Optimum DesIgn
Of
AUtomotive Bumper

Presenter : 이동근(2006058579)

박동균(2007007541)

Contents

1. Introduction

Automotive bumper

❖ 충돌시 차량의 기계적인 손상을 방지하고 승객을 보호하는 역할

❖ 일반적으로 셀구조인 범퍼빔과 발포체 구조의 충격 흡수제로 구성되어 있음

2. Problem Statement

- ✓ 차량 용 전방범퍼의 셀 구조물인 범퍼 빔의 거동해석
- ✓ **3차원 셀 구조물을 창문모양의 단면을 가진 1차원 빔으로 모델링**
- ✓ 에너지 보존법칙을 빔 이론과 결부 시켜서 발생된 응력과 변형 길이를 계산
- ✓ **충격흡수제의 충격 량 흡수를 고려**
- ✓ **충격흡수제는 축 하중 상태에 있다고 가정**
- ✓ 재료의 거동은 탄성영역에서만 이루어짐
- ✓ 항복이 일어나는 지점을 한계점으로 설정
- ✓ 운동에너지는 손실 없이 모두 변형에너지로 전환된다고 가정
- ✓ 충돌은 균일한 면에서 일어남
- ✓ 운동에너지는 등가의 분포하중으로 대체 가능

3. Data and Information collection

Material properties of Al6082T6

- Young's modulus(Mpa) : 70000
- Poisson's ratio : 0.33
- Yielding stress(tens or comp.,Mpa) : 240
- Yielding stress(shear,Mpa) : 138
- Density(kg/m^3) : 2773
- Length(m) : 1.036
- Width(m) : 0.1

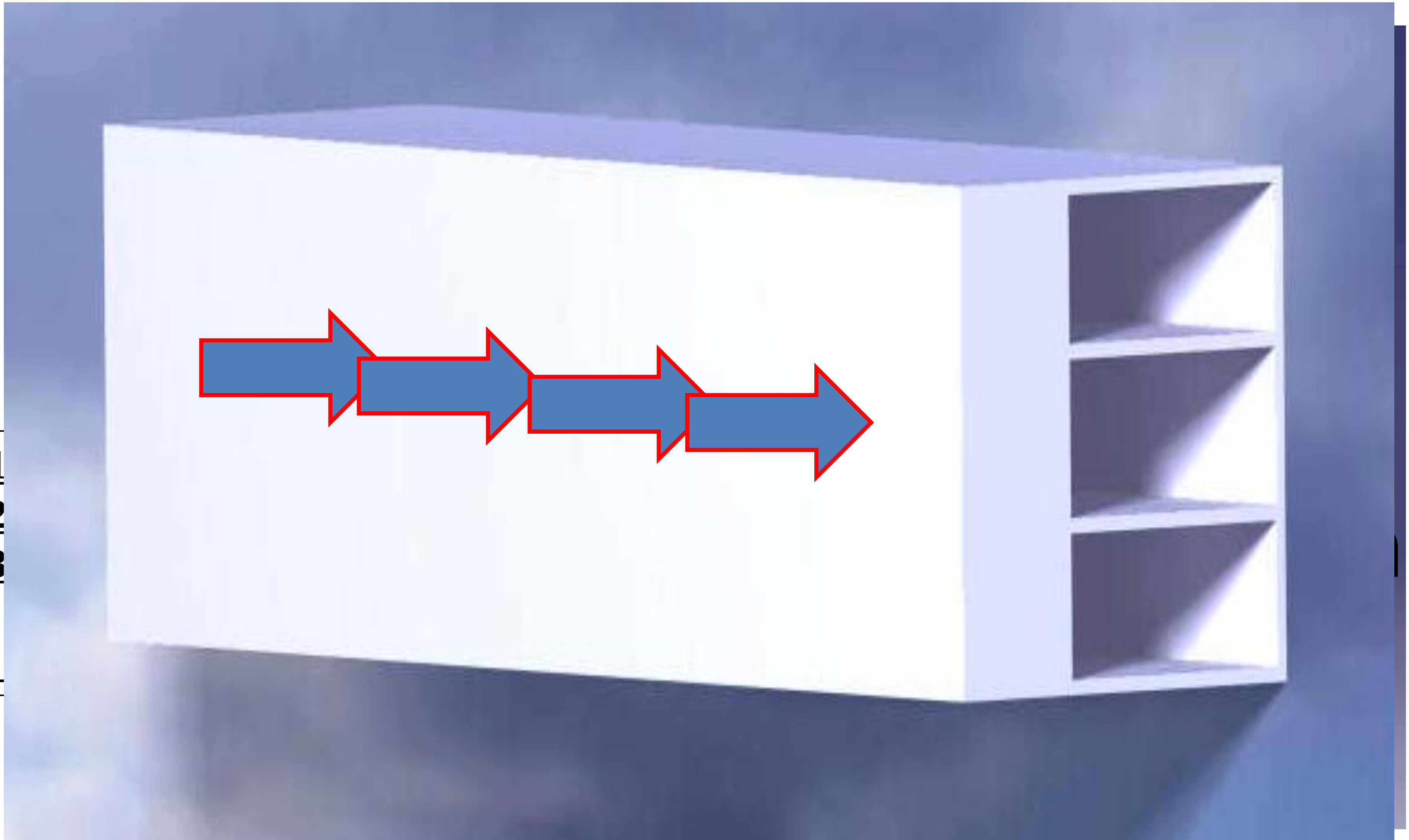
Mass of the car : 1820(kg)

