Validity of Applying the Current Headform to the Pedestrian Head Protection Performance Evaluation Test of a Car at Low Impact Speed

UNECE GRSP
Task Force of Deployable Bonnet Systems for Pedestrian Safety
(TF-DPPS)
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Japan Automobile Standards Internationalization Center (JASIC)

Contents

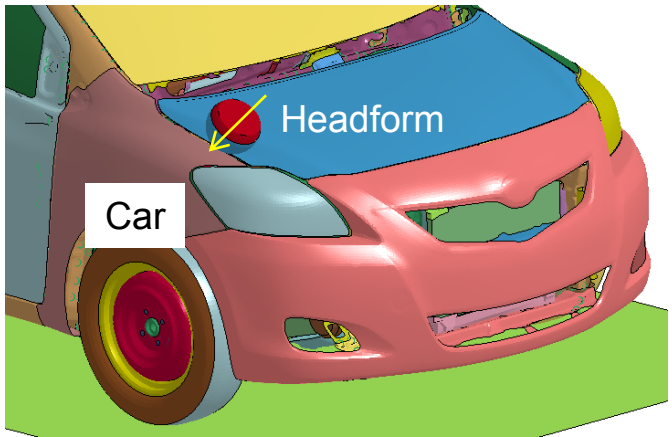
1. Background

- ✓ The UN/GRSP Task Force (TF) for the Deployable Pedestrian Protection System (DPPS) is now developing an evaluation test protocol with regards to the pedestrian head protection performance of a car, which has a DPPS.
- ✓ In one of the TF activities, the TF is now trying to develop an evaluation test protocol with regards to the pedestrian head protection performance of a car, which has DPPS, at lower impact speed (e.g. 20 - 30 km/h) compared to the current one (e.g. 35, 40 km/h).
- ✓ Its purpose is to evaluate the pedestrian head protection performance of a car, which has DPPS whereas it does not deploy based on its design concept because of low car-pedestrian impact speed.
- ✓ However, some TF members opposed to the lower impact speed test because the validity of the current headform when applied at the lower impact speed is unknown.

Evaluation Test

Pedestrian Head Protection Performance of a Car

Headform Impact Speed to a Car
35, 40 km/h (GTR9, NCAP)



(image)

Headform Impact Speed to a Car
20 - 30 km/h (TF DPPS)

Is it appropriate?

