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Development of Detailed AM50%ile Hybrid III Dummy FE Model

Presented at
LS-DYNA Forum, 13 October 2011,
Filderstadt (Stuttgart), Germany

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CONTENTS

1-1. Background

- The dummy's injury measurements are evaluated in FMVSS 208, such as head G, chest deflection and so on.
- FE analysis recently is utilized to predict the dummy responses.
- Miyazaki et al. developed a FE flex impactor model using reverse engineering technique with CT scan measurement.
- Developing a fine dummy FE model with the technique is also expected.

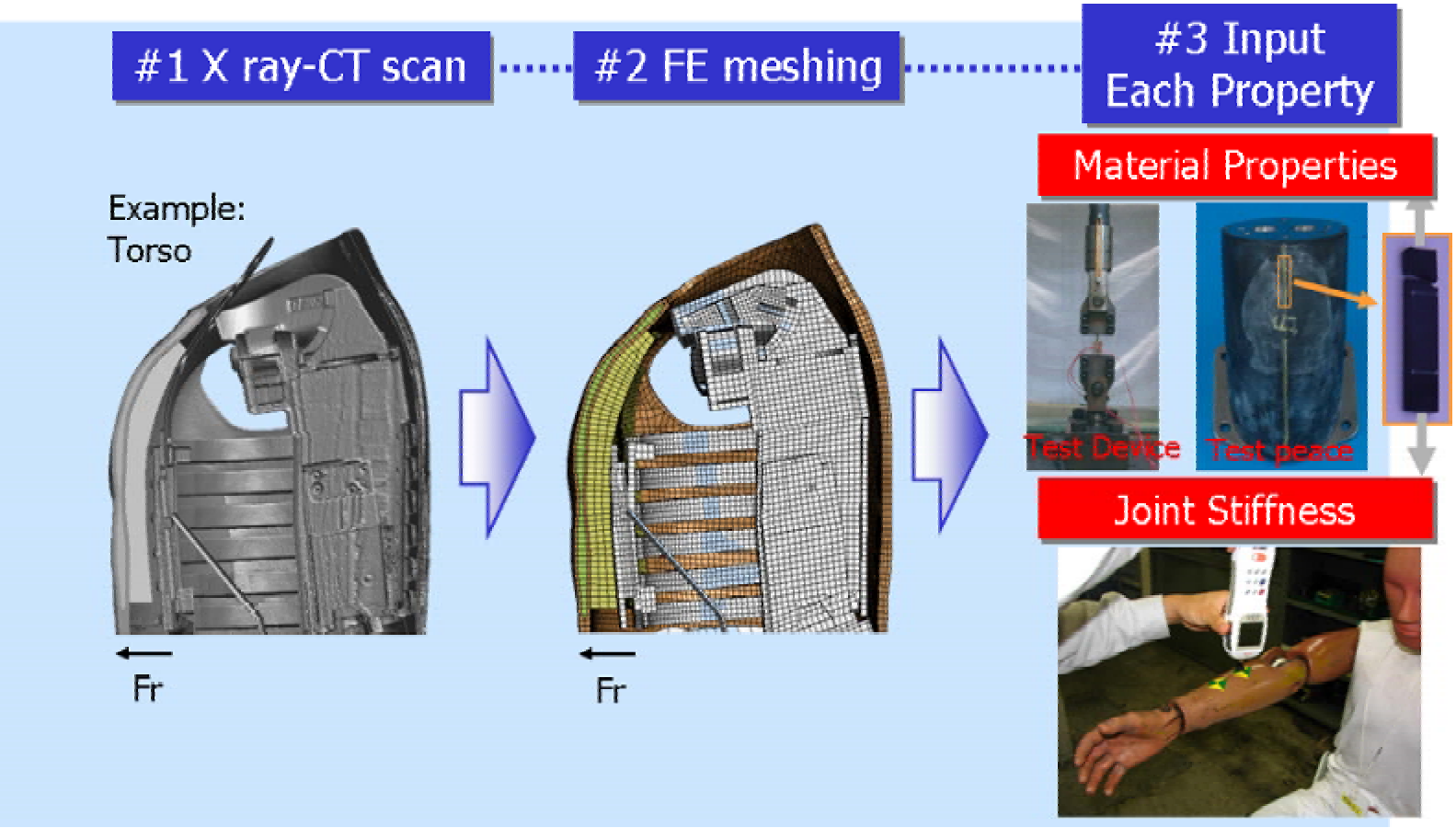
1-2. Objectives

- To develop a HybridⅢ AM50%ile dummy model using the reverse engineering technique.
- To examine the kinematics and injury responses by comparing to those from the tests.

2-1. Reverse Engineering

・Fine mesh from the geometry data scanned by X ray CT.

・Input the experimentally measured material properties and joint stiffness.



