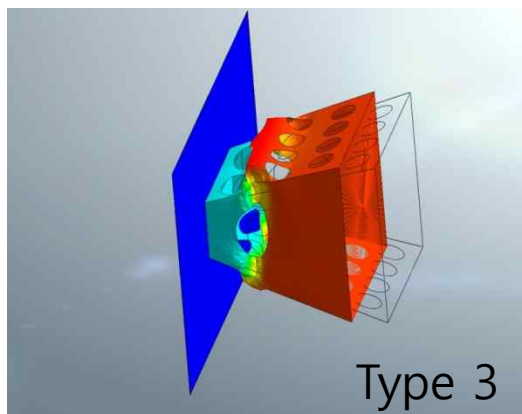
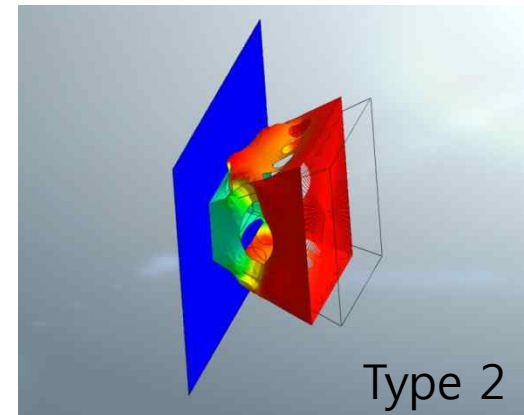
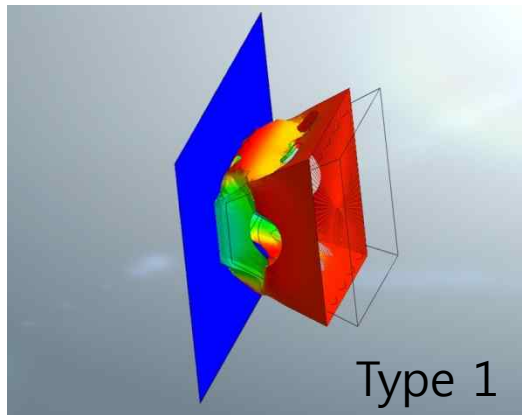
√ Features

- 재질 : 2T의 철판
- 조건 : 총중량이 300kg인 차량의 전방에 부착
7m/s의 속도로 단단한 벽으로 돌진
충돌할 때 평균감속이 20g, 최대감속이
40g를 초과하지 않아야 한다.

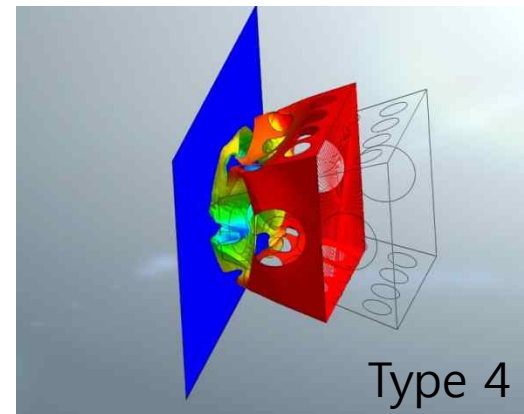
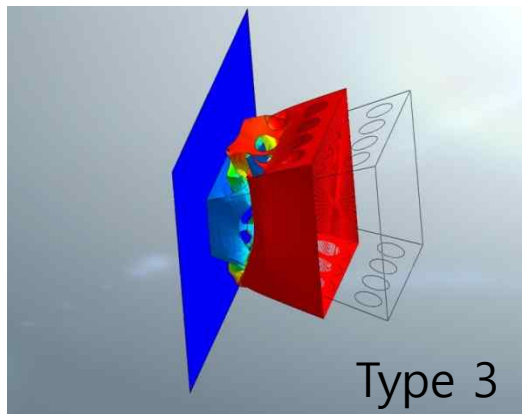
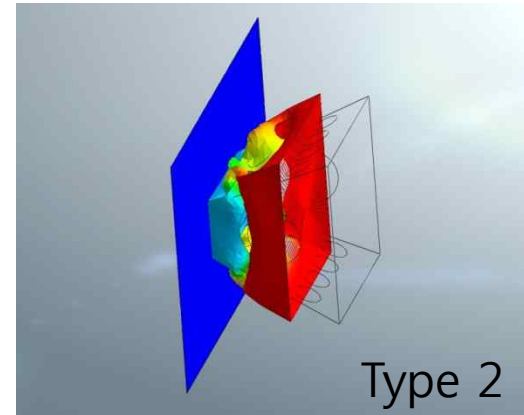
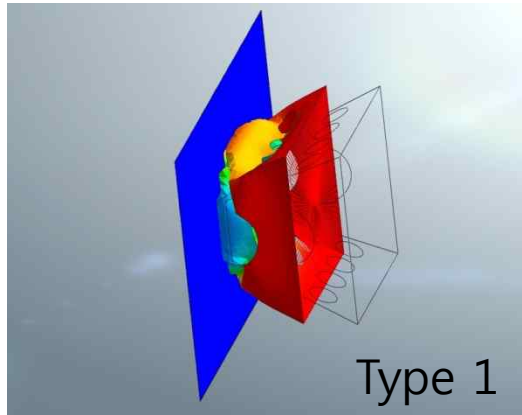
Design of Crash Damper