Velocity of the car : 2.235 (m/s)

Material properties of Polyurethane

- Young's modulus(Mpa) : 4.9
- Density(kg/m^3) : 60
- Length(m) : 1.036
- Height(m) : 0.045
- Width(m) : 0.1

4. Design variables



t1
t2
t3

h

5. Objective function

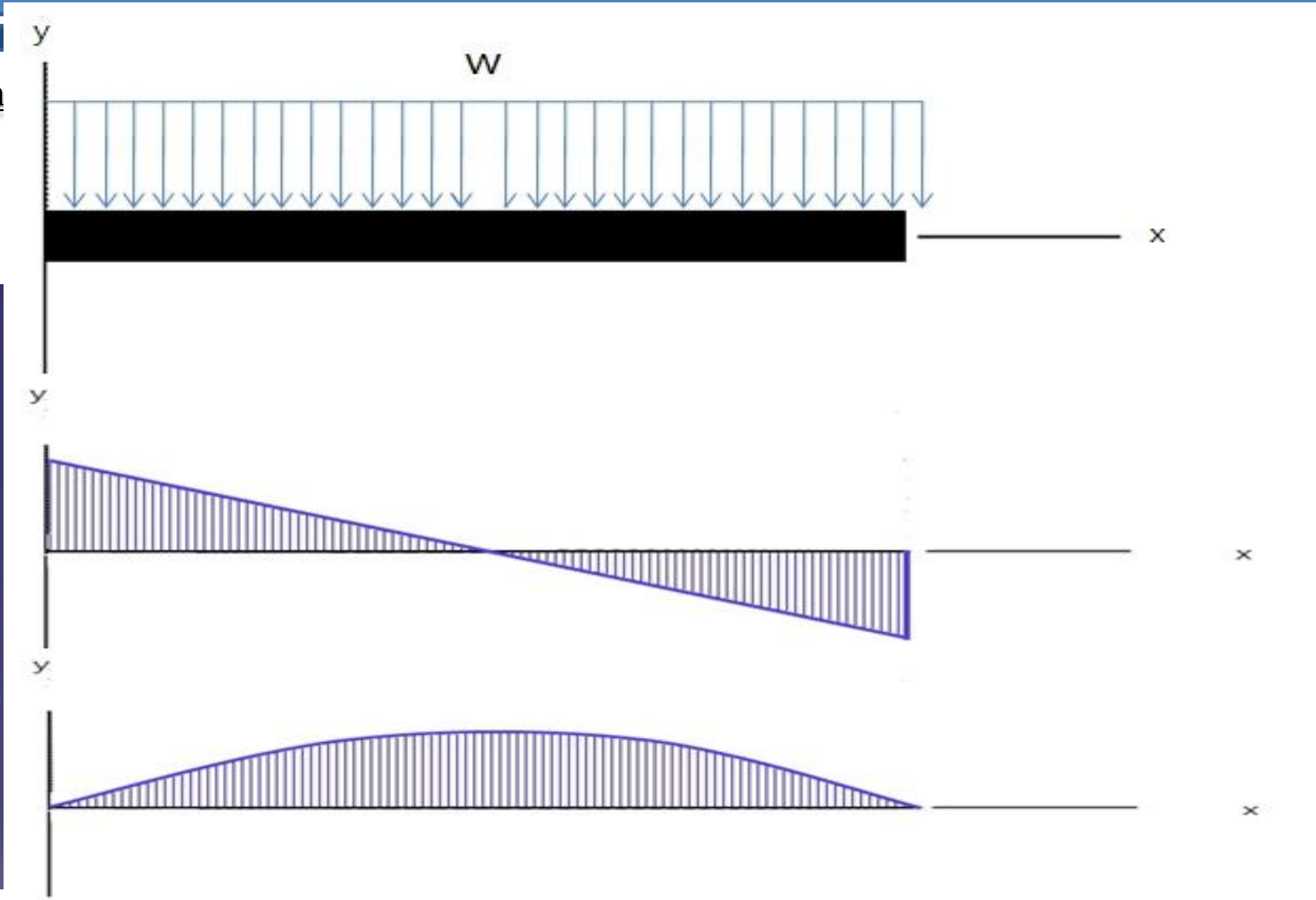
Minimize total mass of the bumper

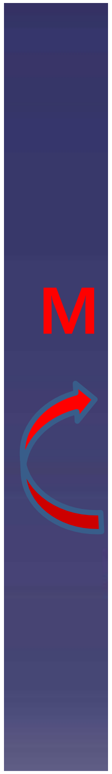
$$f = L(A_{AL}\rho_{AL} + width \cdot \rho_{absorber})$$

