The study of Side Structure Optimization of the SUV for New Side NCAP tests

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ABSTRACT

NCAP(New Car Assessment Program) Test will be revised from 2015. For this paper, two types of side impact test have implemented. One was Korea NCAP Side MDB test and the other was Euro NCAP Side Pole Test.Korea NCAP Side MDB test have done two times with old(R95 MDB) and new(AE-MDB) version[1]. And Euro NCAP Side Pole test also have done two times with (90degree side pole test) and new(75degree oblique side pole test) [2]. Thus total amount of test was four times.In case of the side MDB test of Korea NCAP, R95 MDB test and AE-MDB test were compared. And in case of the side pole test of Euro NCAP, 90 degree side pole test and 75 degree oblique test were compared. From the test data and CAE result, structure deformation and dummy injury (ES-2 and SID-2) characteristic were somewhat different by test mode of each. Therefore, the purpose of this paper is to reduce dummy injury data by optimization of structure and stiffness and apply new project.

INTRODUTION

Because enhanced crash test regulations & NCAP, the vehicle manufacturer has responded in several ways to improve the crashworthiness. For instance, to change and reinforce steel material, to insert shock resistant form in door panel are the one of the way. Korea and Euro NCAP have two types of side impact test. Side MDB Test for CAR to CAR Side is the one and Side Pole Test for Car to Pole is the other. Both tests will be revised in 2015 and various institutions such as EEVC/WG13, IHRA, SIWG and APROSIS have been studying for new revised test. Therefore, firstly this paper introduce about AE-MDB Test and 75 degree oblique side pole test which will be revised. Secondly, the result of new test mode will be shown by comparing with old version and then find differences about characteristics of structure deformation and dummy injury. Finally, this study propose SUV side structure optimization plan.

METHOD

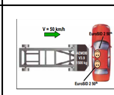
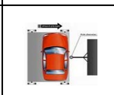
Test Configuration		Korea NCAP		EURO NCAP	
		R95 MDB	AE-MDB	90° Pole	75° Pole
					
Dummy	FR	ES-2	ES-2	ES-2	ES-2
	RR	SID IIs	SID IIs	-	
Test Speed		55km/h	55km/h	29km/h	32km/h

Table1. Test configurations and dummies used in side impact crash tests.

In this paper, the side impact tests was performed total four times in respond to the amended NCAP tests(AE-MDB Test & 75 ° Oblique Side Pole Test). and Table1 below shows a summary of the test methods and used a dummy.

R95 MDB test

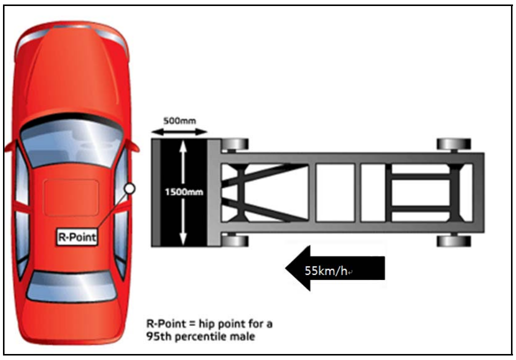


Photo1. R95 MDB test

Photo1 shows the test configurations and conditions In the present study, Impact velocity of The MDB(Movingt Deformable Barrier) was 55 km/h, striking on the R-point as refer to R95 test procedure. ES-2 dummy was placed in the front seat on the struck side, and SID-IIs was seated behind driver to acquire injury data on experimental purpose. [3]

AE MDB test

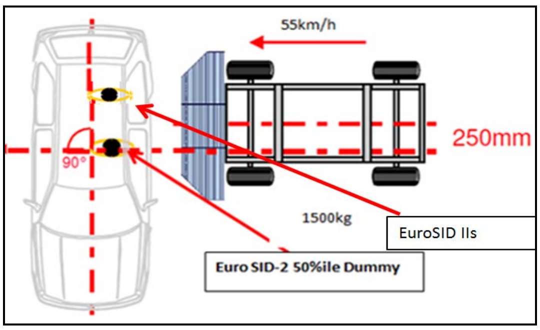


Photo2. AE-MDB test

The AE-MDB(Advanced European Moving Deformable Barrier) developed based on the car dimension, mass and front stiffness in the current vehicle fleet. The test is prepared as to the EEVC(European Enhanced Vehicle-safety Committee) WG13 test procedure. the ES-2 was placed in driver seat and SID-IIs was behind the driver. The impact point is centered on R-point +250mm rearward. (See Photo2) [4, 6]

90degree Side Pole Test

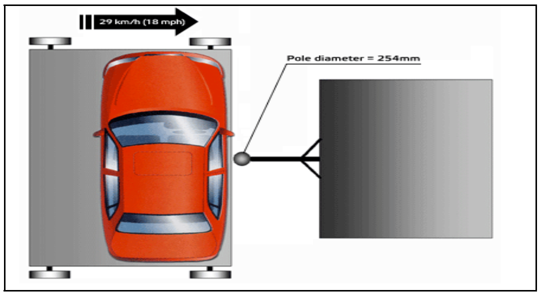


Photo3. AE-MDB test

The 90degree side pole test was according to the car-to-pole test proposed by ECE/R95, where the impact velocity is 29 km/h and the impact angle is 90 degrees. The pole diameter is 254 mm. The ES-2 was placed in the front seat according to the ECE/R95 Draft. When the ES-2 is used, the seat was set in the midway position in the seat slide range. The gravity center of the dummy head in a front seat was in alignment with the center of the pole. (See Photo3)[7]

75degree Oblique Side Pole Test

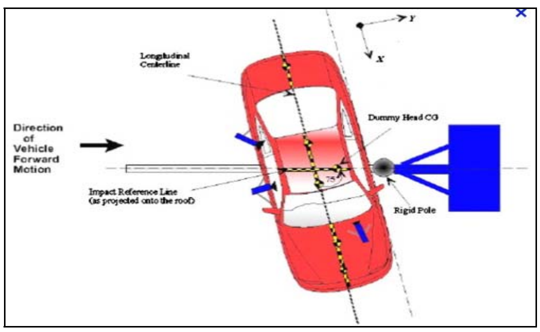


Photo4. 75° Oblique pole test

The 75degree side oblique pole test was according to the car-to-pole test proposed by NHTSA (FMVSS/214 Draft), where the impact velocity is 32 km/h and the impact angle is 75 degrees. The pole diameter is 254 mm. The ES-2re was placed in the front seat according to the FMVSS/214 Draft. When the ES-2re is used, the seat was set in the midway position in the seat slide range. The gravity center of the dummy head in a front seat was in alignment with the center of the pole. (See Photo4) [8]

Test Vehicle Specifications and Measuring Position

The detailed specifications of the test vehicles and honeycomb barriers are following (see Table2 through 4, Photo5).