2-2. X-ray CT scan

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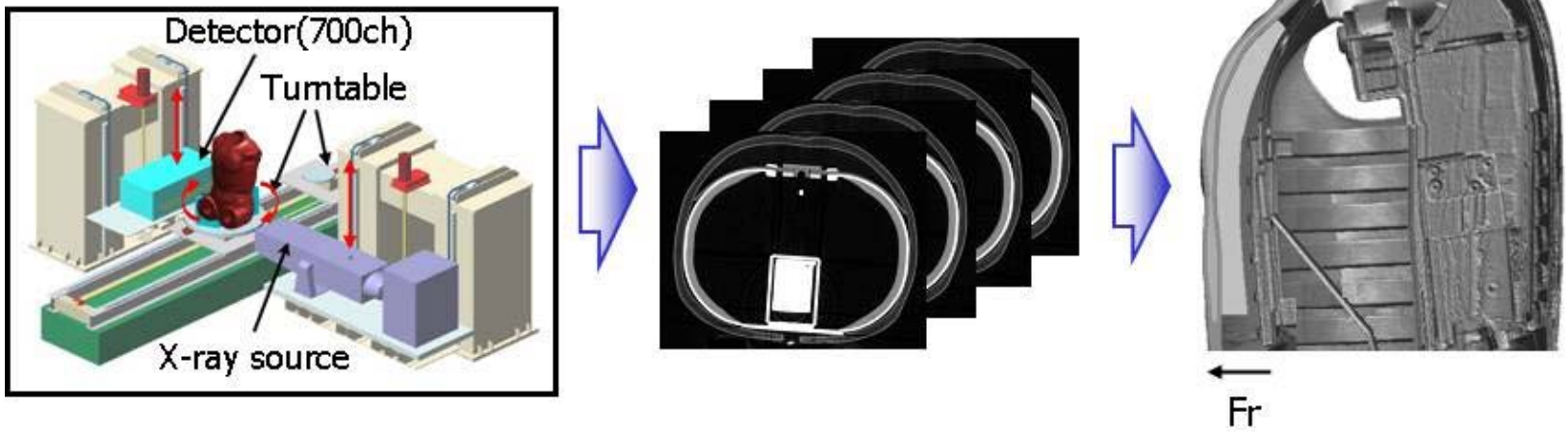
・Geometry data is obtained with a physical dummy at 1mm scan pitch by TMC-owned X-ray CT scanner.

・Metal and non-metal 2D images are obtained by setting X-ray threshold levels.

・3D geometry is obtained by image reconstruction.

〔Example：Torso〕



X-ray CT scanner　　Sectional points groups　　3D geometry (STL)

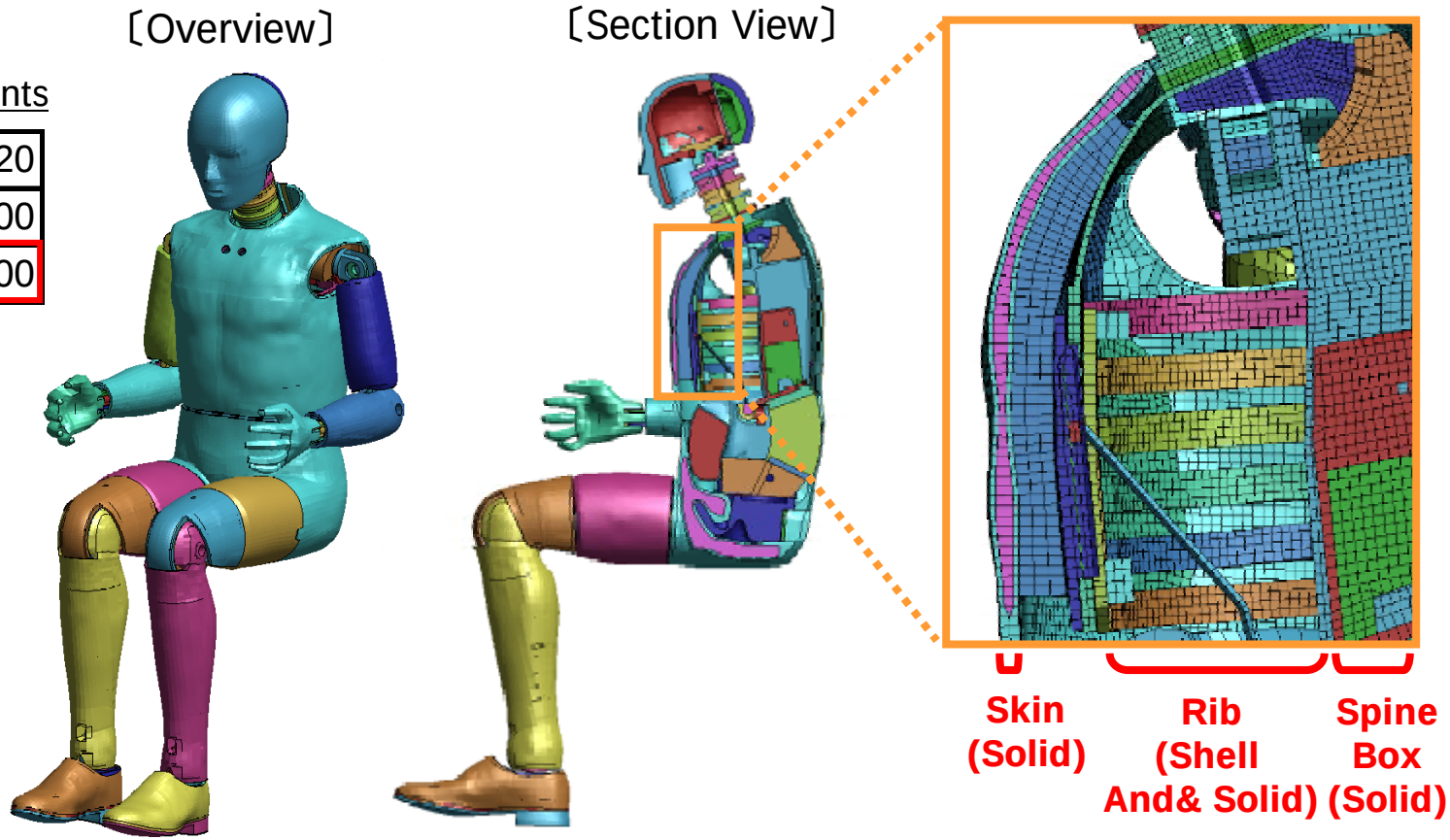
2-3. Mesh Generation

FE mesh is made in detail to represent 3D data w/o omission

- Element size: 3-5mm for deformable parts
- Skin parts: Meshed with Solid Element