$$f = 2\rho Lt(b + h)$$

6. Constraints

Max n

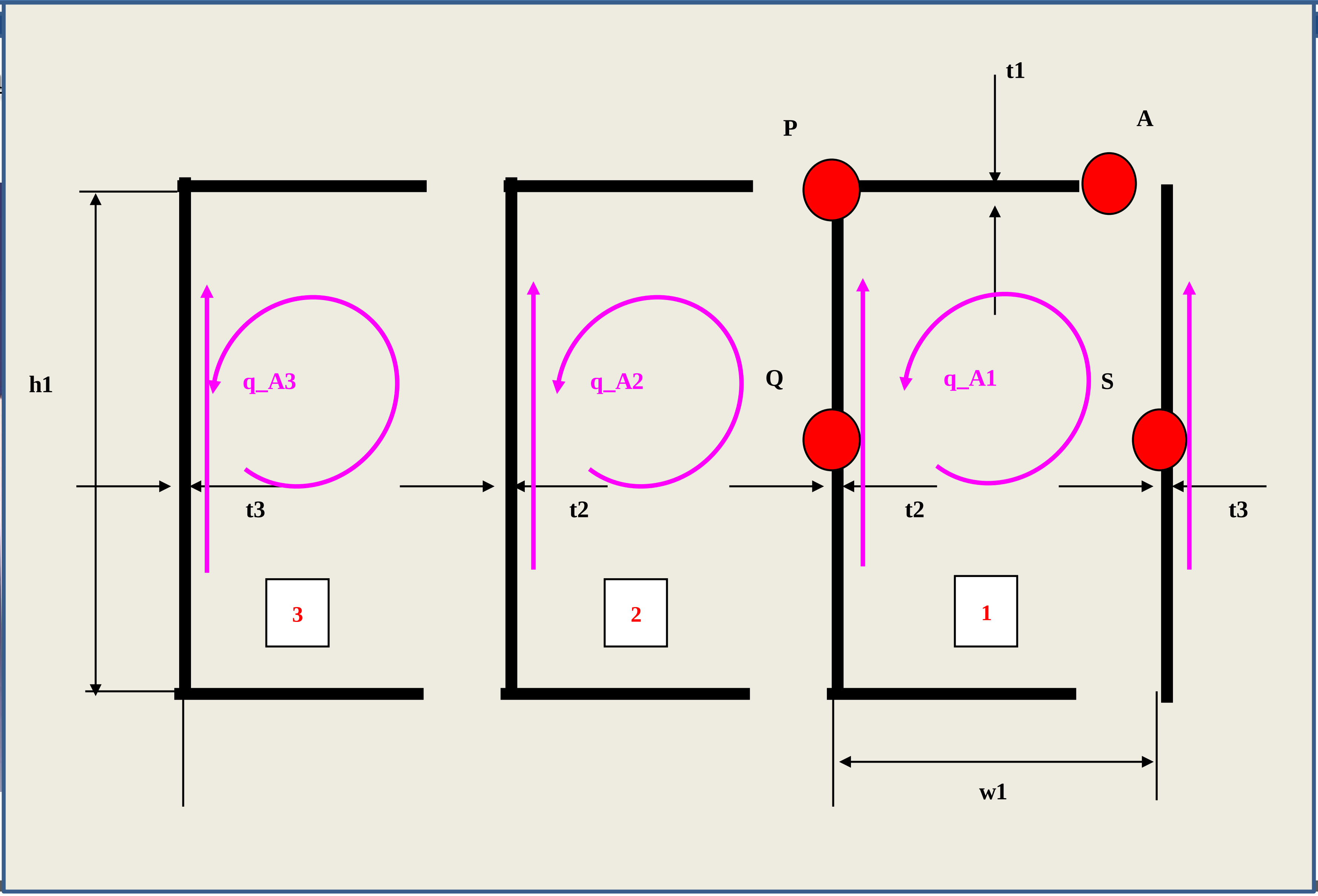




a

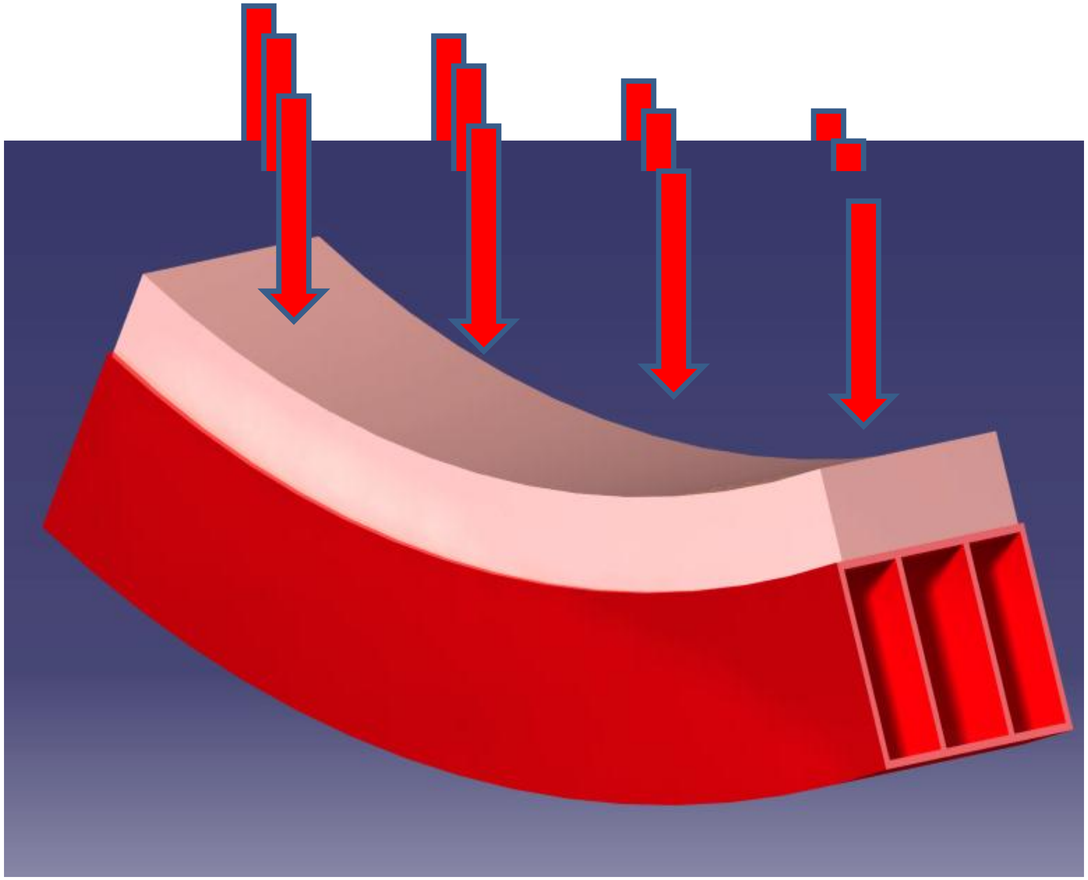
6. Constraints

Ma



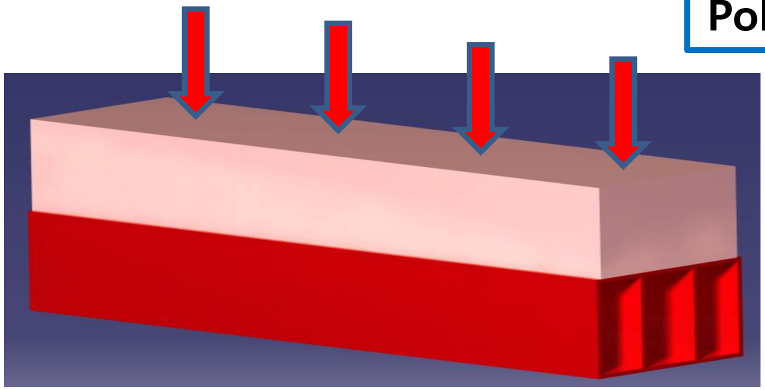
