Motor compartment size optimization for minimizing yaw motion in small overlap crash

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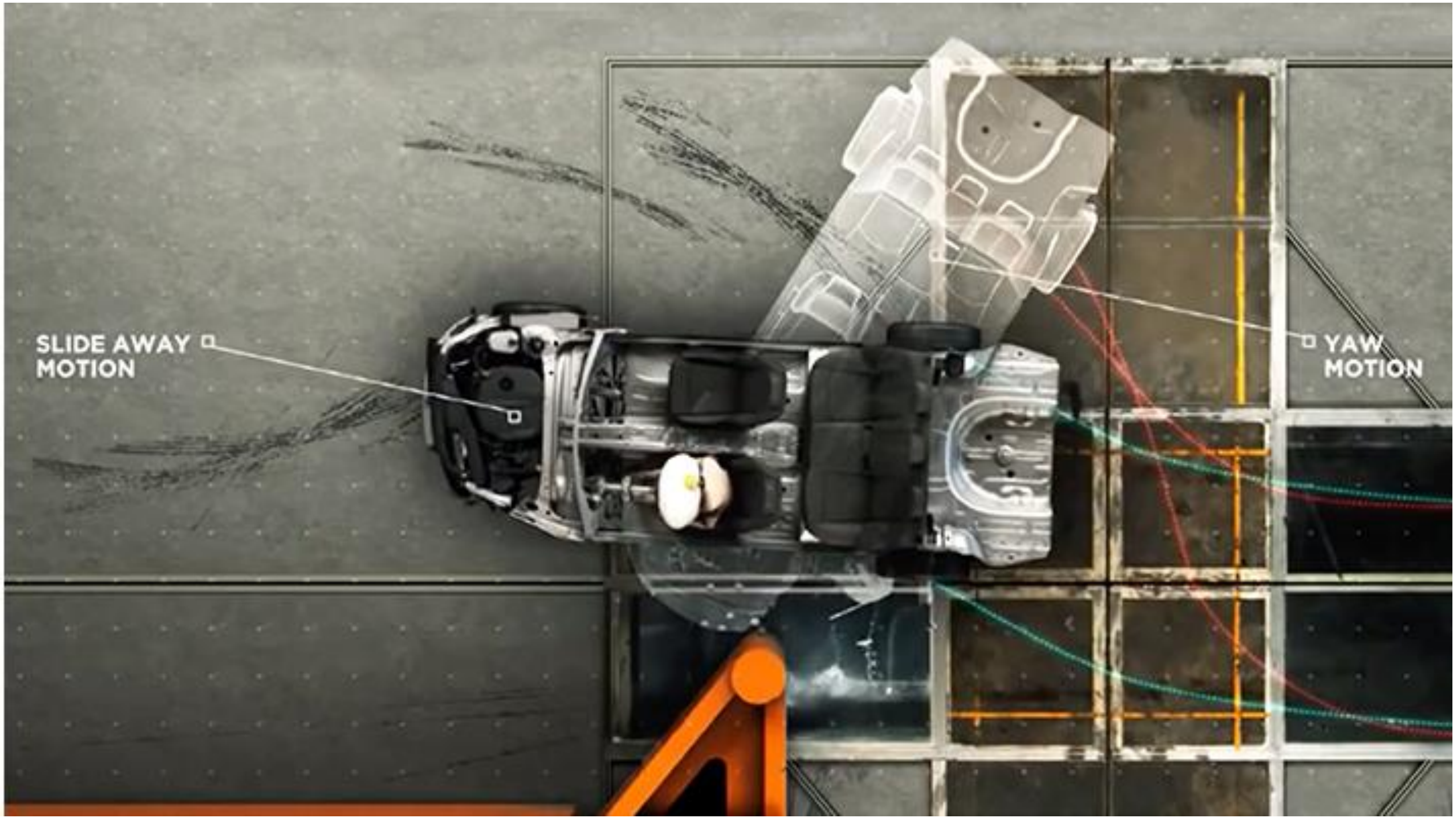
Motivation