The number of elements

Part	320
Node	450,000
ELEMENT	390,000



Hybrid Ⅲ AM50%ile FE Model

2-4. Material Properties

Test specimens are taken out of a new physical dummy

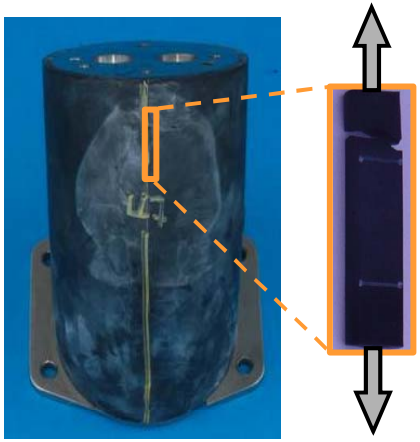
- Static tension tests for 49 parts
- Dynamic tension tests for 7 parts such as “Lumber spine”

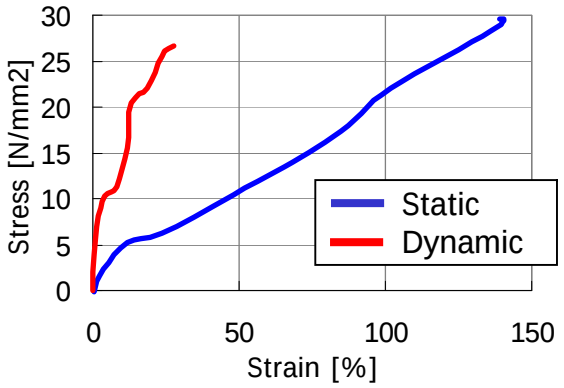
The Number of Test Specimens

Material	The No. of Specimens
Steel	26
Aluminum	5
Dumping Material	2
Rubber	8
Vinyl	5
Ensolite	1
Etc.	2

Total 49

〔例：Lumber Spine〕

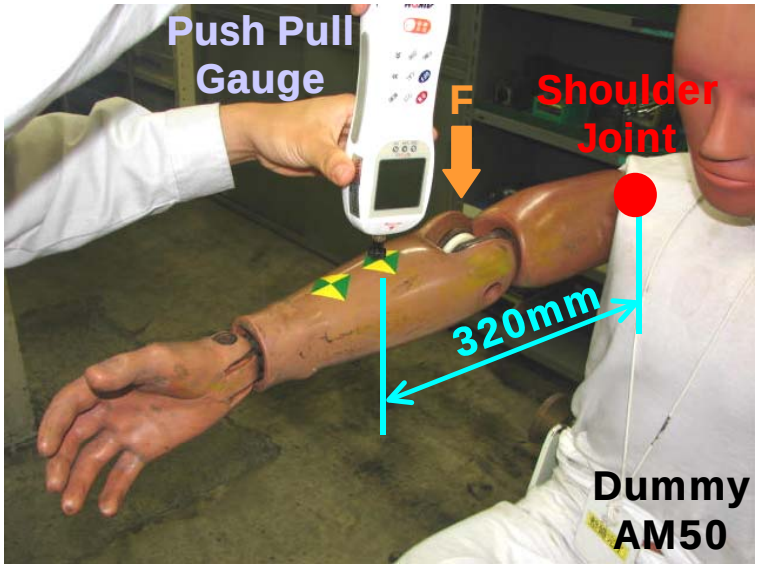




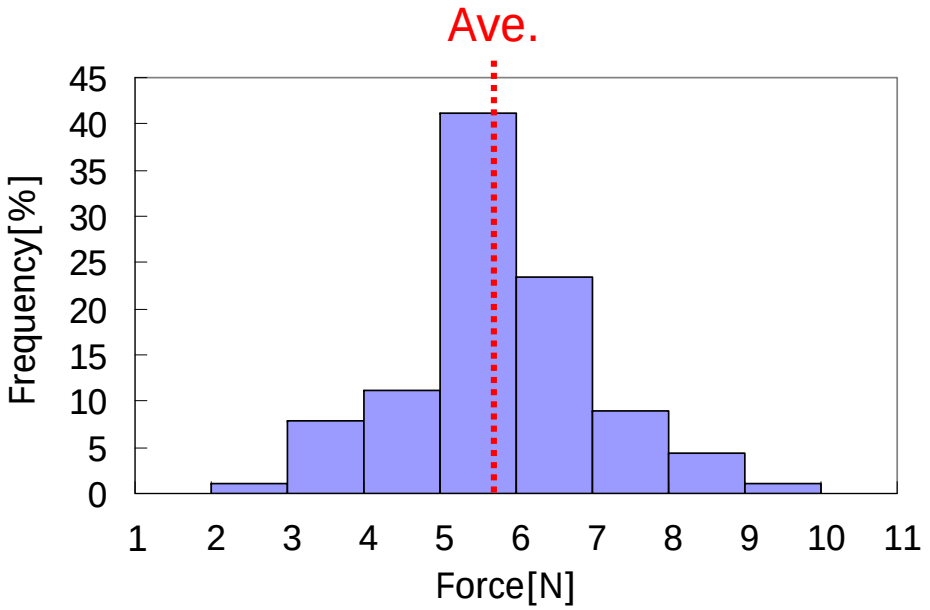
2-5. Mechanical Properties

- Joint stiffness is measured at 27 joints
- Ave. value from 90 data obtained at each joint is applied