6. Constraints

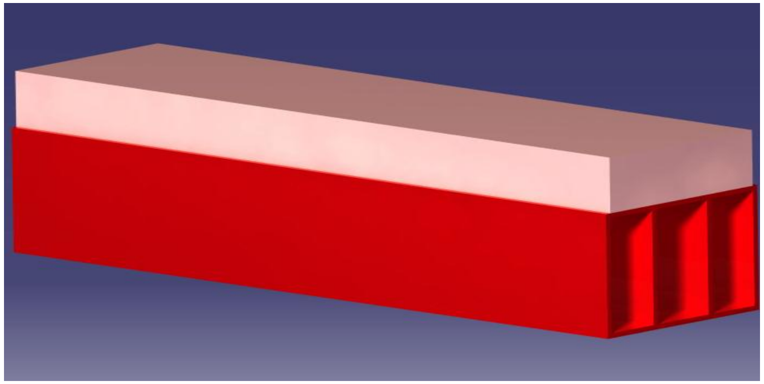
Deflection due to transverse loading



6. Constraints

Deflection due to transverse loading





Poly urethane portion

1.Using w obtained previously

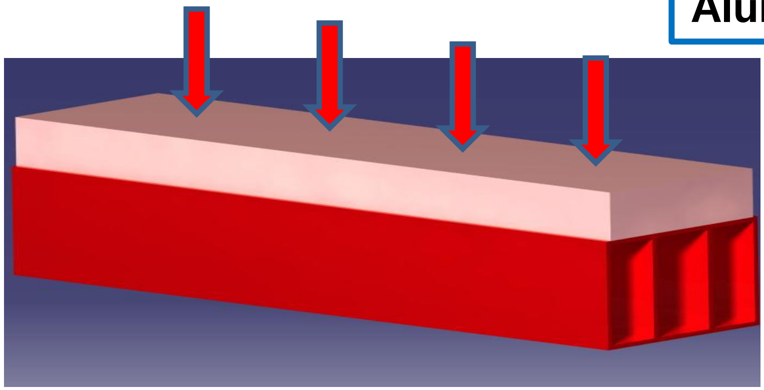
$$w = \sqrt{\frac{1}{2} m v_o^{\,2} / \left(\frac{L^5}{240 E_{AL} I_{AL}} + \frac{L^2}{2 E_{PU} A_{PU}} \right)}$$