Slide away motion



https://news.hmgjournal.com/Tech/hyundai-sonata-platform-safety

Yaw motion after crash

https://www.youtube.com/watch?v=KNfZSgZ3p1k

Effort to reduce yaw motion

Example : Hyundai 3rd platform

At the motor compartment

- Increase energy absorption
- Optimize load path
- Higher strength of frames

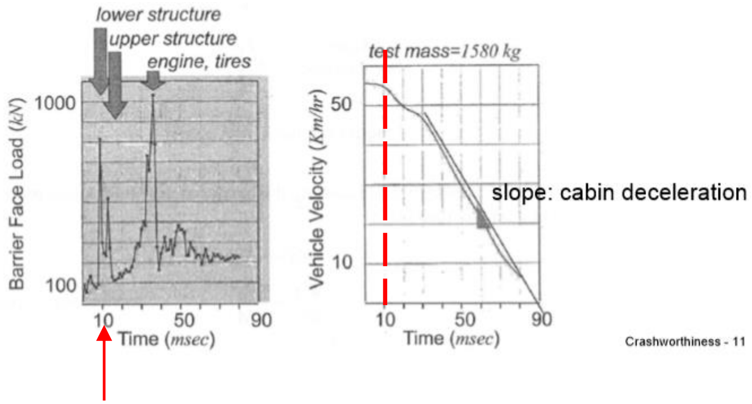
https://news.hmgjournal.com/Tech/hyundai-sonata-platform-safety

Concept and Modeling

Concept

Situation

- Right after crash
- Before buckling of upper rail and mid rail
- Elastic deformation

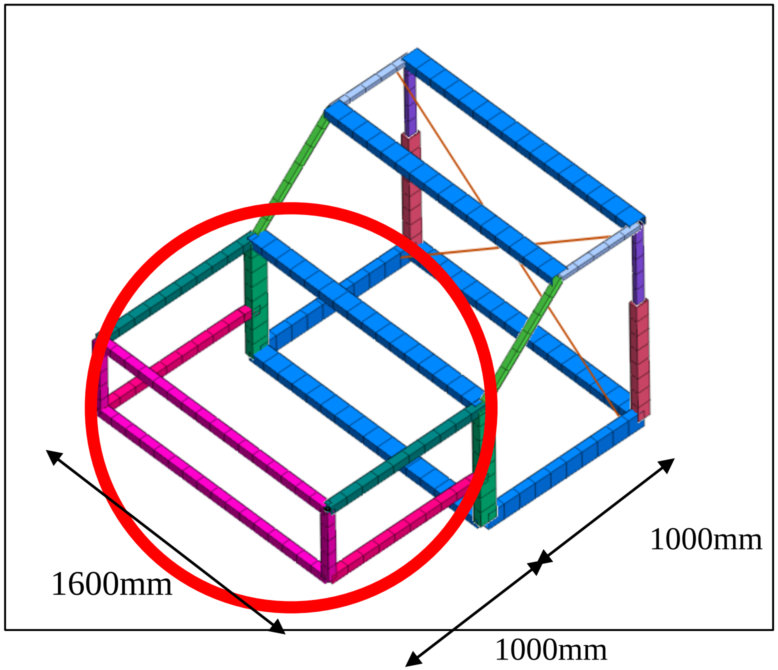


Minimize yaw

- By changing strength of rails (length, thickness)

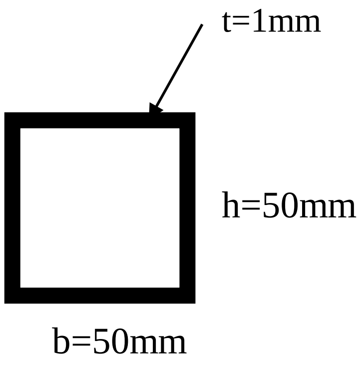
Model

Geometry



Motor compartment : general assumption

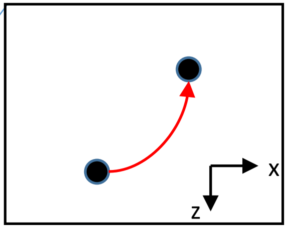
Cross section and cabin size : from lecture note