〔Example〕



Measurement of Shoulder Joint



Measurement Result

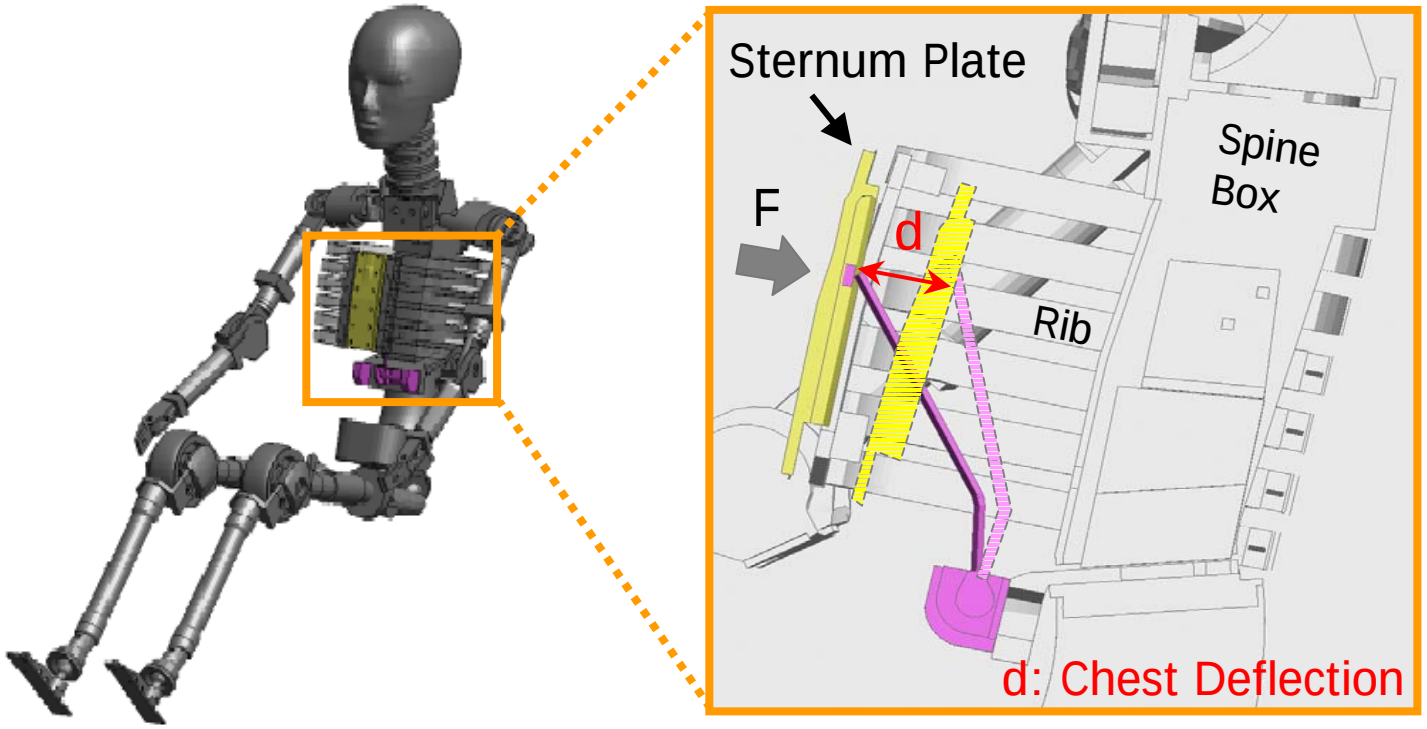
3-1. Model Validation

- 10 certification tests based on FMVSS208 are conducted
- Tests for chest characteristics and sled test are added

	Assembly	Standard Certification Test	Result	Additional Test	Result
Componrent	**Head**	Head Drop Test	○		
	Neck	Neck Pendulum Test (+)	○		
		Neck Pendulum Test (-)	○		
	Thorax	Thorax Impact Test	○	Thorax Impact Test (Low Speed)	○
				Rib Static compression Test	○
				Thorax Dynamic Seatbelt Test	○
	Pelvis	Hip Joint-Femur Flexion Test	○		
	Knee	Knee Impact Test	○		
		Knee Slide Impact Test	○		
	Leg	Upper Foot Impact Test - without Shoe	○		
		Lower Foot Impact Test - without Shoe	○		
		Lower Foot Impact Test - with Shoe	○		
Sled	**All**			**Full Lap Sled Test**	○

3-2. Measurement of Chest Deflection

- Chest deflection is equal to the displacement of the sternum plate relative to the spine box.

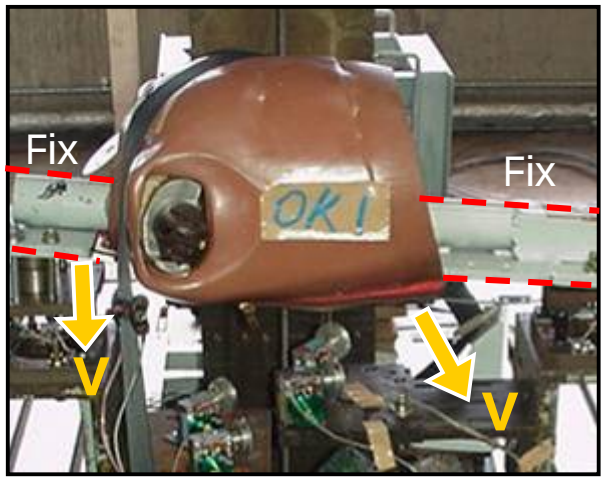


〔Overview〕 〔Central Section View〕

Measurement of Chest Deflection

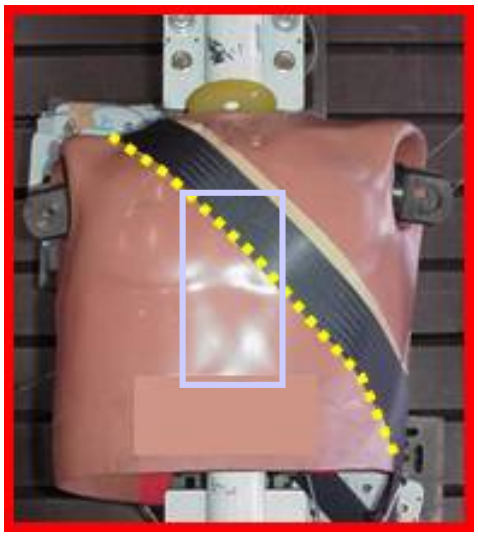
3-3. Dynamic Seatbelt Loading

- Seatbelt tension loading on the chest fixed spine rigidly
- 2 tests of different belt path on the chest are evaluated