.	Korea NCAP (R95 MDB)	Korea NCAP (AE-MDB)
Test Speed	55km/h	55km/h
Test Weight	1845kg	1850kg
Restrain Sys.(1st)	SAB+CAB	SAB+CAB
Restrain Sys.(2nd)	CAB	CAB
Dummy Type(1st)	Euro SID-II	Euro SID-II
Dummy Type(2nd)	Euro SID-IIs	Euro SID-IIs
Impact Line	R-point	R-point+250mm (Vehicle rear direction)

Table2. Comparison of Vehicle Specifications

	90degree Pole	75degree pole
Test speed	29km/h	32km/h
Test weight	1,805kg	1,849kg
Restrain sys.(1st)	SAB+CAB	SAB+CAB
Dummy type(1st)	Euro SID-II	Euro SID-II Re
Impact line	Daylight zone Min.50mm	Head center point of Final Seating Position

Table3. Comparison of Vehicle Specifications

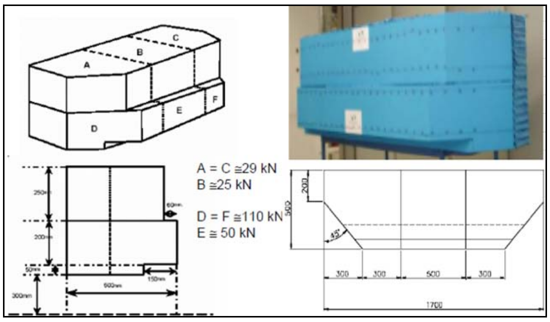


Photo5. AE-MDB Barrier dimensions[5]

	Weight [kg]	Width [mm]	Depth [mm]	Height from Ground [mm]	Stiffness
R.95 MDB	950	1500	500	300	Low
AE-MDB	1500	1700	500	350	High

Table4. Comparison of R.95 MDB &AE-MDB[5]

Accelerometers were attached to B-pillar rockers, front and rear door inner panels on the struck side. And 3DMM(3-Dimensional Measuring Machine) was used to measure the deformation of the B-pillar inner panel, C-pillar panel, and Body outer line at the phase of both pre- and post-test.(See Photo6 through 8) [3]

Photo6. Front & Rear Door Sensor Positions

Photo7. B-Pillar & C-pillar Measuring Positions

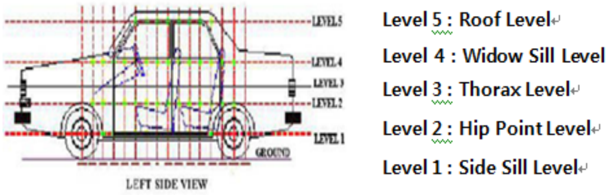


Photo8. Vehicle Measuring Positions

Result Analysis of the Side Impact Tests

These tests (See Table1) carried out the evaluation of the dummy injury value in accordance with the test procedures and the evaluation methods of Korea NCAP, Euro NCAP and FMVSS214. And the test vehicle deformation value was measured with 3DMM (three-dimensional measuring machine).

<u>Analysis of vehicle deformation</u>

The test vehicle was engraved with pattern tapes, that highlight the reference impact lines. Every 100mm steps was measured with 3DMM(hree-dimensional measuring machine), in order to compare displacements of impact lines with pre- and post measurement of each point on the impact lines. (see Photo9,10)

Photo9. AE-MDB Impact Line

Photo10. 75°Oblique Pole Test Impact Line

<u>1. Vehicle deformation(AE-MDB vs R95 MDB)</u> The vehicle outer line deformation of the side impact tests compared through Figure1 through 3. On area "A"(figure 1), on the AE-MDB Test, the vehicle body was prominently deformed more than R95 MDB test. Because the width of AE-MDB is wider, furthermore, even impact point was moved 250mm rearward. As a result of that, the rear wheel housing was damaged significantly. Also, C-pillar, B-pillar and rear door were more severely deformed on AE-MDB test(see Figure2). Door deformation aspect of Level2(See figure2) and Level 3(figure3) are, because door impact beam restrained the door panel's intrusion. Overall deformation aspect of AE-MDB is bigger on Level 2 and 3 (from Figure2 and 3). and one thing that we have to check is that AE-MDB's intrusion value of Level 3 is lower than Level 2. This is because of side impact beam located in Level 3 which absorb impact energy. Section 'B' on Figure2 and Section 'C' on Figure3 show that the deformation aspect of area 'B' is bigger than area 'C'. The reason why is that honeycomb initial height of AE-MDB is 50mm higher so energy distribution by side sill and impact beam was not proper.