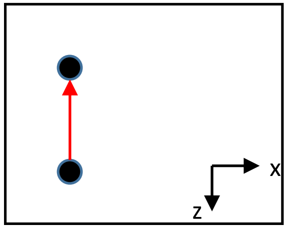
Simulation

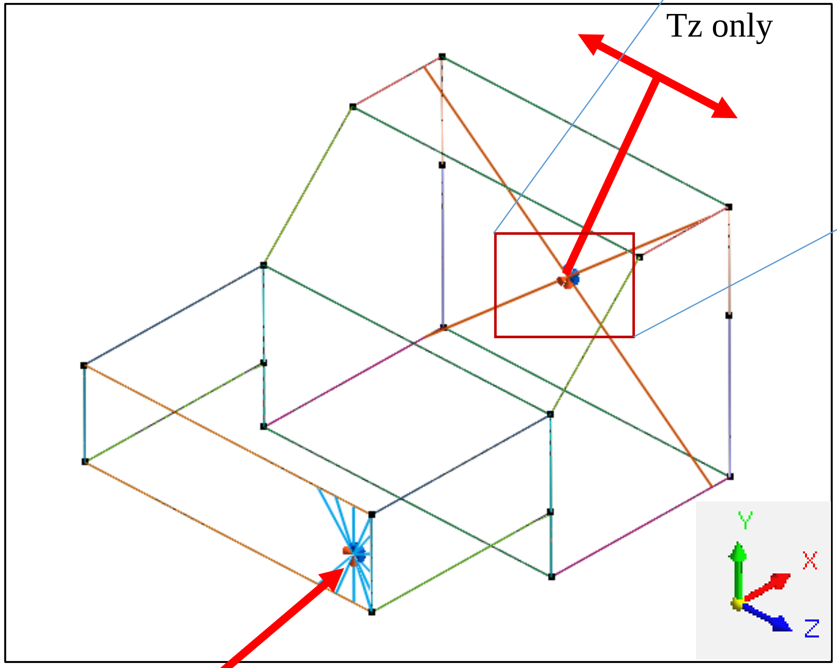
Boundary condition

In real



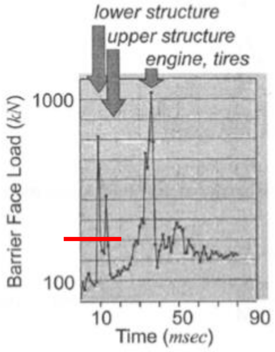
For static analysis
need constraint of x direction





small overlap F

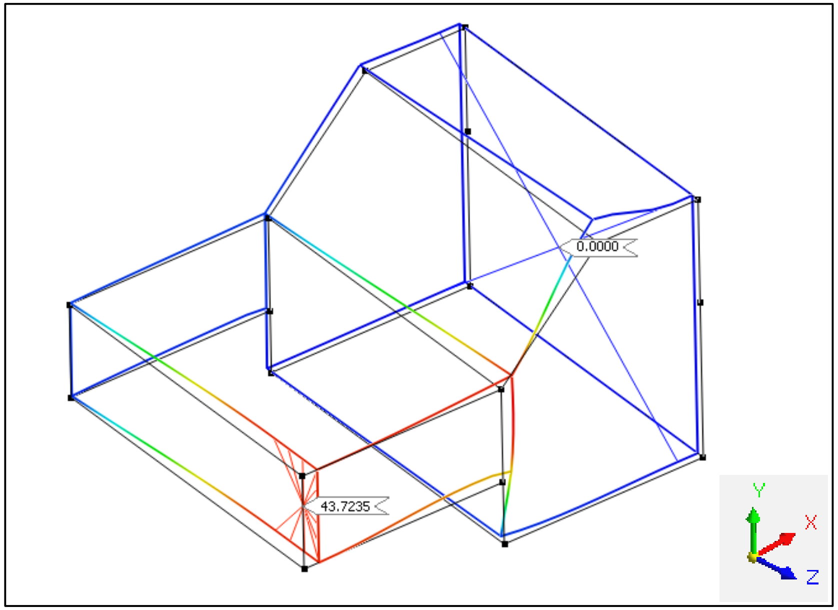
Tx only (barrier impact)