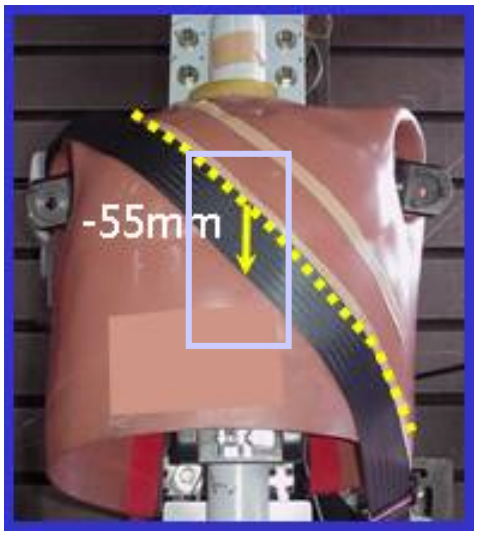


Test Condition

Tension velocity is aimed to simulate chest deflection rate in crash tests.



〔Path A〕



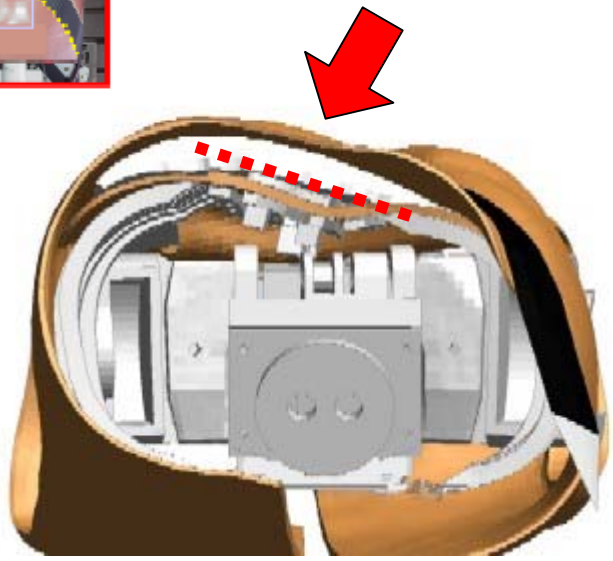
〔Path B〕

Comparison of Seatbelt Path

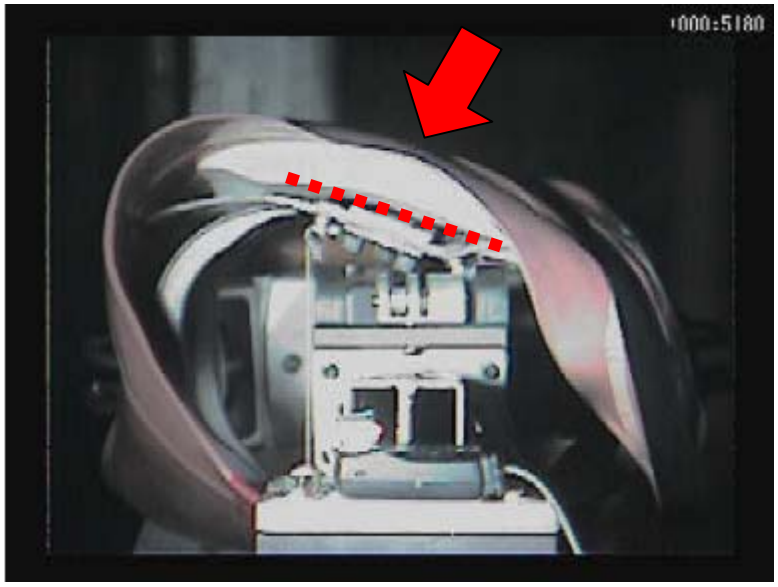
3-4. Comparison of Internal Kinematics

- The sternum plate kinematics coincide with the test.

