Study of occupant lower leg injury value using interface new function

Takashi Ishihara, Hisaki Sugaya, Kazunori Maehara, Hiroyuki Mae

Honda R&D Co.,Ltd.

1 Background

In recent years, the use of comuputed aided engineering (CAE) in the automotive development is an indispensable technology to shorten the development period and reduce the prototype cost. CAE is used in crash safty as well, the occupant crash safty CAE models contain the deformation of the car body and restraint device. Therefore, when studying the occupant injury value in car development, it is necessary to verify the influence of deformation of the car body and the restraint device. Since the restraint device often has few related parts and the desired deformation can be reproduced relatively easily on the CAE, but the deformation of the car body is influenced by many parts and it is difficult to reproduce the desired deformation on the CAE. In addition, the occupant dummy contains a large number of softer tissues than the body structural members, leading that the simulated occupant injury values might differ with a difference in the deformation of the car body. From the above, it is beneficial function to be able to examine the influence of the deformation of the car body on the occupant injury value parametrically in the occupant crash safety CAE.

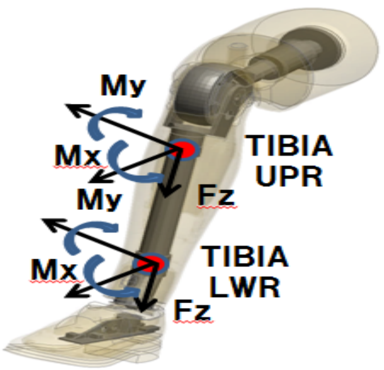
2 Objective

The objective of this study is to develop the new function that can easily change the deformation of the car body at the occupant crash safety CAE, and to verify its influence on the lower leg injury value which might be particularly affected by the deformation of the car body. In the new function we developed with LSTC and JSOL, the amount of the body deformation which come from the car body crash CAE can be easily scaled and reflected on the occupant crash safty CAE. This function is named **`*Interface_local`** and will be released in the future version of LS-DYNA. This presentation reports the results that is verified by the occupant crash safety model of full frontal crash in the front seat passenger side AM50% dummy by using the implemented LS-DYNA new function as an example. In this study, the development version of MPP-DYNA (SVN 112127) is used.

3 Example of Parameter Study by interface_local function

3.1 Lower leg injury index

Tibia index is the well-known index to evaluate lower leg injury value as shown below. In this presentation, we evaluate the influence on lower leg injury when changing the body deformation using this index.



$$TibiaIndex = \left|\frac{M_R}{(M_c)_R}\right| + \left|\frac{F_Z}{(F_c)_z}\right|$$

$$M_R = \sqrt{(M_X)^2 + (M_Y)^2}$$

$$M_C = 225(const.)$$

$$F_C = 35.9(const.)$$

Fig.1: Injury value (Tibia Index)

3.2 Lower leg input mechanism

The input path to the lower leg is as shown in Fig.2. The lower leg injury is influenced by the inertial force of the lower leg and the body deformation. The inertial force of the lower leg is decided by the relation between the car body deceleration G and the restraint device. The body deformation is decided by the body structural members. The lower leg's moment is further influenced by the Force from the body deformation and the distance between the input and the measurement point. Therefore, it is effective tool to change the amount of body deformation easily in the simulation model for conducting the parametric study of lower leg injury.