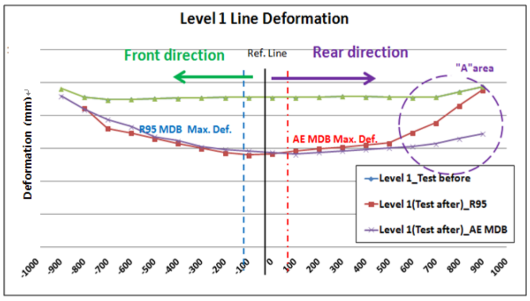


Figure1. Vehicle Level 1 Line Deformation

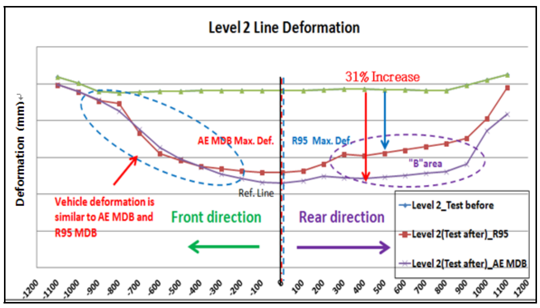


Figure2. Vehicle Level 2 Line Deformation

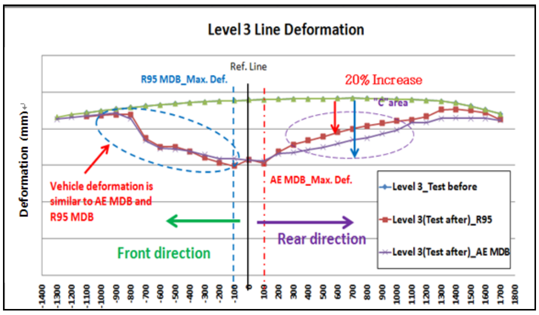


Figure3. Vehicle Level 3 Line Deformation

Figure4 &5 represent The B-pillar and C-pillar intrusion deformation. Two graphs describe that the deformation of C-pillar is 70% higher than that of B-pillar. The deformation of B pillar was slighter, because kinetic energy of AE-MDB was distributed to driver seat and rear wheel housing, however, The C-Pillar has not been influenced.

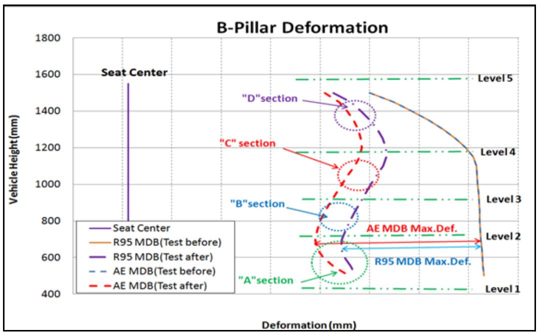


Figure4. Comparison of B-Pillar Intrusion Deformation

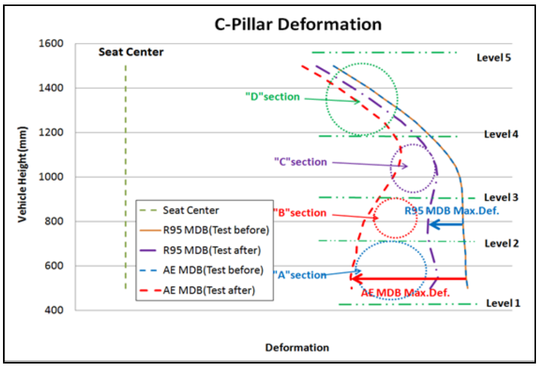


Figure5. Comparison of C-Pillar Intrusion Deformation

2. Vehicle deformation(75degree oblique side pole vs 90degree side pole test) Figure6 and Figure7 show that the deformation between 75degree oblique side pole test and 90degree side pole test. The peak deformation of 90degree side pole test is higher than 75degree oblique side pole test because the side sill of the vehicle generated concentrated load. However, overall deformation of 75degree oblique side pole test tend to be wider than 90degree side pole test. The reason is that impact angle is diagonal. And rood line(See figure8) represents the identical aspect but the deformation of 75degree oblique side pole test shows higher than 90degree side pole test because the roof side structure absorbed separately of the impulse.

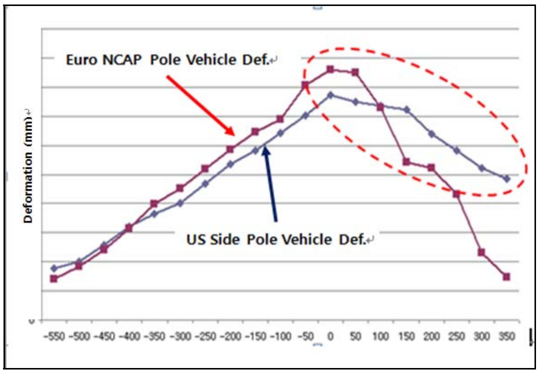


Figure6. Comparison of Vehicle Deformation (Door &H Point Line)

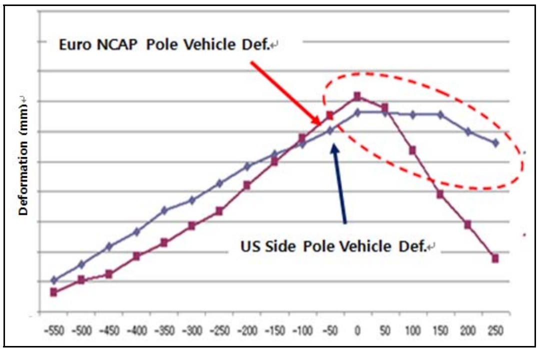


Figure7. Comparison of Vehicle Deformation (Door &H Point Line)

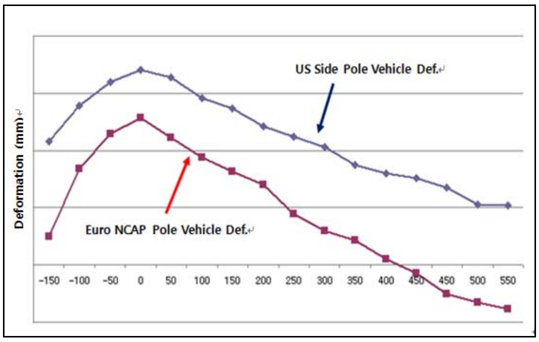


Figure8. Comparison of Vehicle Deformation (Roof Line)

Analysis of vehicle dynamic crash characteristic

1. Dynamic crash characteristic(AE-MDB) Figure9 through 12 below show that the maximum acceleration and velocity of B-pillar. Figure13 trough 16 show that the maximum acceleration and velocity of front and rear door. Type1 is R95-MDB test and type2 is AE-MDB test. Also photo9 shows ruptured part at lower B-pillar.