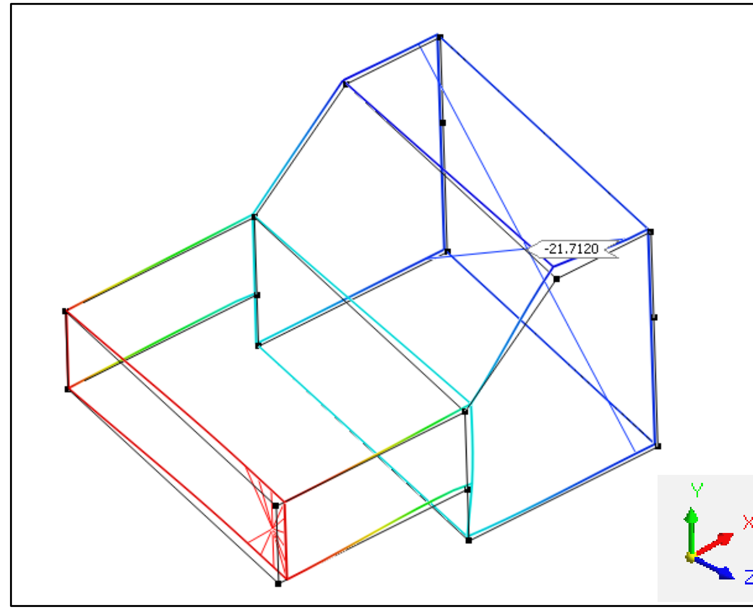
F=20g x 1600kg

F = 300kN

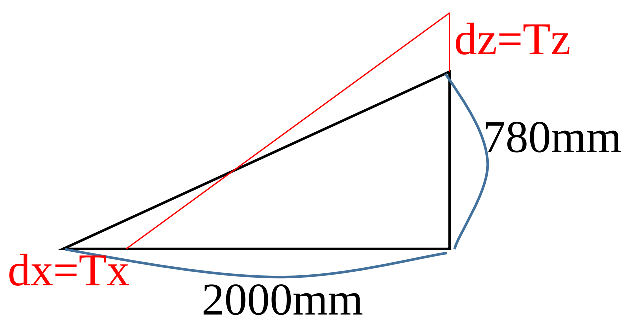
Simulation



Tx = 43.7mm



Tz = 21.7mm



$\Delta\Theta = 0.98\text{deg}$

Size Optimization

Design variables

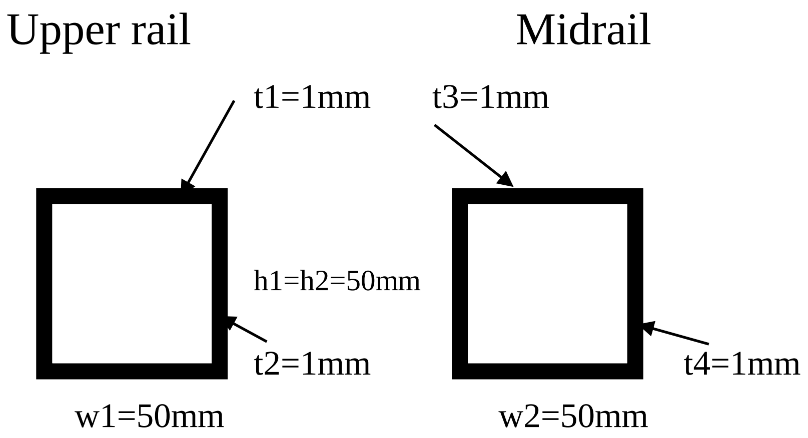
8 variables

Width and height

- w1, w2, h1, h2
- w1, w2, h1, h2

Thickness

- t1, t2, t3, t4
- t1, t2, t3, t4



Objective function and Constraints