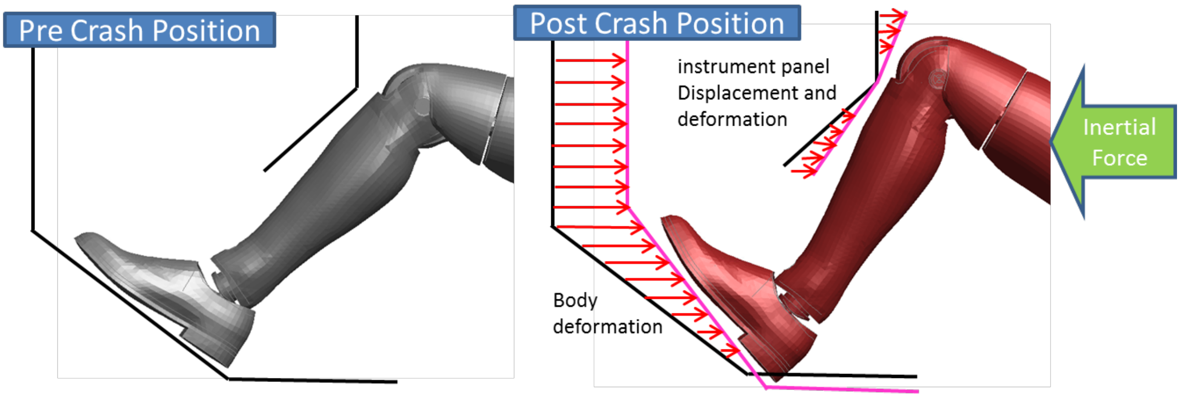


Fig.2: Input path to lower leg

3.3 Simulation Method

The CAE model that verified the occupant injury value combines the deformation of the car body outputted by the car body crash CAE with the models of the restraint system.The merit of this method is that if the occupant injury model is calculated with both the constraint system and the body deformation at the same time, the size of the model becomes too large leading to the large calculation time. It is not efficient in changing only the restraint models.
With the conventional interface function, that is able to scale the amount of movement in the global coordinate system, so not scaling the body behavior and the amount of deformation separately. Therefore, it is benefit to develop a function that scales only body deformation based on the local coordinate system without changing the behavior of car body.
Fig.3 shows the difference between the conventional method and the new method. In the conventional method, it was necessary to obtain various deformation results by newly calculating the car body crash CAE with different stiffness. However, by using the newly developed function, it is not necessary to newly calculate car body crash CAE. If there is a base model and a scaling factor, it is easy to investigate the effect of changing the deformation of the car body in a short time.

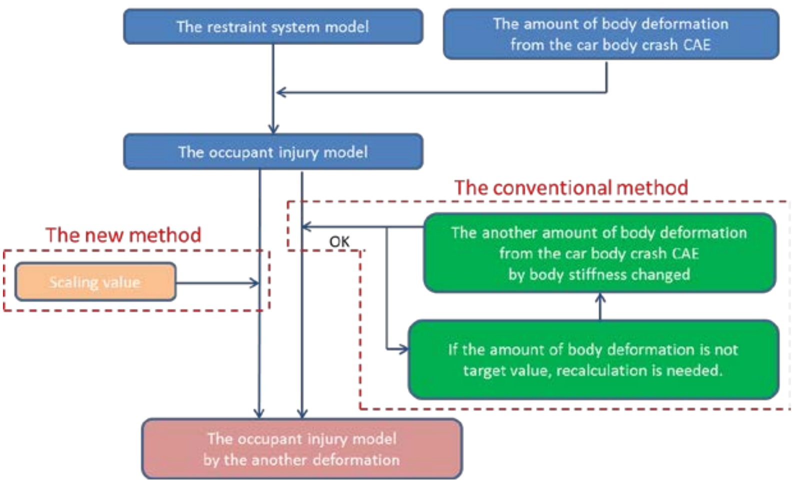


Fig.3: Difference between the conventional method and the new method

Five simulation cases were conducted as shown in Table 1. The body deformations were defined in the upper half of the dash lower and the lower half of the dash lower, respectively. In both half of dash lowers, the +/- 20% of the magnitude of the deformation is modeled by using the **`*Interface_local`** function. Fig.4 shows the example of the snapshots of the scaling body deformation.

Table 1 Simulation cases of the parameter study

	Upper	**Lower**
Base	100 %	100 %
Case 1	80%	80%
Case 2	80%	120%
Case 3	120%	80%
Case 4	120%	120%

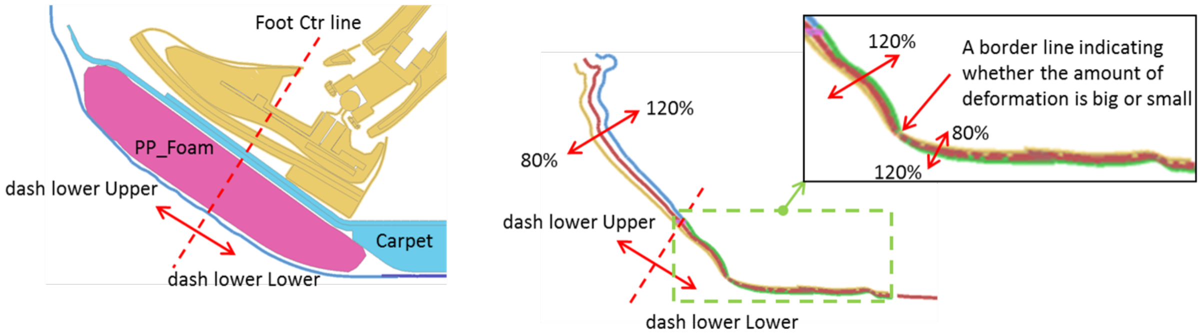


Fig.4: Body deformaiton scaling

4 Results and Discussion

4.1 Example of Parameter Study result

Fig. 5 shows the tibia lower compression forcesZ in the left foot, indicating the difference in each case tends to be small. Since the main cause of the higher tibia lower force is due to the inertial force, it is not influenced by the difference in the body deformation magnitude.
Fig.6 shows the tibia lower moment Y in the left foot. It is shown that the moment tends to increase as the amount of deformation increases. It is considered that the momentY increases when the deformation scale in CASE 3 and CASE 4 are 120%, because it is close to the upper limit of the movable angle range of the ankle and the stiffness is raised.