Pass A



Simulation

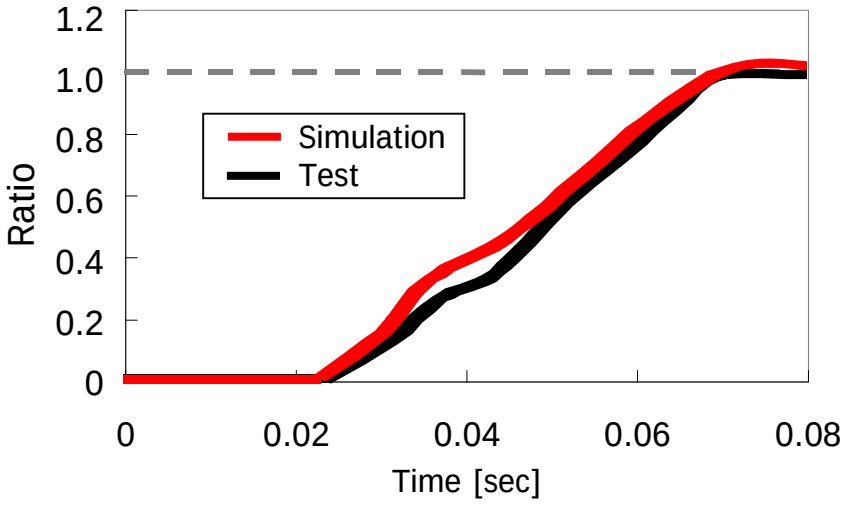


Test

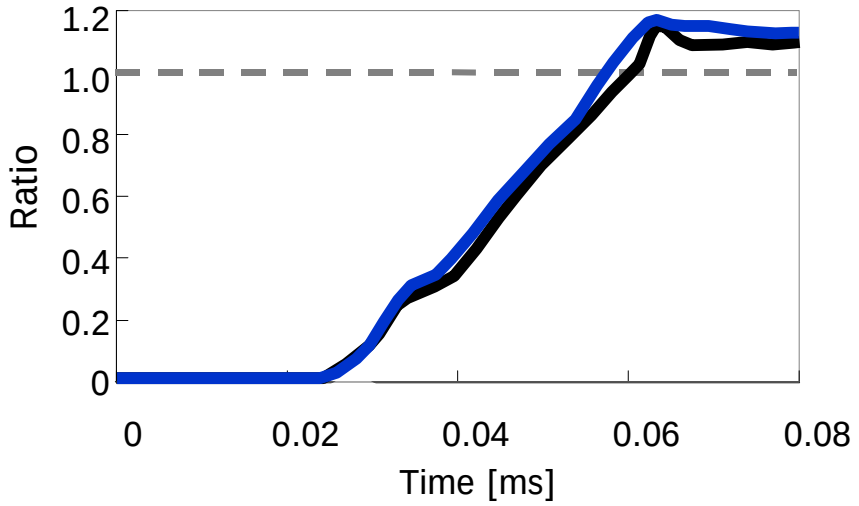
3-5. Comparison of Chest Deflection

- Chest deflection is well coincide with the test in both 2 path conditions.

〔Path A〕



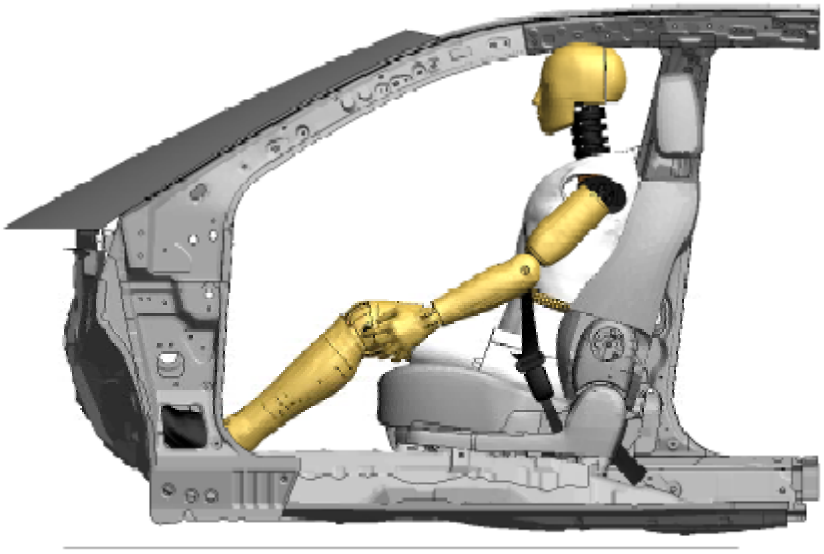
〔Path B〕



Chest Deflection (Test Max. Value Original Pass=1.0)

3-6. Frontal Full Lap Sled Test

- Sled condition: 48km/h Full lap frontal crash
- Restraint system: Seat, Seatbelt with force limiter



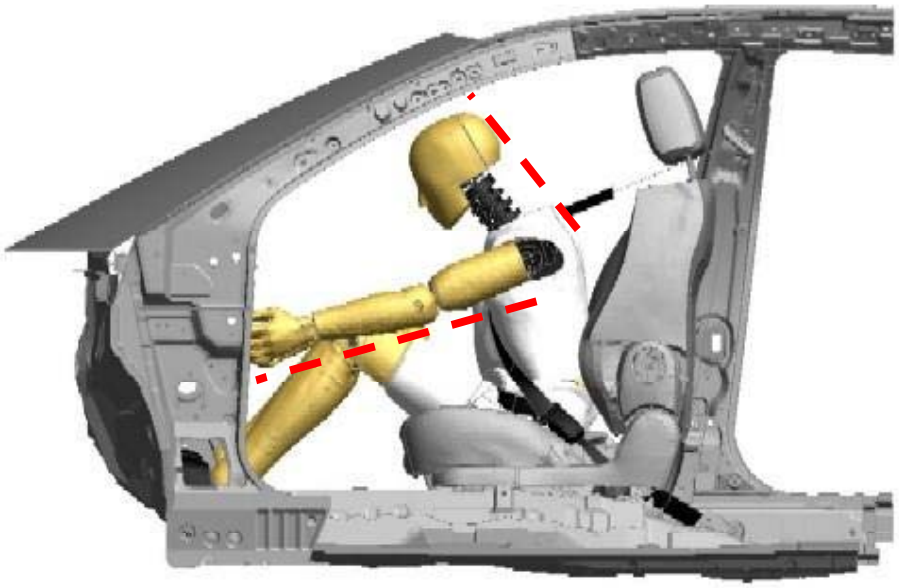
Simulation Model

Simulation Condition

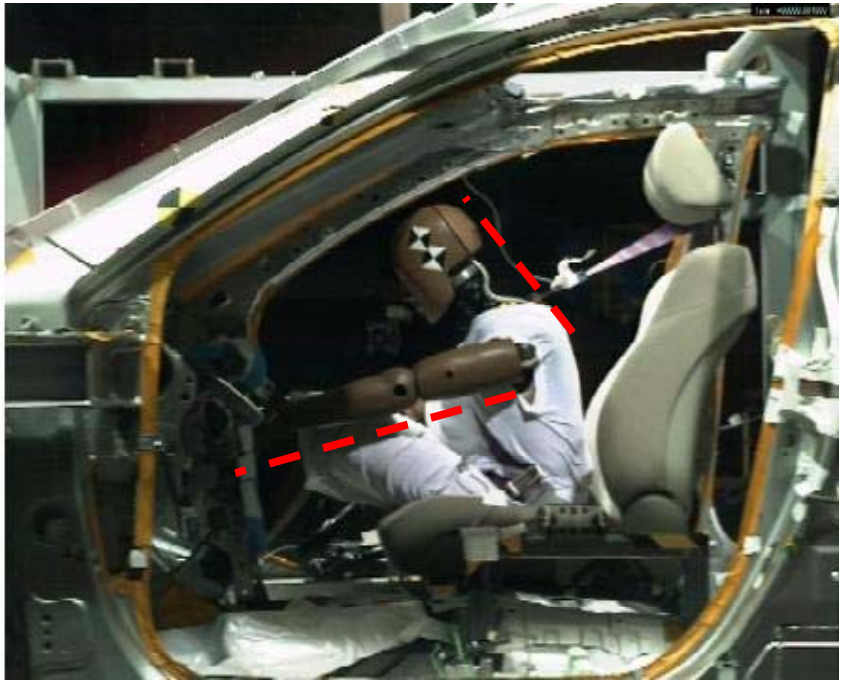
Impact Velocity	48 km/h
Occupant	Passenger
Airbag	Not Available
Instrument Panel	Not Available
Seatbelt	Available
Pretensioner	Activated
Force Limiter	4 kN

3-7. Comparison of Kinematics

- Kinematics of FE model correlates to test.