Design of Crash Damper



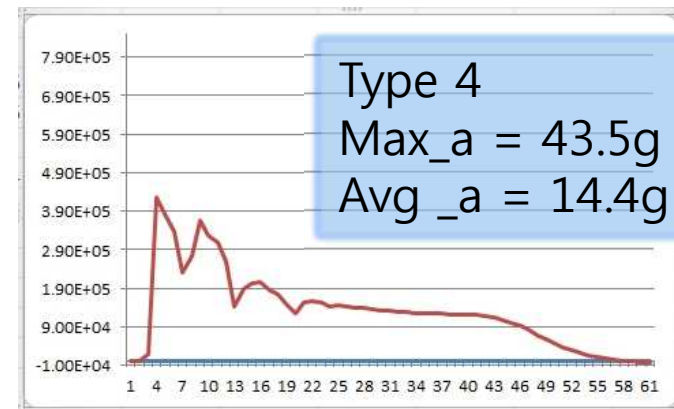
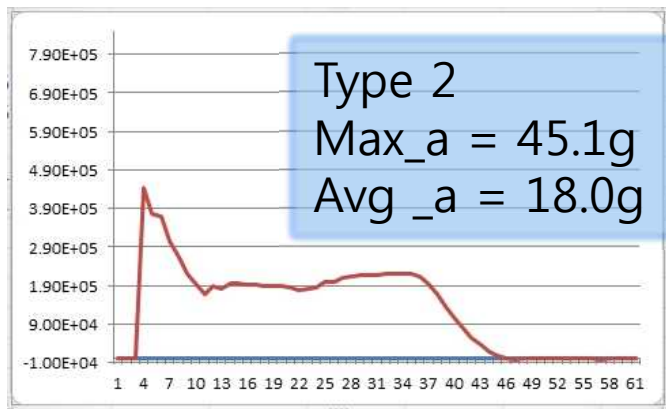
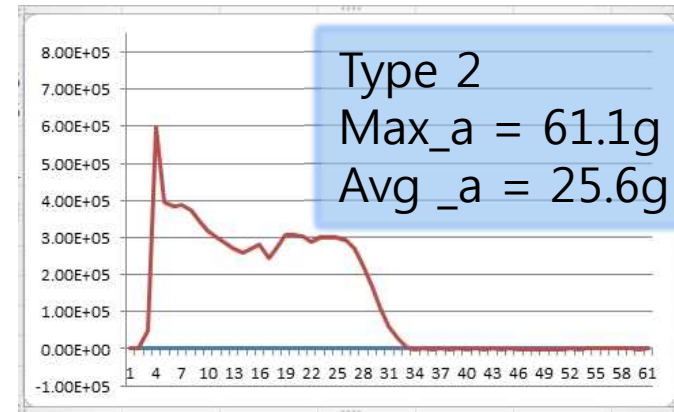
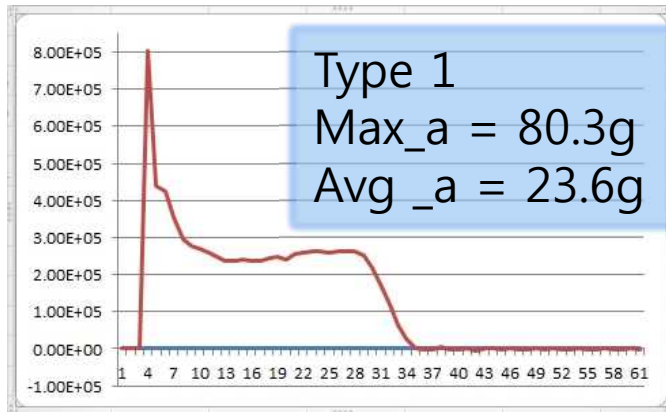
Design of Crash Damper