Objective function

Displacment of cabin center

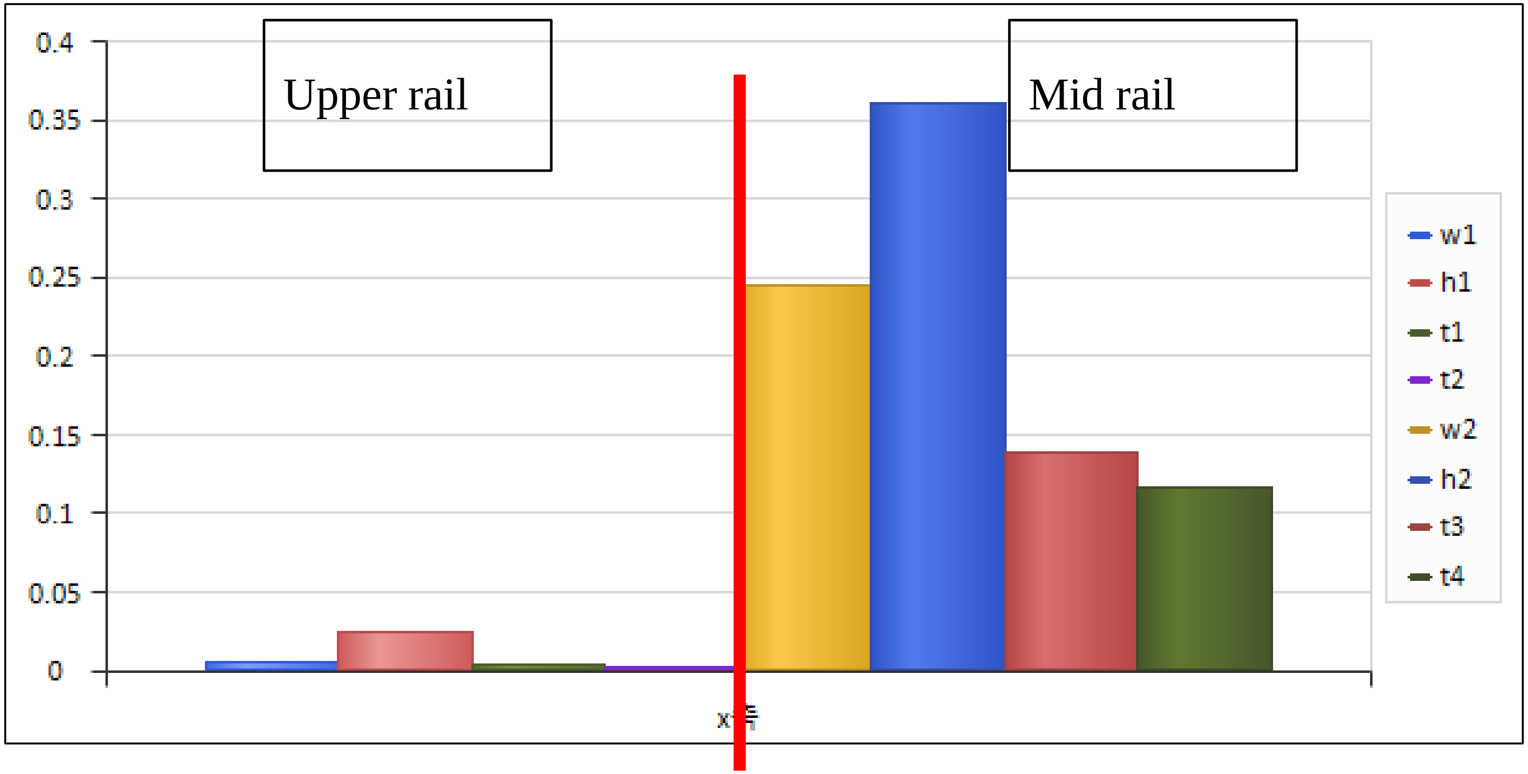
- Minimize z direction displacement

Design constraints

번호	이름	최소값	초기값	최대값
1	w1	5.000000	50.000000	95.000000
2	h1	5.000000	50.000000	95.000000
3	t1	0.100000	1.000000	1.900000
4	t2	0.100000	1.000000	1.900000
5	w2	5.000000	50.000000	95.000000
6	h2	5.000000	50.000000	95.000000
7	t3	0.100000	1.000000	1.900000
8	t4	0.100000	1.000000	1.900000