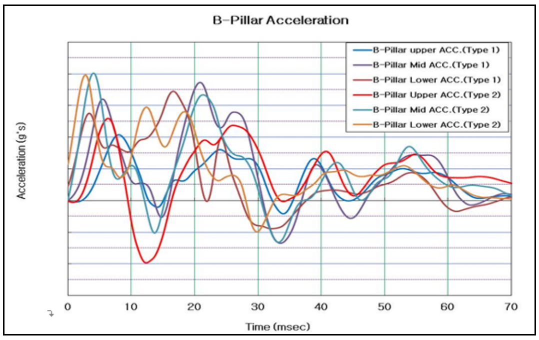


Figure9. Comparison of B-Pillar Acceleration

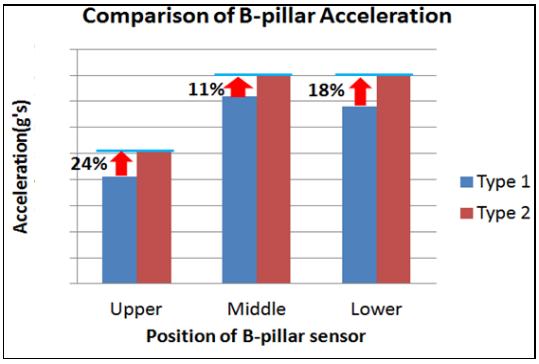


Figure10. Comparison of B-Pillar Acceleration

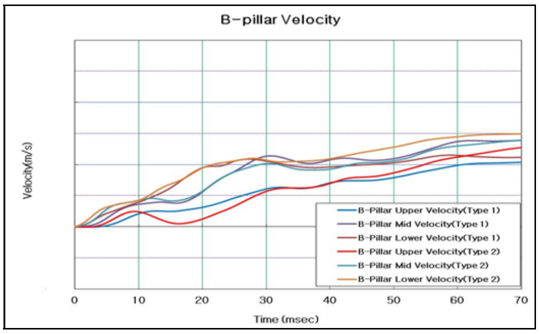


Figure11. Comparison of B-Pillar Velocity

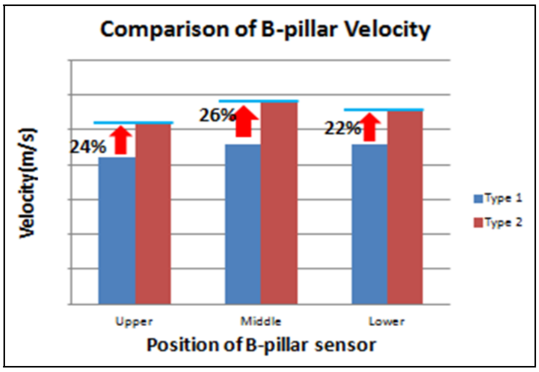


Figure12. Comparison of B-Pillar Velocity

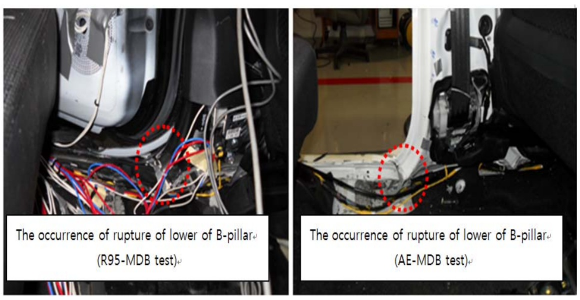


Photo11. Comparison of B-Pillar Acceleration

The graphs above show the maximum acceleration (See Figure9, 10) and velocity (See Figure11, 12) on B-pillar upper, middle, lower position. The max value of B-pillar acceleration and velocity tend to be higher than R95-MDB test and the colliaion energy of both test is concentrated on middle and lower B-pillar. Therefore the lower position of the B-pillar was ruptured (see Photo11).

The graphs above show the maximum acceleration (See figure13,14) and maximum velocity (See figure15, 16) on B-pillar upper, middle, lower position. From figure13 through 16, AE-MDB test instantaneous velocity of front door is increase 29% but the max peak acceleration value is decreased 16% compare with R95-MDB. The reason is impact base line moves to 250mm rearward and AE-MDB contact directly to B-pillar and rear wheel housing. Therefore the energy of front door is distributed..