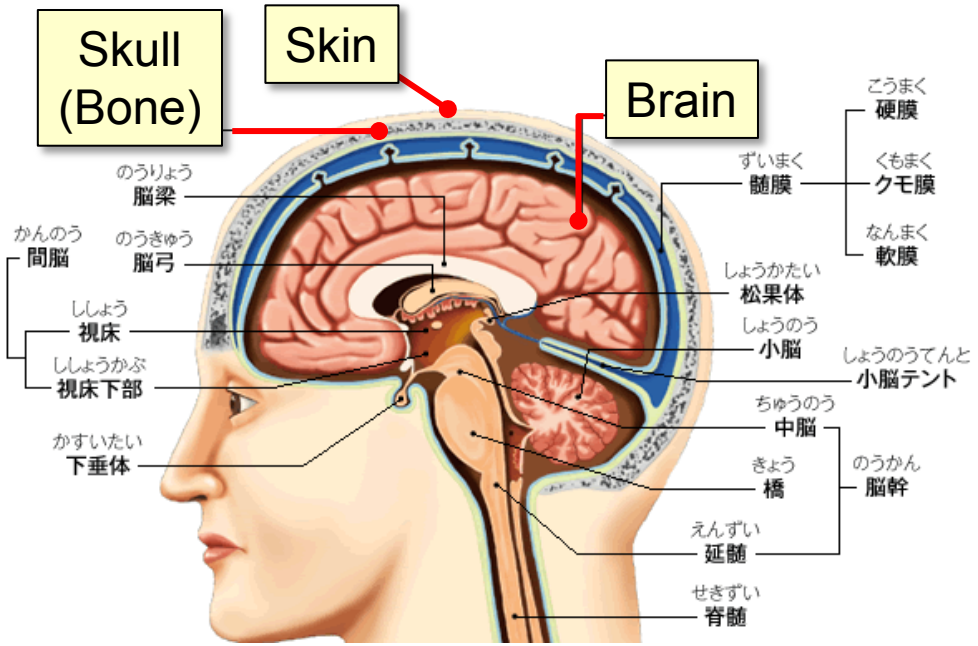
2. Objectives

- Evaluate the validity of applying the current headform to an evaluation test with regards to the pedestrian head protection performance of a car at low impact speed (e.g. 20-30 km/h).

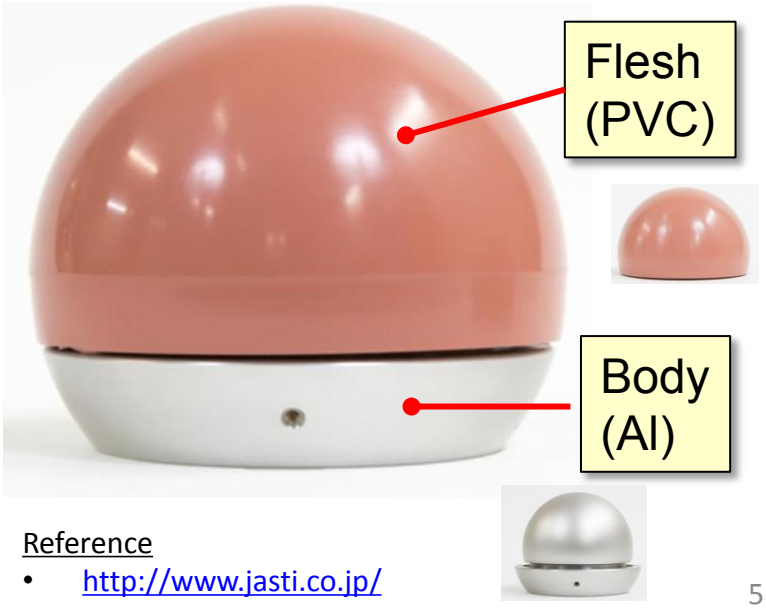
3. Comparison of Human Head & Headform Construction

- At first, we reviewed a human head and headform construction to have a basic understanding.
- A human head consists of several parts (e.g. skin, skull, brain), then its impact response is determined by the integral impact responses of those parts.
- On the contrary, the headform simply consists of two parts (flesh and body), and its impact response is determined by the impact response of the flesh part (Polyvinyl Chloride (PVC)).
- The impact response of the headform is comparable to that of the human head, then it is used for 35 or 40 km/h impact speed tests worldwide.