Fixed volume

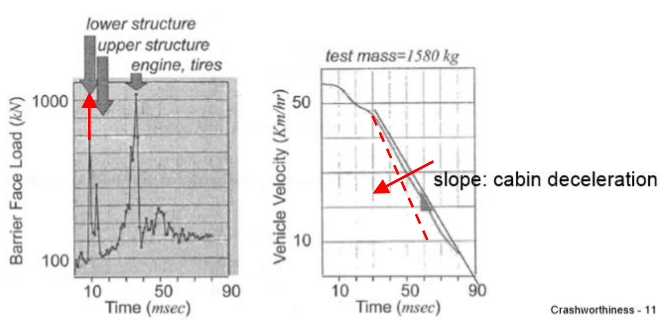
Correlation analysis



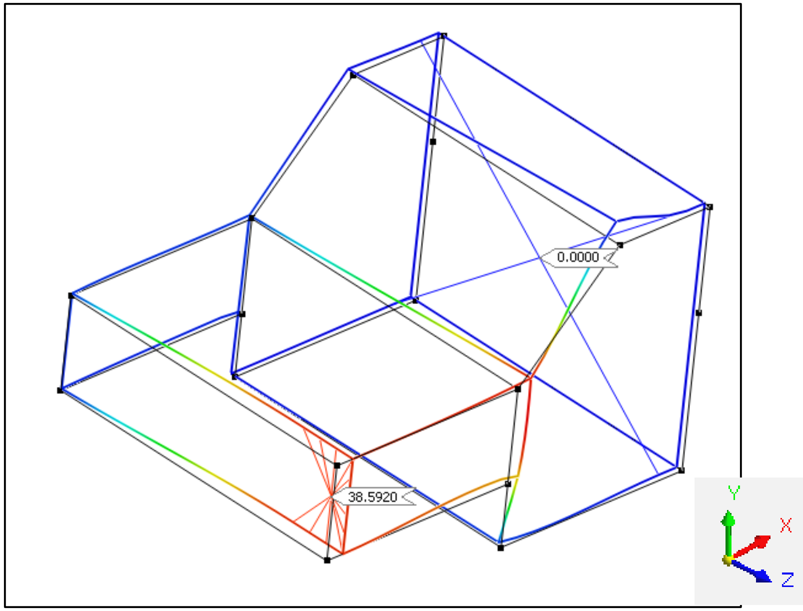
Size optimization

	설계변수 이름	초기값	최소값	최대값	설계안 1	설계안 2	설계안 3	사용자 설계안
					입 력			
▶	w1	50	5	95	34	34	31	34
	h1	50	5	95	20	23	24	20
	t1	1	0.1	1.9	0.69	0.56	0.57	0.69
	t2	1	0.1	1.9	1	0.55	0.62	1
	w2	50	5	95	74	71	60	74
	h2	50	5	95	86	69	80	86
	t3	1	0.1	1.9	0.99	1	0.9	0.99
	t4	1	0.1	1.9	0.75	0.84	0.96	0.75

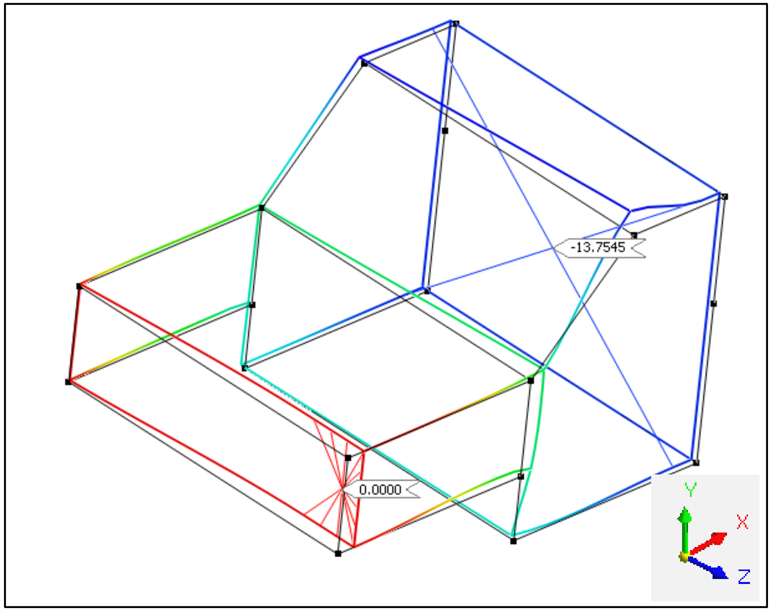
	출력 (예상값 / 해석값)												
	목적함수 변화율 (%)	0				-37		-29		-29			
	제약조건 최대위배율 (%)	1.6				6.1		14		13			
	목적함수-1	21				13		15		15			
	제약조건-1	7.9e+005		7.8e+005	7.8e+005	7.3e+005		6.7e+005		6.8e+005			
*													