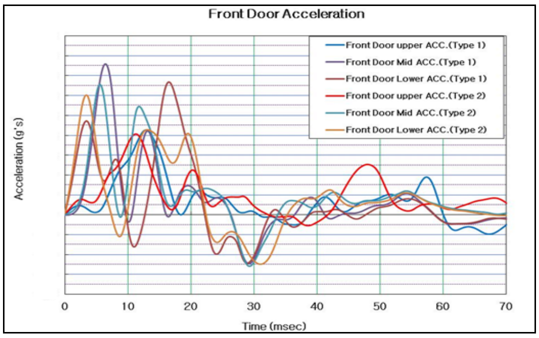


Figure13. Comparison of Front Door Acceleration

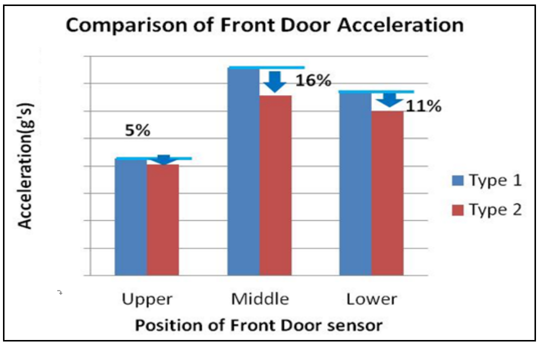


Figure14. Comparison of Front Door Acceleration

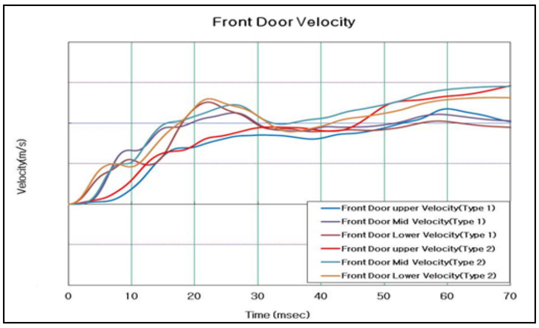


Figure15. Comparison of Front Door Velocity

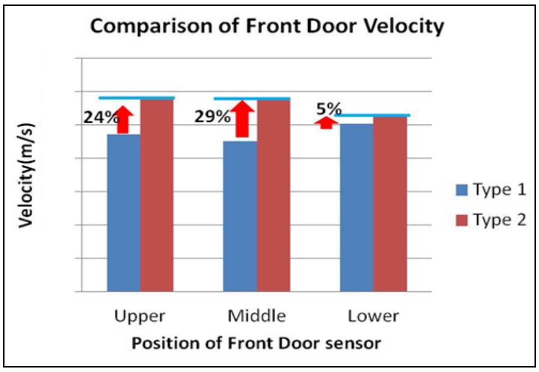


Figure16. Comparison of Front Door Velocity

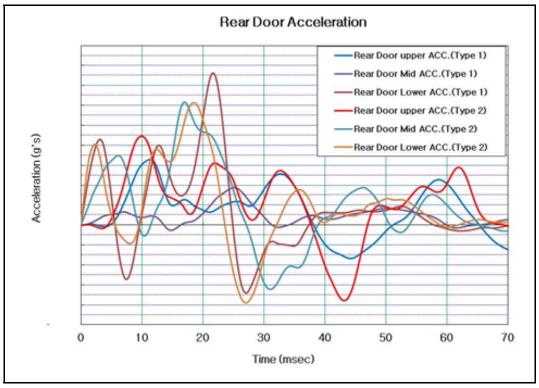


Figure17. Comparison of Rear Door Acceleration

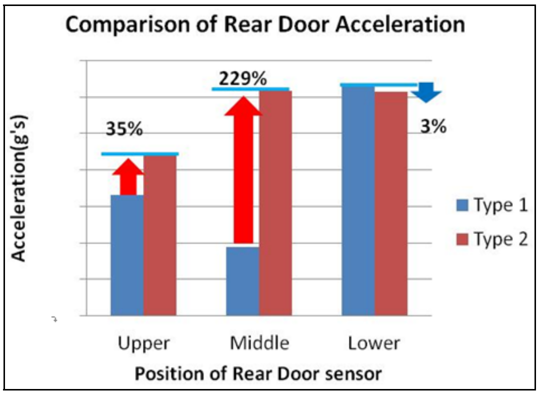


Figure 18. Comparison of Rear Door Acceleration

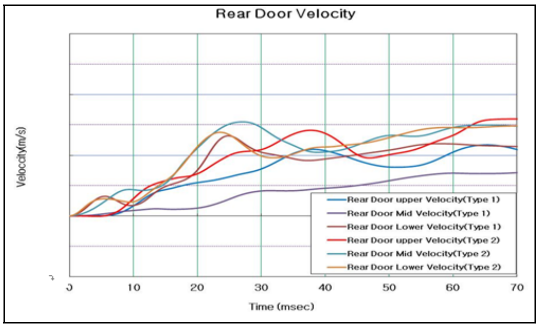


Figure19. Comparison of Rear Door Velocity

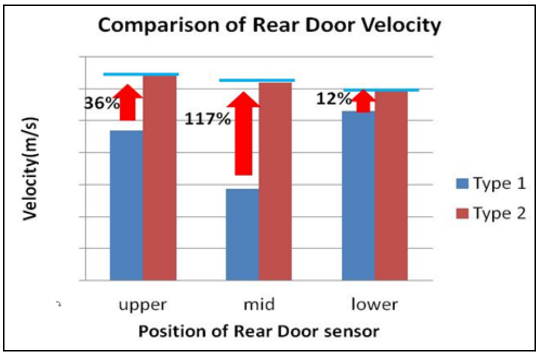


Figure20. Comparison of Rear Door Velocity

The graphs above show the maximum acceleration (See Figure17,18) and maximum speed (See Figure19,20) on B-pillar upper, middle, lower position. From figure17 through 20, acceleration and velocity of upper, middle and lower on rear door are increased except lower acceleration value. It shows that the distribution energy on rear wheel housing, side sill and C-pillar is huge. As a result depending on the setting location of the sensor as shown in the Photo12 below, the acceleration and velocity were increased to maximum 220% and 117%.

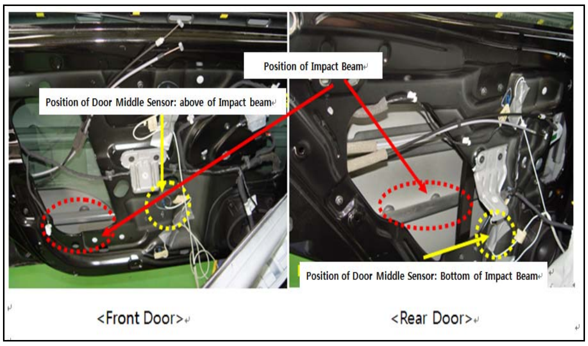


Photo12. Comparison of Door Side Impact Beam & Sensor Position

<u>2. Dynamic crash characteristic(75° oblique pole test)</u> The below graphs show the acceleration of B-pillar, deceleration of B-pillar and the deceleration of front door middle position.(see Figure20,21,22).