Human Head



Headform



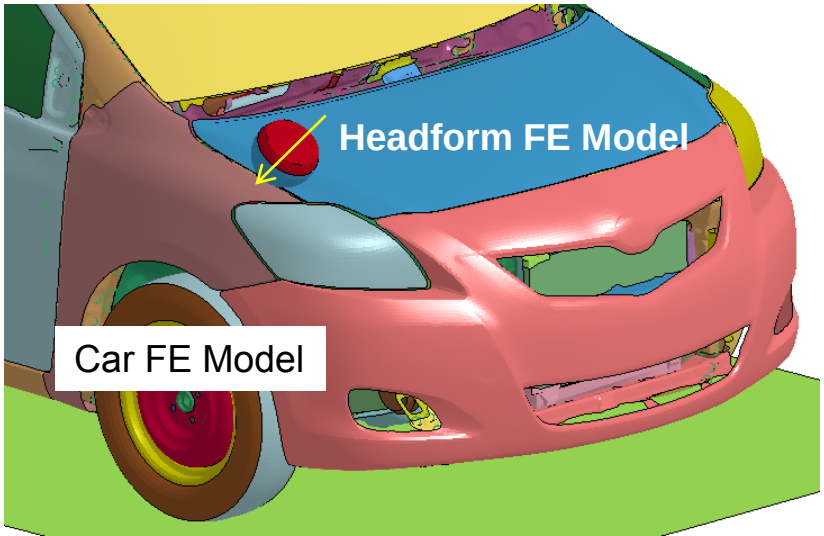
Reference

- http://www.jasti.co.jp/

4. Variability of the Strain Rate of the Headform Flesh and Its Influence

- In this study, we analyzed the strain rate generated at the headform flesh at a high and low impact speed because only the strain rate of the flesh (PVC) has a chance to vary the headform response based on its strain rate dependency.
- In this study, we used (1) Headform FE Model (LS-DYNA) which has high fidelity to an actual headform and (2) Car FE Model (LS-DYNA) which was downloaded from the NCAC database.
- Three headform impact speeds (20, 30, 40 km/h) and two car stiffnesses (original, hard (thickness x2)) were selected for this study to investigate the variability of the strain rate of the headform flesh.
- The strain rate of the headform flesh was obtained by differentiating the maximum principal strain by time. (LS-DYNA cannot output the strain rate of the headform flesh directly)

FE Models for the Evaluation Test
Pedestrian Head Protection Performance of a Car



Headform Impact Speed to Car
20, 30, 40 km/h

Car Stiffness
Original, Hard (thickness x 2)

4. Variability of the Strain Rate of the Headform Flesh and Its Influence, contd.

- As a result, we found that the strain rate of the headform flesh tends to be decreased by decreasing the impact speed, then, the difference became approximately double at the maximum.

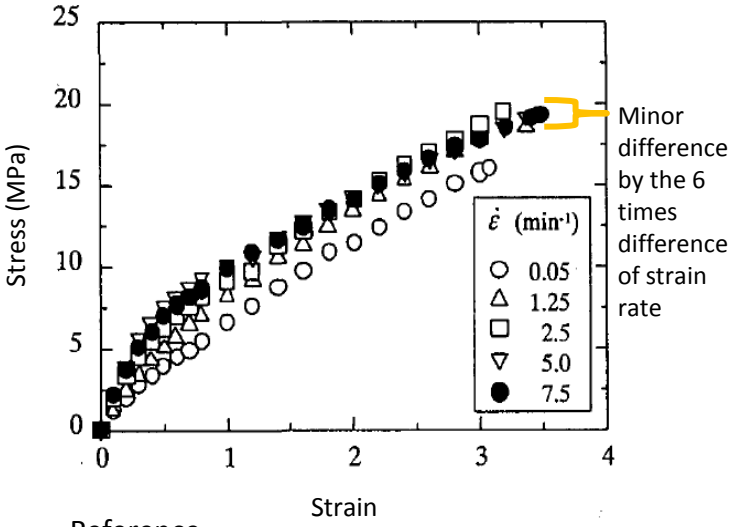
CAE Results	Car (Stiffness: Original)		
	40 km/h	30 km/h	20 km/h
HIC	1112	589	259
Strain Rate (max.)	**223**	**208**	**125**

CAE Results	Car (Stiffness: Hard)		
	40 km/h	30 km/h	20 km/h
HIC	3189	1689	626
Strain Rate (max.)	**222**	**212**	**110**