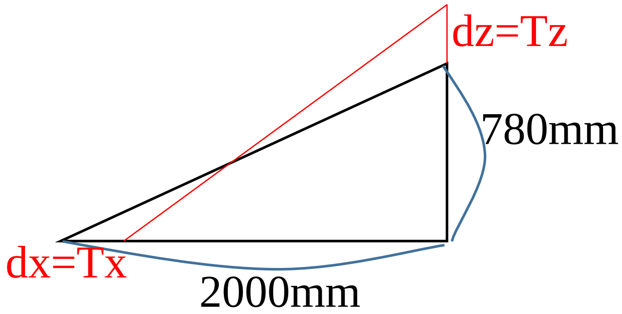
Simulation



Tx = 38.6mm



Tz = 13.8mm



ΔΘ = 0.98deg

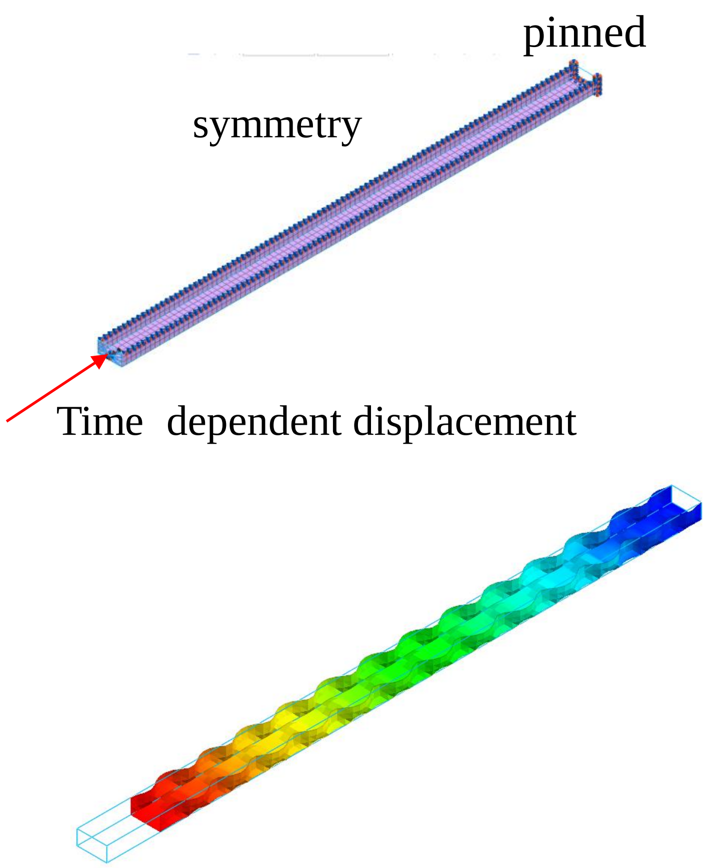
↓

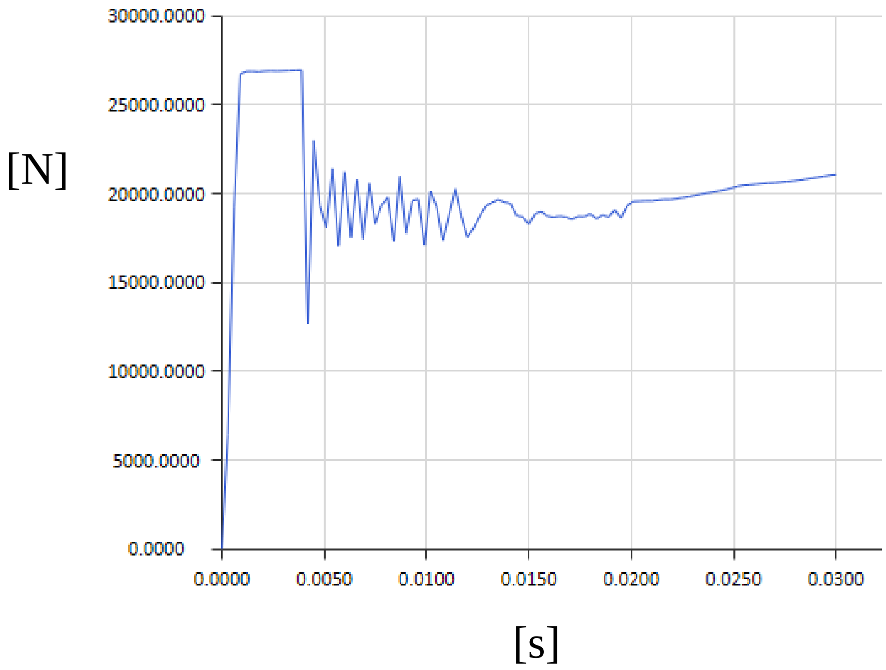
ΔΘ = 0.73deg

25.5% reduced

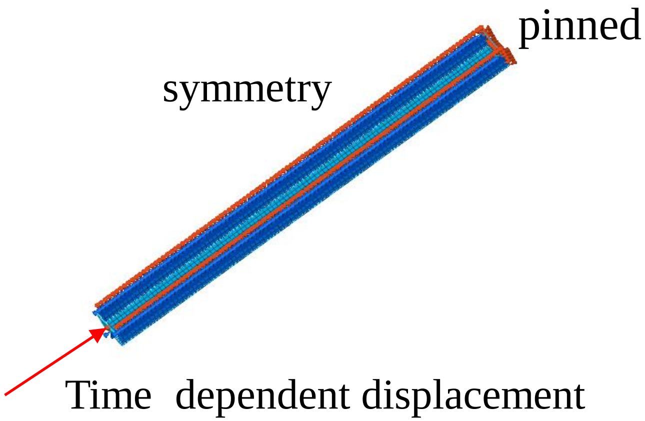
Energy absorption test

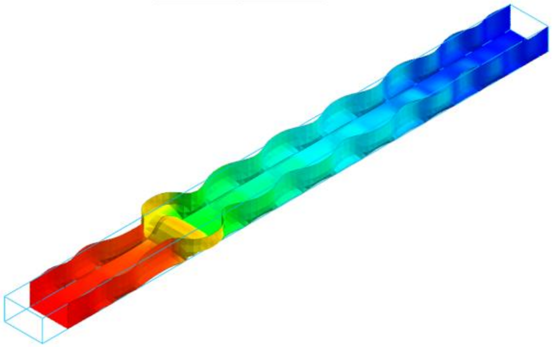
Before optimization

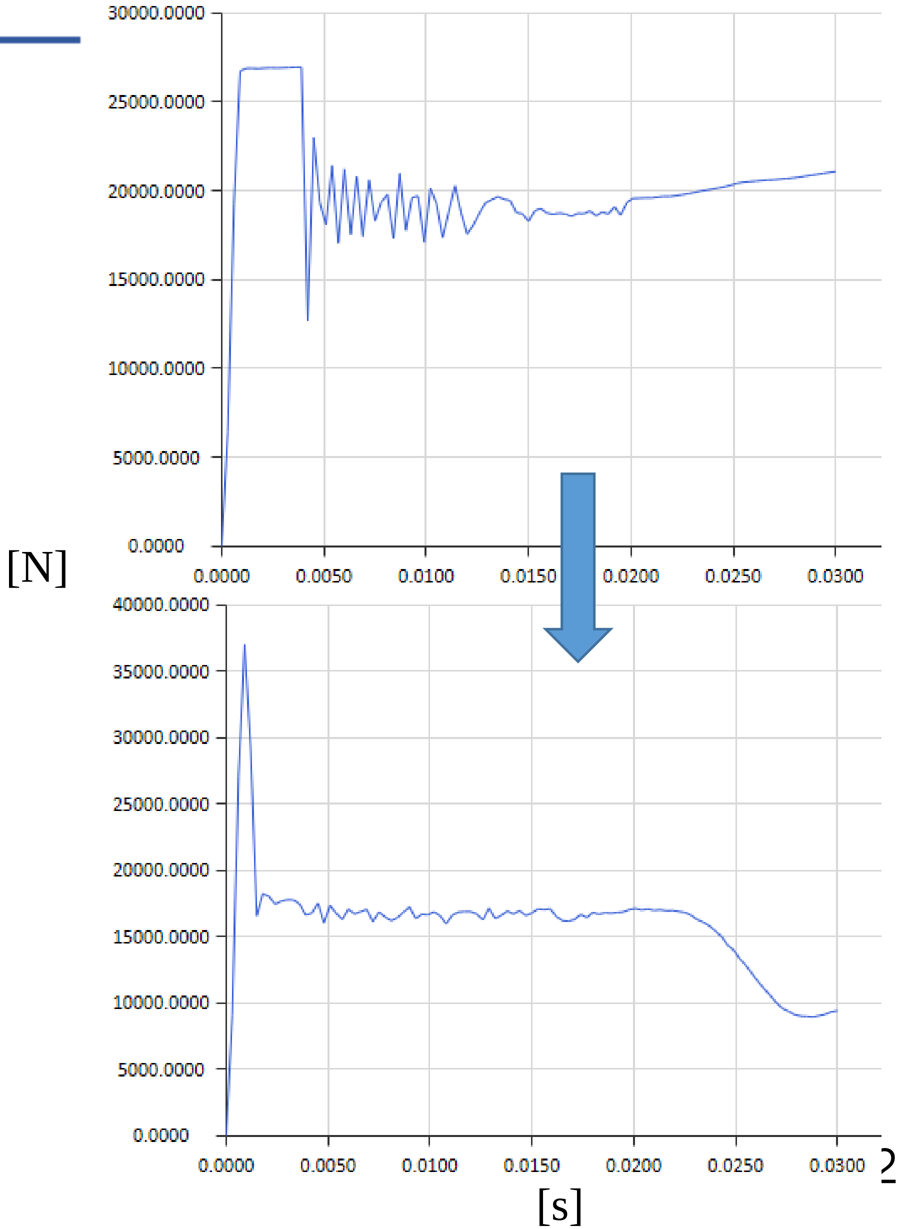




After optimization







Conclusion

Conclusion

- Reduce yaw motion by size optimization of motor compartment rails

- Trade off : energy absorption decrease

- In real world yaw motion is more risky for passenger
  reinforce safety by small yaw motion after small overlap

Thank you!

Reference

Chen, H. & Yang, Y. & Wang, L.. (2015). Vehicle front structure energy absorbing optimization in frontal impact. 9. 168-172. 10.2174/1874155X01509010168.