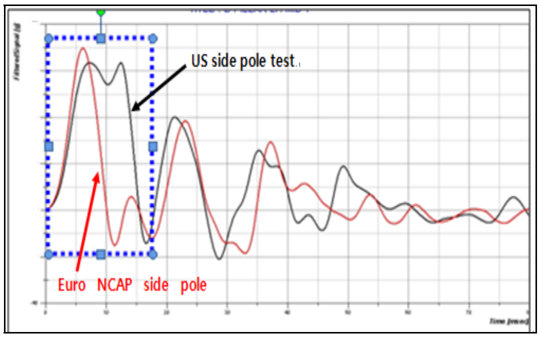


Figure20. B Pillar LH Mid Y Deceleration

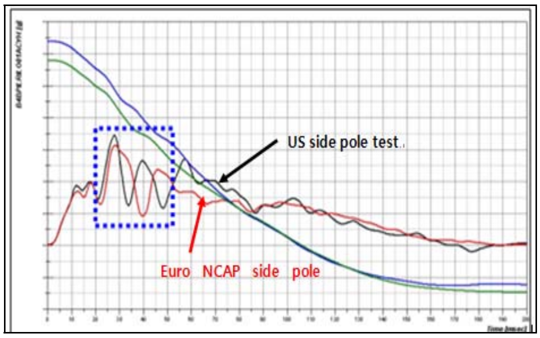


Figure21. B Pillar RH Y Deceleration & Velocity

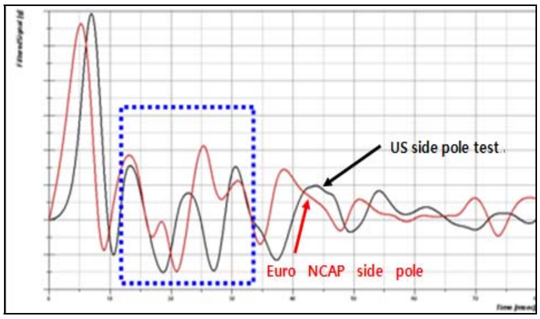


Figure22. FRT Door Mid Y Deceleration

Comparing the results of the B Pillar LH deceleration graph after the pole crash, the sudden deceleration which occurs between 5 and 20msec. The 75degree side pole test is characterized in maintaining for long time of the maximum value than 90degree side pole test. As a result, the vehicle of US side pole test will be a constant force for a period of time by the pole. And comparing the results of the B-pillar RH deceleration graph after the pole crash, the graph of US side pole test represents to large deceleration and velocity in the range of approximately 30msec. Because concentrated load on B-pillar RH occurs. When comparing the results of the front door deceleration graph after the pole crash, the initial deformation by pole crash represents as similar deceleration patterns, because the door structure is not able to absorb the shork compared to the B-pillar. But The deformation of US side pole test was occured twice large deceleration in range of approximately 30msec, but the deformtaion of Euro Side pole test was occured the deceleration as the characteristics of shock absorption. Accordingly the U.S. side polet test occurs crash acceleration continuously, and the deformation appears as a wide range. Therefore US side pole test is considered to the aspect of vehicle deformation in adverse condition.

Analysis of Dummy Injury Value

To study the dummy, injury values with respect to vehicle deformation patterns, induced from the vehicle accelerometer.

1. Dummy injury value(AE-MDB)

The table5 & table6 below showed the value of the driver's seat and front passenger seat Dummy Injury.

			R95 MDB	AE-MDB	Rate (%)
Head	HIC		30.1	60.7	101
Chest	Defection (mm)	Upper	18.1	20.5	13
		Middle	21.9	25.2	15
		Lower	23.5	27.5	17
	VC(m/s)	Upper	0.13	0.13	0
		Middle	0.17	0.21	23
		Lower	0.20	0.28	40
	Back Plate(kN)	Fy(kN)	0.77	1.39	80
	T12	Fy(kN)	0.73	0.95	30
		Mx(Nm)	0.06	0.06	0
Abdomen(kN)			0.33	0.37	12
Pubic(kN)			0.96	1.28	33

Table5. Driver Dummy Injury(Euro SID II)

			R95 MDB	AE-MDB	Rate (%)
Head	HIC36		86.6	192	
Chest	Defection (mm)	Upper	9.5	11.3	
		Middle	6.8	7.3	
		Lower	12.1	14.5	
Sum of Acetabular and iliac force (N)			1714	3076	79%↑
Individual Probability of Injury			0.009	0.034	
Relative Risk (P/base)			0.06	0.23	

Table6. 2nd Rear Passenger Dummy Injury(SID IIs)

Dummy head injury value The dummy head injury value of AEMDB test increased 101% than the dummy head injury value of R95-MDB, but it is difficult to judge as increase because the dummy head injury value is lower compared to the injury performance limit values. For the reason, the dummy injury values of the test are not high because the dummy head has been well protected by the curtain airbag.

Dummy chest injury value The below Figure23 is accelerometer value of B-pillar rockers, and The Photo13 is a modified photo by the crash between B-pillar lower position and seat frame. The Figure24 is dummy chest maximum injury graph, and The Figure25 is a graph to analyze to relation between the B-pillar and dummy behavior. Figure23 graphs are shown to occur the reaction force due to the contact of B-pillar rockers inner panel and seat frame at between 25msec and 40msec. In case of the AE-MDB test, the maximum chest deflection is showed at 40msec, and the maximum chest deflection of R95-MDB test is showed at 43msec. The Figure25 graphs are shown to transfer sequentially faster and higher the B-pillar velocity of AE MDB test from lower to middle due to the crash energy of MDB. In case of the chest middle velocity value, R95 MDB and AE-MDB are occurred to the maximum value at 20msec and 40msec respectively. The reasons for the maximum dummy chest middle velocity difference, R95 MDB test are well protected to the dummy at 20msec by the side airbag. But AE-MDB test is not performed to perfectly the function of side airbag at 17msec due to the dummy behavior, and so that is occurred to the maximum chest velocity value at 40msec by the contact of dummy chest and door inner panel. As a result, the dummy behavior of AE-MDB test is seen to the faster than R95 MDB test because of the contact of B-pillar lower and seat mounting frame. So the dummy injury value of AE-MDB is increased to 15% than R95 MDB. The chest injury value of 2nd seat dummy is not considered because the injury performance limit values lower (See Table6).

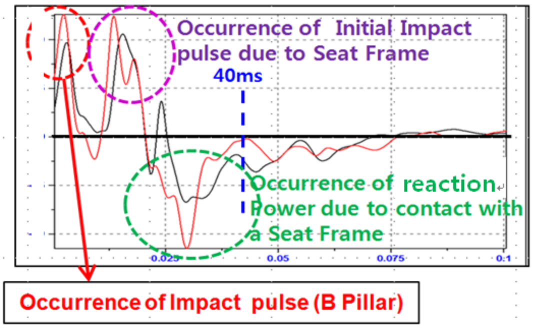


Figure23. Comparison of b-pillar lower ACC.

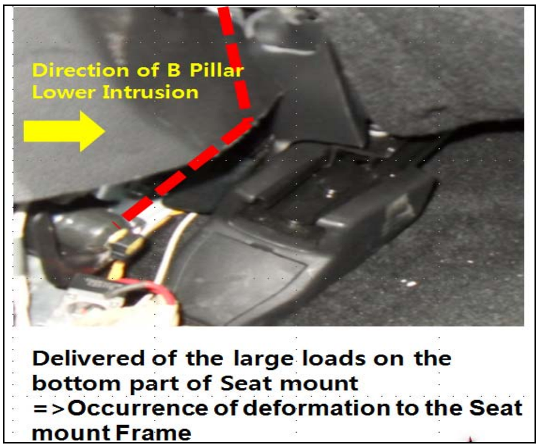


Photo13. Deformation to the seat mount frame(AE-MDB)

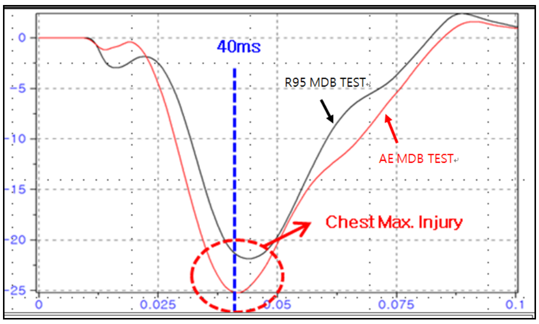


Figure24. Comparison of driver dummy chest ACC.