4. Variability of the Strain Rate of the Headform Flesh and Its Influence, contd.

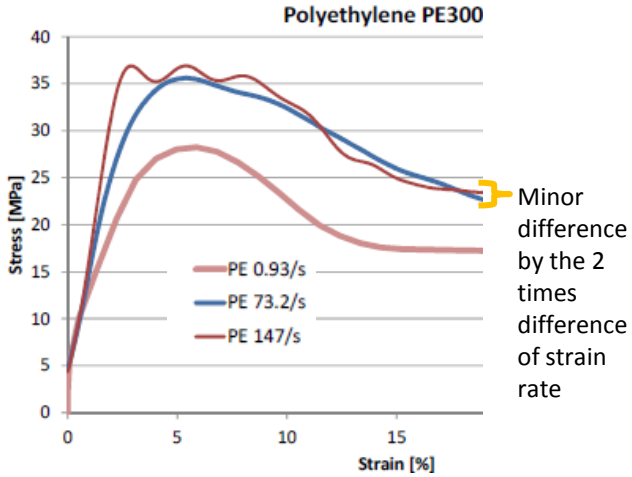
- In parallel, we found that the characteristics of the headform flesh material (PVC) as well as polyethylene and human bone for reference are moderately varied by the variability of the strain rate in the log scale.
- Therefore, the difference of the strain rate of the flesh, approximately double at the maximum, does not affect the headform impact response significantly.
- This lead a conclusion that no concern exists for applying the current headform to an evaluation test with regards to the pedestrian head protection performance of a car at low impact speed (e.g. 20-30 km/h).

Strain Strain Rate Dependency
Headform Flesh/PVC
(Strain-Stress Curve)



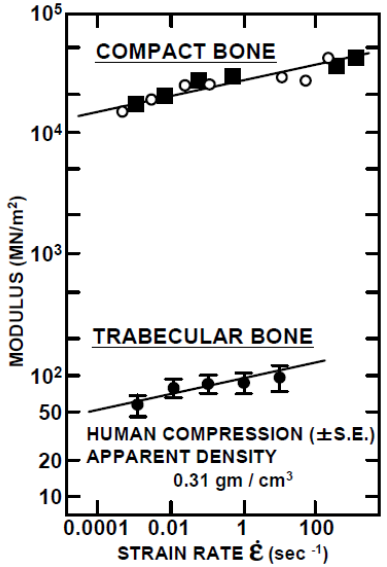
Reference
- Kano S., et al. (2013)

Strain Strain Rate Dependency
Polyethylene
(Strain-Stress Curve)



Reference
- Pipkorn B., et al. (2014)

Strain Strain Rate Dependency
Human Bone
(Modules)



Reference
- Carter D.R. Hayes W.C. (1976, 1977)

5. Conclusions

- In this study, we evaluated the validity of applying the current headform to an evaluation test with regards to the pedestrian head protection performance of a car at low impact speed (e.g. 20-30 km/h).
- As a result, we found that the strain rate of the headform flesh (PVC), which only has a chance to vary headform impact response based on its strain rate dependency, tends to be decreased by decreasing the impact speed with a maximum of approximately double.
- In parallel, it is also found that the strain rate dependency of the headform flesh is moderate in the log scale, that means the difference of the strain rate of the flesh does not affect the headform impact response significantly.
- This lead a conclusion that no concern exists for applying the current headform to an evaluation test with regards to the pedestrian head protection performance of a car at low impact speed (e.g. 20-30 km/h).

References

- Hodgson and Thomas (1971) "Comparison of Head Acceleration Injury Indices in Cadaver Skull Fractures", Paper 710854, Proceeding of Fifteenth Stapp Car Crash Conference, P-39, New York; Society of Automotive Engineers, Inc.
- Hodgson and Thomas (1973) "Breaking Strength of the Human Skull vs Impact Surface Curvature", Contract No. DOT-HS-146-2-230, Final Report, DOT-HS-801-002
- Carter D.R. Hayes W.C. (1977) "*The compressive behaviour of bone as a two-phase porous structure*", Journal of Bone and Joint Surgery, 59-A
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- Kano S., et al. (2013) "Study on Deformation and Strength Properties of Water Proof Sheet - Tensile Strength Property on Various Temperature Conditions and Stress Relaxation Property -", Journal of Japan Society of Civil Engineers, Ser. B3 (Ocean Engineering), Vol. 19
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