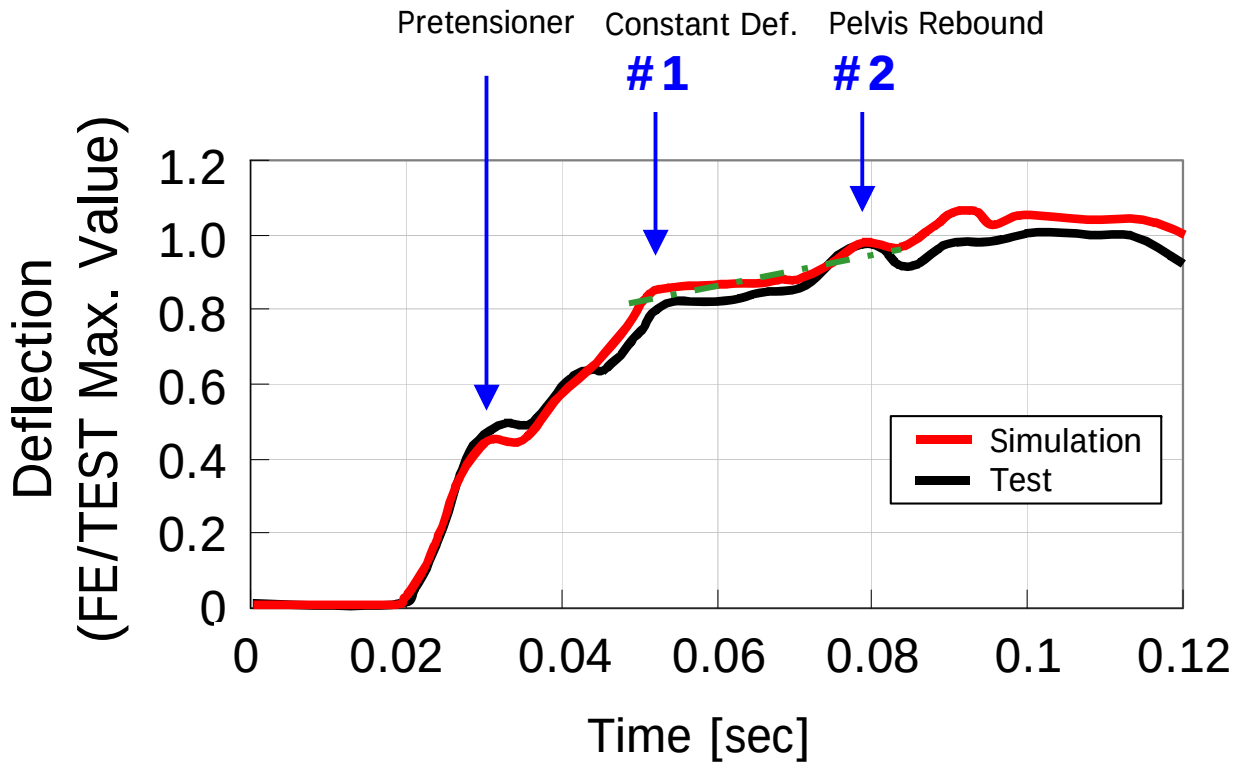
Simulation



Test

3-8. Comparison of Chest Def.

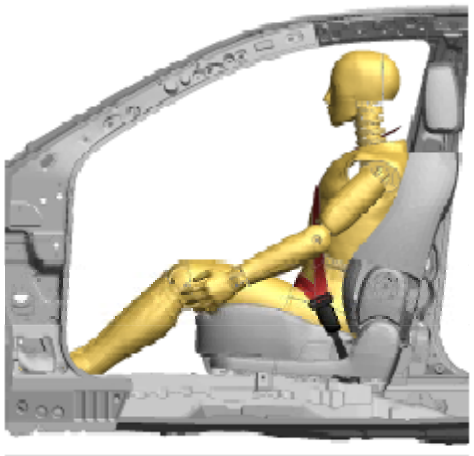
- Chest deflection of FE model correlate to test data.



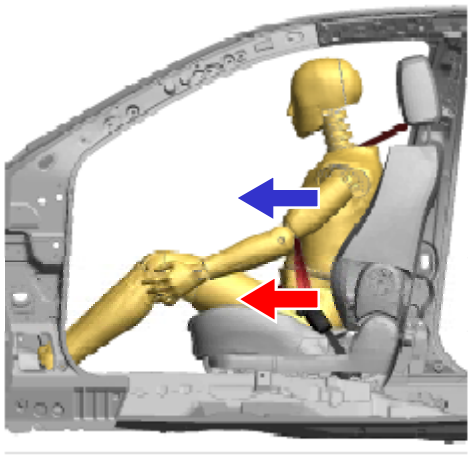
Chest Deflection

4-1. Kinematics

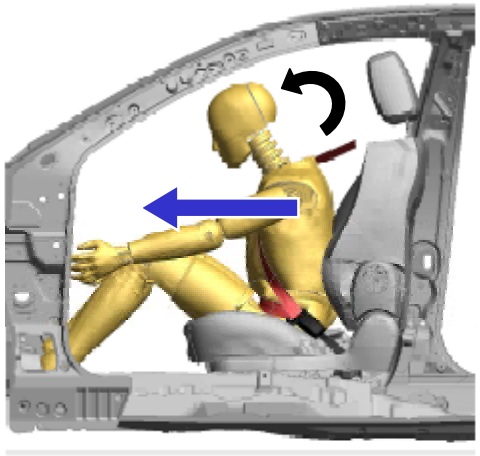
- 0～50ms：Translational movement bet. chest and pelvis
- 50ms～：Forward movement with rotation in thorax