Design of Crash Damper



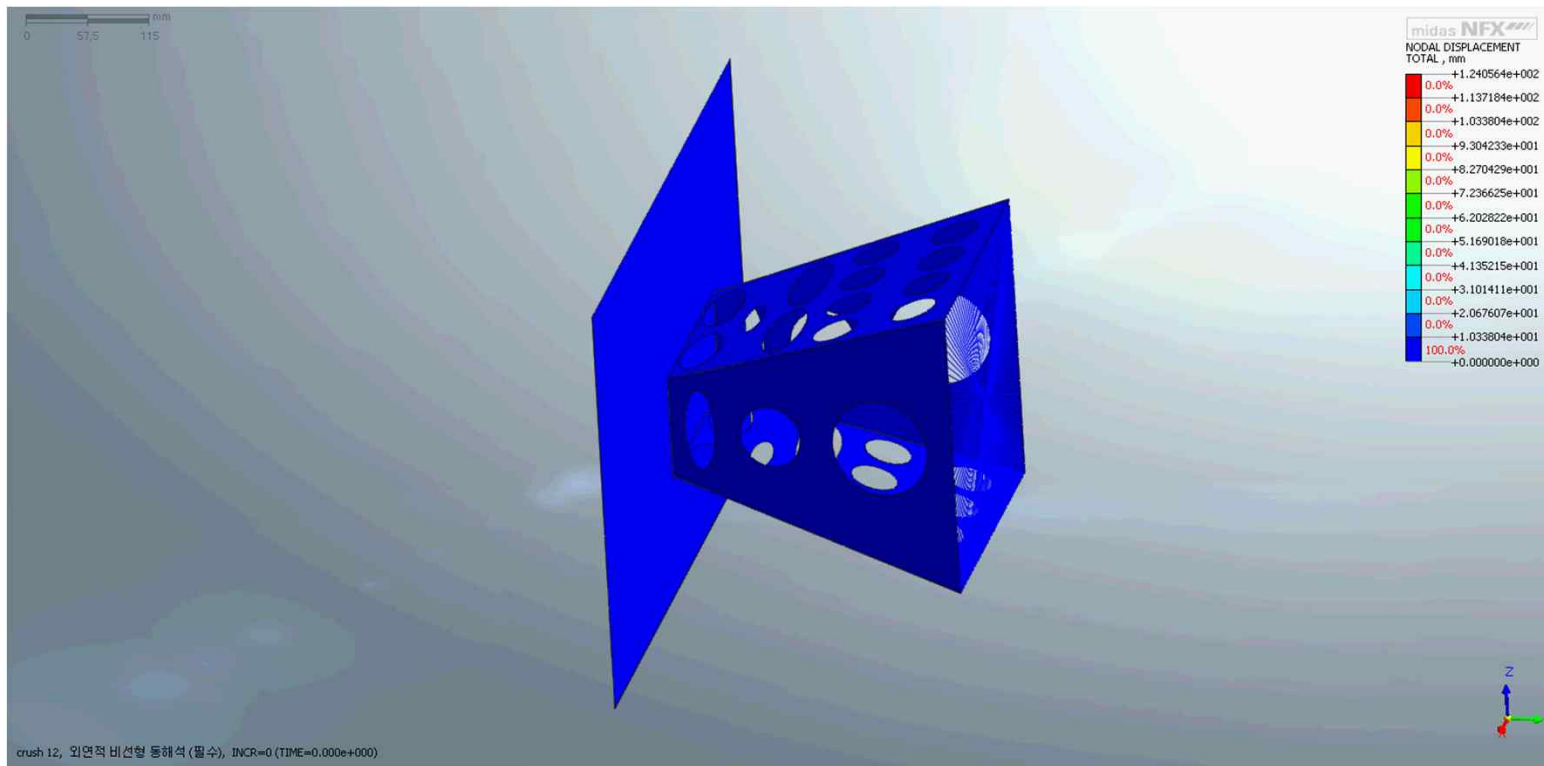
Grand Prix



Design of Crash Damper



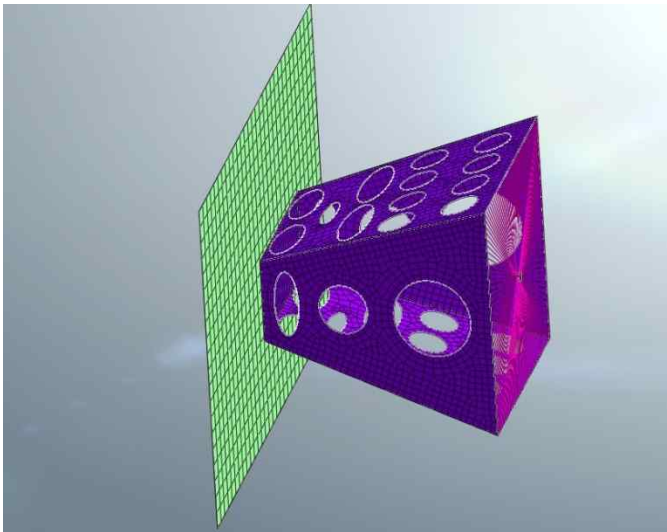
Crashing Video



Design of Crash Damper



Conclusion



- 목표치인 $a_{max} < 40g$ 달성 실패
 - 재료의 차이라고 추정
 - 앞부분에 탄성체(고무) 필요.
- 여러가지 형상의 모델을 테스트 해 보면서 파괴 거동에 대한 지식을 쌓음.
- 추돌사고시 Crash Damper의 역할이 매우 중요함을 알 수 있었음.

Reference



- KSAE baja : <http://jajak.ksae.org>
- Computation Laboratory – MIDAS 실습, 한양대학교, 민승재 교수
- MIDAS 매뉴얼, 기술자료 : <http://www.nfx.co.kr>
- 이겨레, 황의상, 민승재, " Design of a Space Frame Car using Topology Optimization", 한양대학교



Thank you



Q & A