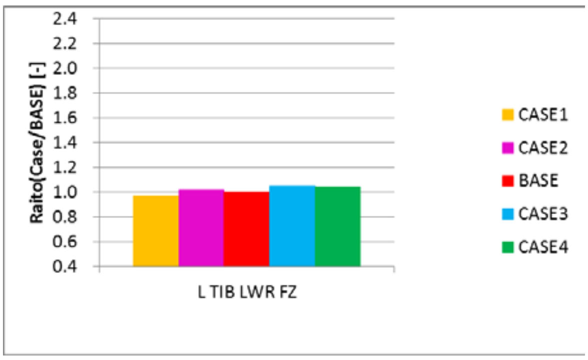


Fig.5: Tibia compression result

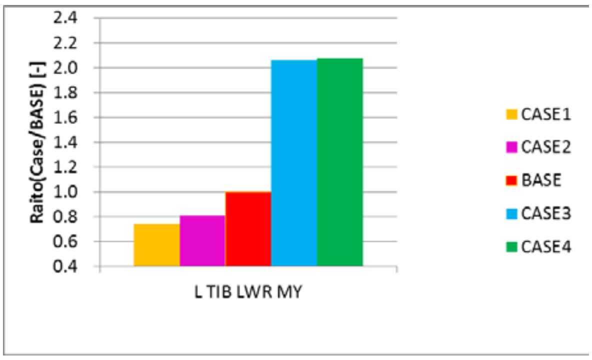


Fig.6: Tibia MY result

Fig. 7 shows the tibia lower moment X in the left foot, which seems to be less influenced by the difference in the amount of deformation. This is because the ankle angle is more influential than the amount of deformation because monentX is caused by twisting of the ankle

Fig.8 shows the tibia index in the left foot. It is shown that the tibia index increases as the amount of deformation increases.

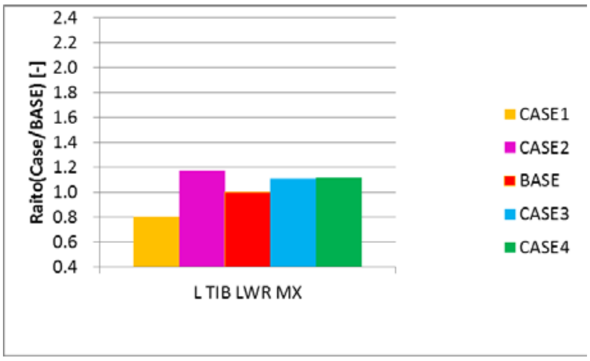


Fig.7: Tibia MX result

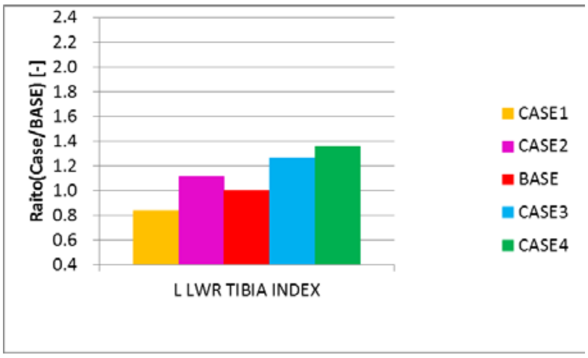


Fig.8: Tibia index result

As described above, it becomes possible to examine easily the change of lower leg injury value due to the body deformation.

4.2 Effectiveness effect

When trying to prepare the amount of deformation from the calculation result of the car body CAE by the conventional method, it needs to calculate the change of the stiffness etc. by trial & error. With the new method, it is possible to create the amount of deformation as defined in a short time only by deciding the change area and changing the scale factor. This is an effect of greatly improving the efficiency of examination.

5 Summary

By using the new function, it was possible to conduct efficiently the parametric study about the influence of the body deformation on the lower leg injury values.
This new function will be available from the new LS-DYNA version released in the future.