Evaluation of ES-2re dummy FE model under side impact sled tests with side airbag condition

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Introduction

The ES-2re dummy is used in the United States Federal Motor Vehicle Safety Standards, FMVSS No.214 for side impact test[1]. With the recent development of computational technology and software, the finite element (FE) model of the ES-2re dummy has been developed and widely used for evaluating the effects of countermeasures for side impact crashes. However, the accuracy of any computational model for assessment of injury risk depends inherently on the quality of the model in terms of model geometry and material properties [2]. Thus, the computational model of an anthropometric device should be validated across the various loading conditions, and results in similar interaction forces between vehicle compartment or restraint systems and kinematics due to the interactions. The aim of this study was to evaluate the fidelity of ES-2re dummy FE model under the side impact sled tests with respect to an actual ES-2re dummy. Also, the level of validation was evaluated objectively using the correlation analysis.

Methods

- The LSTC ES-2re (v.0.101 beta) model was used in this research.
- The right side of the dummy was struck at 4.3 ± 0.1 m/s by a rigid wall with the side airbag on a sled. There were fifteen separated load cell plates in the wall buck and those were distributed from the head to low extremity regions, each supported by a load cell (Figure 1).
- A custom large volume, dual inflator side airbag was used in the test and the airbag was mounted using a hinge with a rotational spring (Figure 2). The rotational joint of the mounting system was modeled by using a connector element. The FE side airbag model was modeled by using *Airbag_Hybrid model supported in LS-DYNA [3]. The airbag deployed as shown in Figure 3.
- The objective evaluation of the level of correlation of the FE model responses and those of actual dummy were analyzed using the correlation and analysis method (CORA) [4].
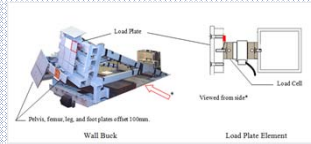
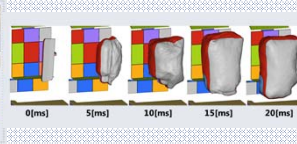**Fig.1. Load cell wall buck** **Fig.2. Side AB mounting system** **Fig.3. Sequences of deployment of the side AB**

Discussion

. The component level rating of LSTC ES-2re model was ranged from 0.354 to 0.776 and the overall average rating was 0.585 which was relatively lower than the rating of LSTC ES-2 FE model (v.5.0, mean rating : 0.730) [5].

. Impact force at lower extremity and the lower spine acceleration showed the best correlation with the test data.

. Although the permeability of the airbag was not considered in the airbag model, the ES-2re dummy model showed twice as high as the peak wall loads of the actual dummy in shoulder and pelvis areas. It implies that the shoulder and pelvis areas of the dummy model need to be examined to improve the validity of the model. To confirm this finding additional rigid wall side impact test should be performed to evaluate the fidelity of the ES-2re dummy model as the next step.

Results

- Impact force time histories summed by each row were represented in Figure 4.
- The time histories of y-axis acceleration from the dummy instrumentation were shown in Figure 5.
- CORA rating of each impact force and acceleration was represented in Table 1. Overall average rating of the ES-2re FE model was 0.585

Table 1. CORA rating results

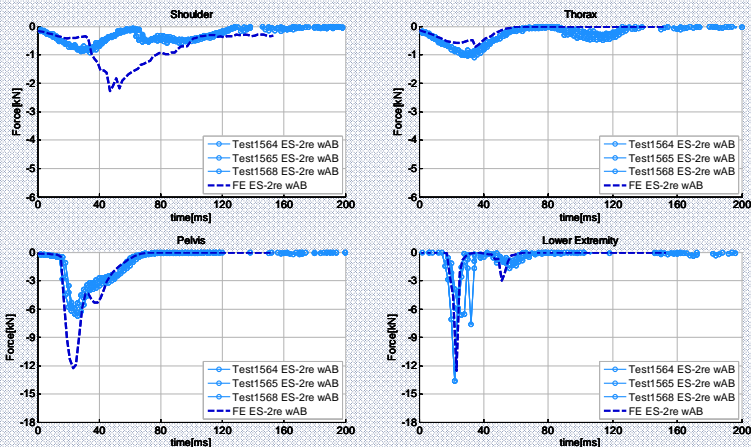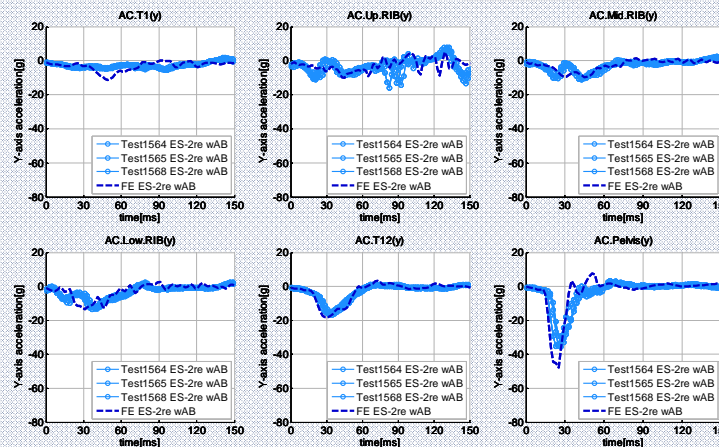| Impact Force	Rating	Acceleration	Rating
Shoulder	0.354	Upper Spine	0.439
Thorax	0.630	Upper Rib	0.443
Pelvis	0.675	Middle Rib	0.711
Low Ext.	0.721	Lower Rib	0.589
Average	0.595	Lower Spine	0.776
		Pelvis	0.513
		Average	0.579

Fig.4. Impact force time history **Fig.5. Y-axis acceleration time history**

Future Work

. Rigid wall side impact test and simulation of the ES-2re dummy to evaluate the fidelity of the FE model.

. Comparison of the responses of ES-2re, WorldSID, and GHBMC models to those of the cadavers under two experimental side impact test conditions, which were a rigid wall condition and a side airbag condition, to evaluate the biofidelity of surrogates

References

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