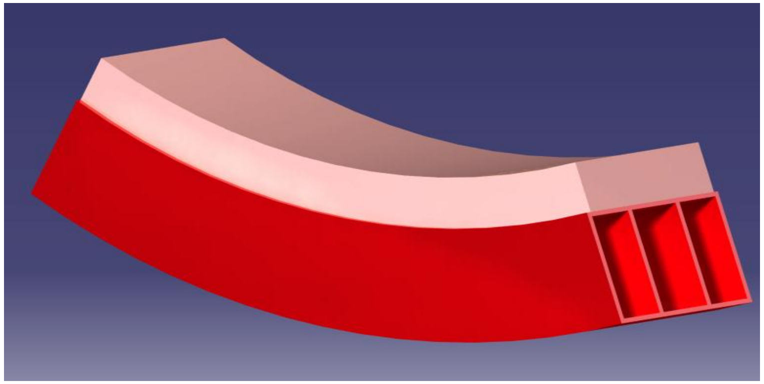
2.Deflection of polyurethane

$$\delta_{PL} = \frac{Ph}{A_{PU} E_{PU}} = \frac{wL}{AE_{PU}} h$$

6. Constraints

Deflection due to transverse loading





Aluminum portion

1.Using w obtained previously

$$w = \sqrt{\frac{1}{2} m v_o^2 / \left(\frac{L^5}{240 E_{AL} I_{AL}} + \frac{L^2}{2 E_{PU} A_{PU}}\right)}$$