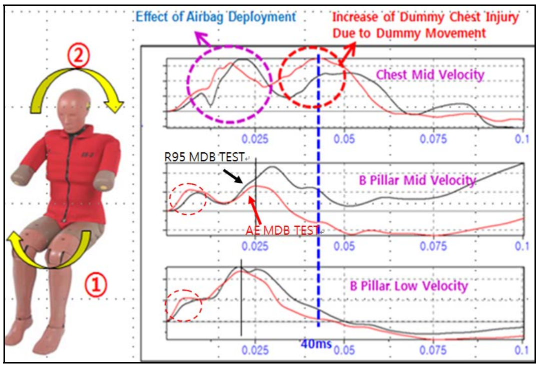


Figure25. Analysis of driver dummy movement

Dummy pelvic injury value Below Photo14 is the rear dummy seat position and c-pillar measurement areas. The table7 is C-pillar maximum deformation on each position, and the Photo15 is a picture to capture high-speed video of rear seat dummy position. The Figure26 through 28 is shown to each graph of the dummy pelvic velocity, pelvic displacement and acetabular & iliac force.

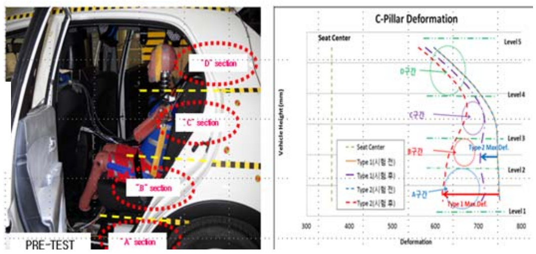


Photo14. Rear Seat Dummy & C pillar measuring Position

위치	ECE R95	AE-MDB	변위 증가량
D section	16mm	40mm	250% ↑
C section	26mm	77mm	296% ↑
B section	40mm	120mm	300% ↑
A section	32mm	133mm	415% ↑

Table7. Static deformation of C Pillar

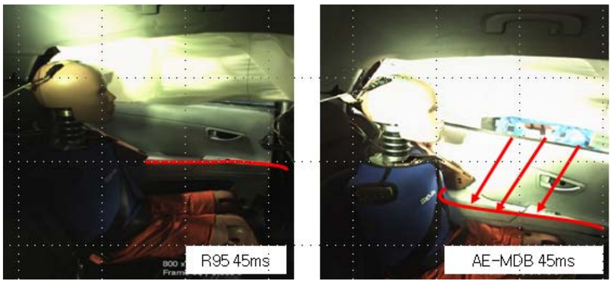


Photo15. Comparison of High Speed Video(SID IIs)

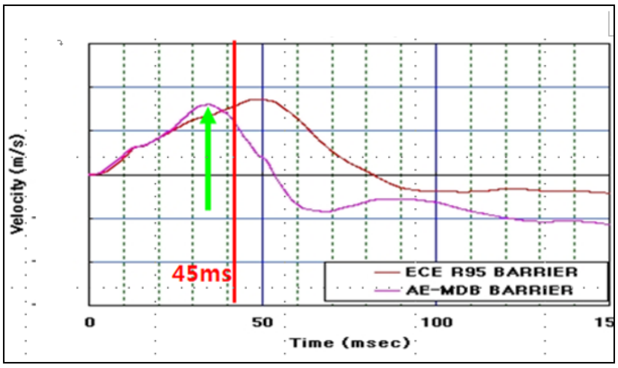


Figure26. Dummy Pelvic Velocity(SID IIs)

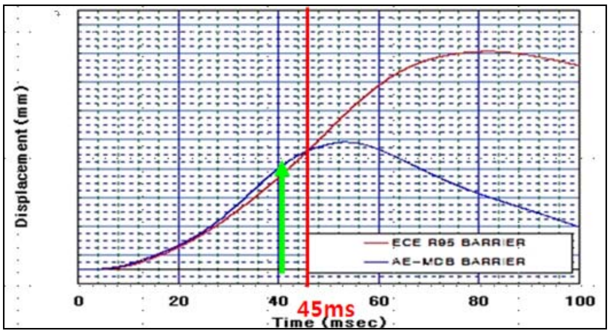


Figure27. Dummy Pelvic-Y Displacement(SID IIs)

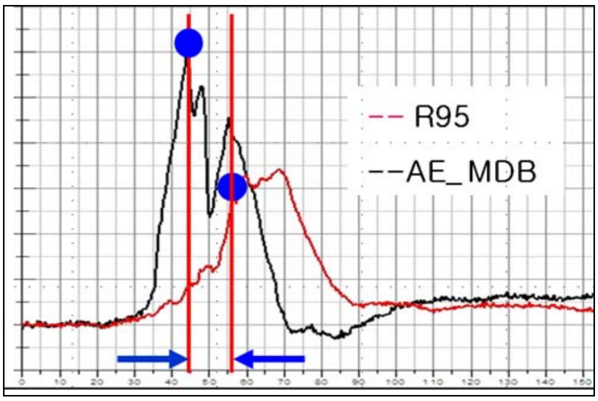


Figure28. Comparison of Sum of Acetabular and iliac force (Rear Seat Pass. Dummy, N)

On the Photo12 and Table7 above, AE-MDB test is increased more 415% and 300% respectively the static deformation in the "A" section and the "B" section than R95 MDB test. and, in the case AE-MDB test, the pelvic load of 2nd passenger is increased to higher maximum 79% in the previous 45msec because of the sharp increase of door inner trim, dummy behavior velocity and dummy behavior deformation (See Figure26 through 28). But the pelvic injury value driver dummy is lower than the injury performance limit values due to the dispersion of crash energy by the rearward 250mm movement of reference line and rear wheel housing contact.

2. Dummy injury value(75degree oblique side pole test vs 90degree side pole test)

The Table8 compared to the test results of two type side pole, and the Figure29 through 32 compared to the injury value of each part of the ES-2 injury value.