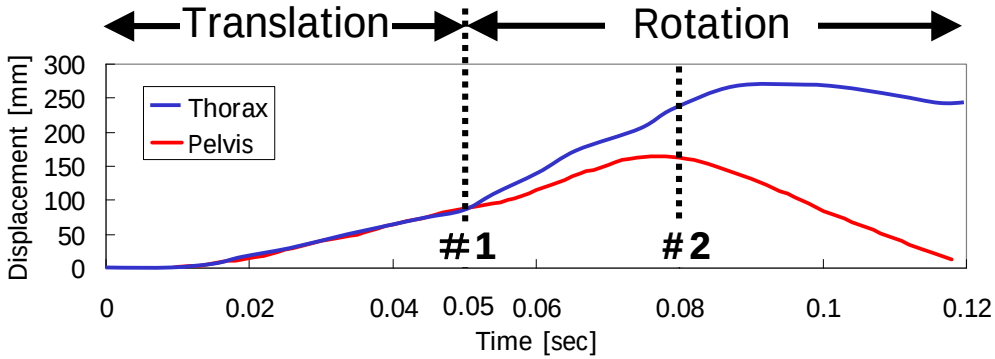
0 ms



50 ms



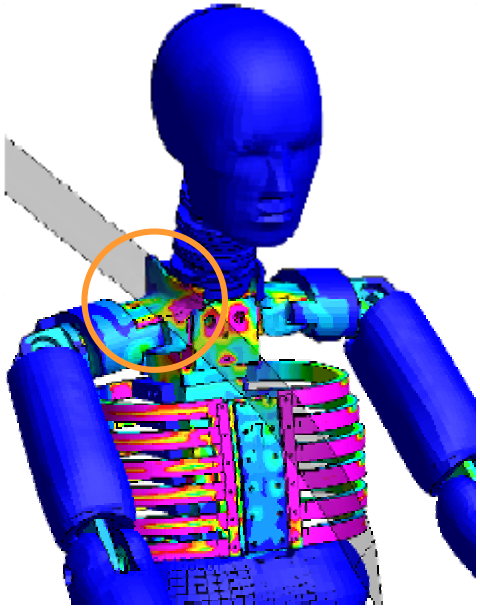
80 ms



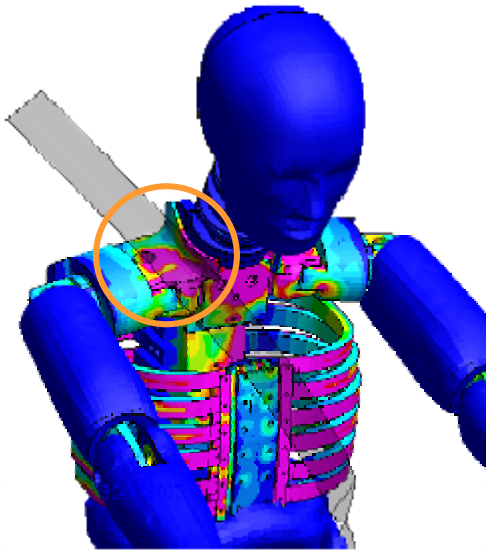
Displacement of Thorax and Pelvis

4-2. Acting Force from Belt

・50~80ms: Acting force on clavicle increases while that Force on rib keeps constant.

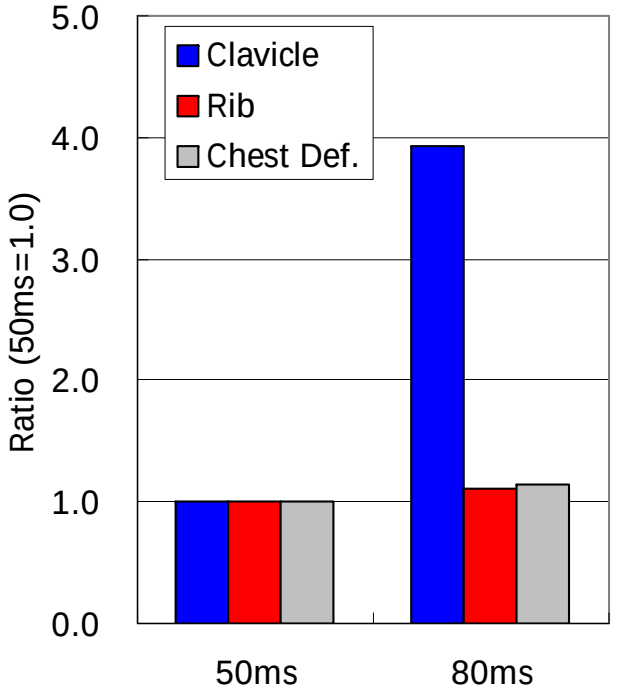


② 50 ms



③ 80 ms

Comparison of Von Mises Stress



Comparison of Force

5. Conclusions

(1) Developed a detailed FE HIII Dummy model with reverse engineering using X-ray CT scans.
(2) Material properties were studied by cutting out test specimens from dummy component parts and performed static and dynamic tests.
(3) The force response of the developed FE model was verified in comparison tests and found to be consistent with the results obtained from a physical dummy.
(4) It was concluded that this detailed FE model is effective for analyzing deformation and force transfer inside the dummy in crash tests.

Thank you for your attention.