2.Deflection of Aluminum

$$\delta_{AL} = \frac{5wL^4}{384 E_{AL} I_{AL}}$$

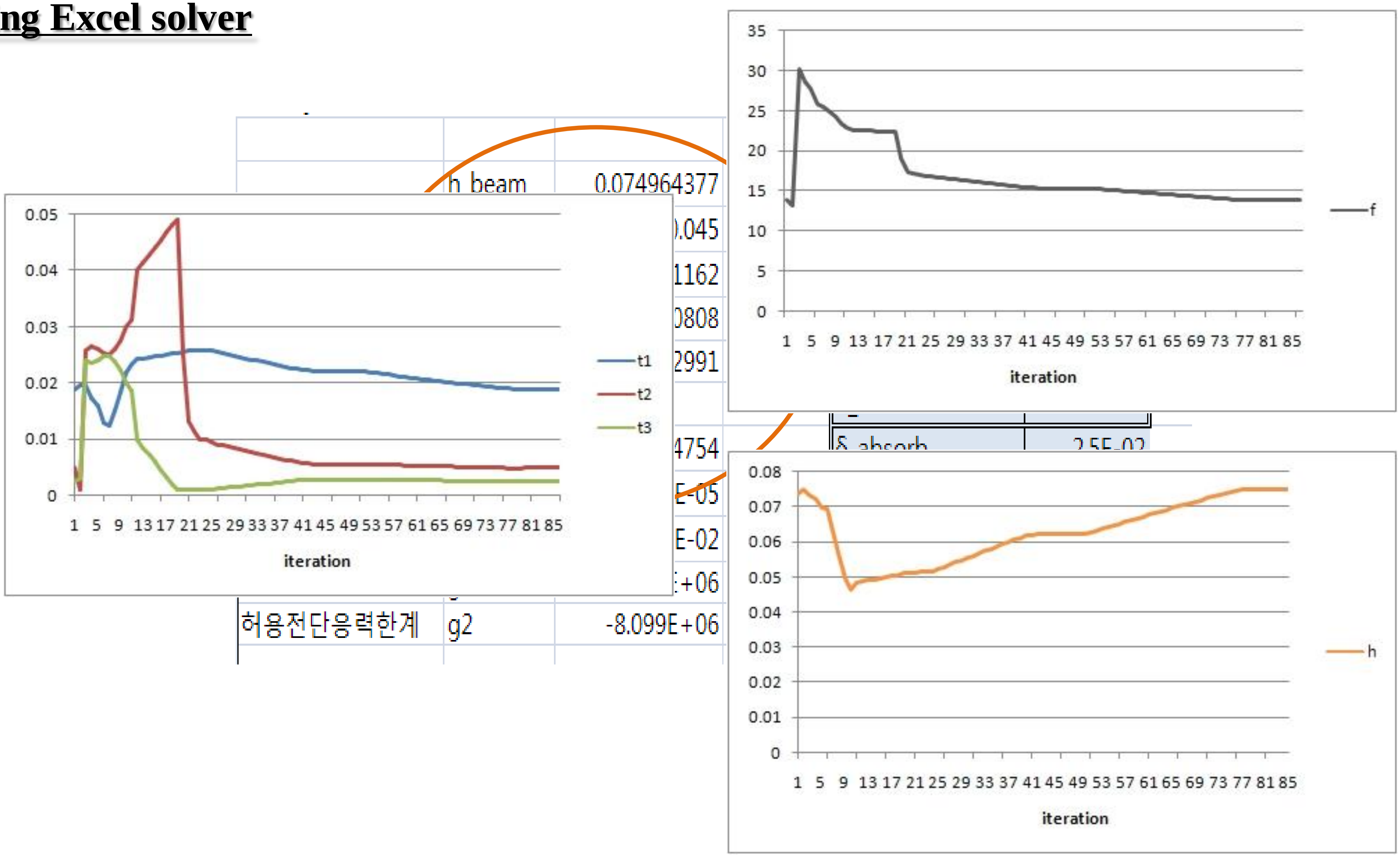
Constraint3

$$g3 = \delta_{\max} = \frac{5wL^4}{384 E_{AL} I_{AL}} - \delta_{allow} \leq 0$$

$$\delta_{allow} = 0.05m$$

7. Solution

Using Excel solver



7. Solution

Using Matlab Fmincon

```
fval =

  14.1565

exitflag =

    4

output =

         iterations: 45
          funcCount: 288
       lssteplength: 1
           stepsize: 1.1941e-019
          algorithm: 'medium-scale: SQP, Quasi-Newton, line-search'
      firstorderopt: 563.0122
    constrviolation: -3.5623e-005
            message: [1x142 char]

lambda =

         lower: [4x1 double]
         upper: [4x1 double]
         eqlin: [0x1 double]
      eqnonlin: [0x1 double]
       ineqlin: [3x1 double]
    ineqnonlin: [3x1 double]
```

범퍼길이한계
변형길이한계
허용수직응력한계
허용전단응력한계

	2.757E+05
	1.428E+05
	3.699E+04
(굽힘)	2.385E+08
	1.299E+08
	1.016E-02
	2.5E-02

기존 설계값에 비해 감소

	값	해찾기	
t	0.02	0.01317	mm
h	0.2	0.11971	mm
g2(normal	-1.[illegible]02	1.73E-03	
g3	-57.25428	0.00186	
sum	163.4292714	[illegible]00254	
	min. f	16.33954	kg

8. Comments

1. 알고리즘의 차이 (GRG vs SQP)

2. 초기치의 중요성

3. 적절한 제한조건

4. 최적화 결과 라그란지 승수가 0
   ⇒ 비정칙최적점

Reference

1. **Mechanics of materials, P. Beer, Mc-Graw Hill, 2006.07.26**

2. **빔이론을 이용한 차량용 프런트범퍼의 구조해석 및 최적설계 (Structural Analysis and Optimal Design of Front Bumper for Automobiles by using the Beam Theory) , 김명훈 , 한양대학교 대학원, 1998.12**

3. **Introduction to Optimum Design, Arora, J. S., Academic Press, 2004**