Position	Euro SID II re	Position	Euro Pole	US Pole	Difference
Head	HIC		245	276	12% ↑
Chest	Def. (mm)	Upp	28.6	56.0	96% ↑
		Mid	26.7	51.5	93% ↑
		Low	27.4	49.4	80% ↑
	V.C (m/s)	Upp	0.26	1.46	460%↑
		Mid	0.22	0.89	300% ↑
		Low	0.25	0.59	136%↑
Abdomen	Force	Abdomen	0.69	0.95	37% ↑
Pubic	Force	Pubic	2.08	0.93	44% ↓

Table8. Comparison of Side Pole Test Result

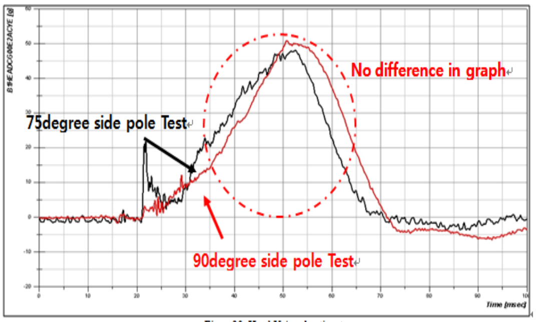


Figure29. Head Y Acceleration

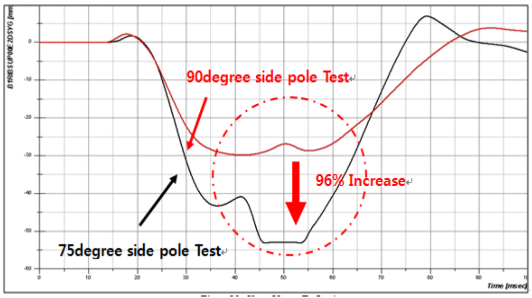


Figure30. Chest Upper Deflection

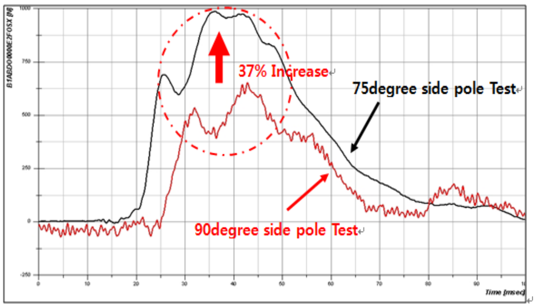


Figure31. Abdomen Force Sum

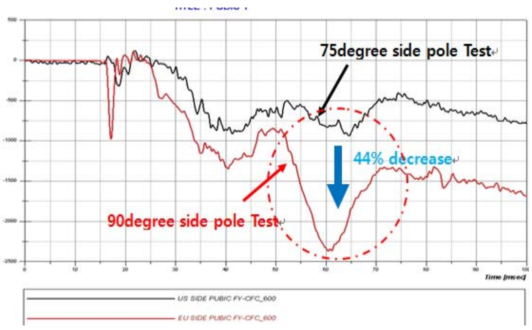


Figure32. Pubic Force

Dummy head Injury value The dummy head injury value of 75degree side pole test increased 12% than the dummy head injury value of 90 degree side pole test, but it is difficult to judge as increase because the dummy head injury value is lower than the injury performance limit values. The dummy injury values of the test are not high because the dummy head has been well protected by the curtain airbag.

Dummy chest Injury value In case of the 90degree side pole test, the maximum chest deflection is showed at approxirately 40msec, and the maximum chest seflection of 75degree side pole test is showed at approximately 50msec. Acoording the chest defflection & VC injury values of 75degree side pole test occurred to more high maximum approximately 96%, 136% respectively than 90degree side pole test. As a result, as shown in the vehicle crash characteristics and CAE analysis(See Photo16), the crash energy of 75degree oblique side pole test were able to confirm to transfer widely in the vehicle body than 90degree side pole test.

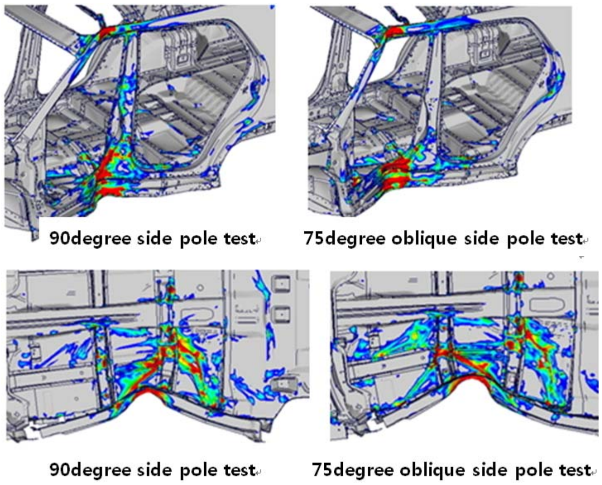


Photo16. Deformation Shape of CAE Model Structure

Dummy abdomen & pubic Injury value The abdomen injury value of 75degree oblique side pole test occurred to more high maximum approximately 37% than 90degree side pole test, but the pubic injury value of 75degree oblique side pole occurred to more low maximum approximately 44% than 90degree side pole test. Because the dummy behavior is changed in accordance with the test mode and force acting on the dummy thighs.

SUMMARY AND CONCLUSION

Corresponding to the newly amended NCAP(New Car Assessment Program), the following conclusions could be confirmed.

1) Reviewing the vehicle body deformation characteristics in the event of AE-MDB test, the vehicle body is increased the stiffness of B-pillar bottom and rear door impact beam, so as to diminish the deformation of the doors and the B-pillar Because the position of a crash base line and the weight of moving deformation barrier was changed. And, in the front door, the pulse traces of the 75 degree oblique pole test showed deceleration and velocity, higher than 90degree side pole test, and the aspect of vehicle body deformation was conformed to show large and widely through CAE analysis. Therefore, the vehicle body of 75degree oblique pole test should be improved the structure stiffness of the front door, side sill and underbody cross member of the direction of Front Door.

2) In case of the AE-MDB test, the maximum deformation, acceleration and velocity of B-pillar increased 31%, 24% and 26% respectively more than R95-MDB test. Also although the crash energy is distributed by the contact of the driver seat and rear wheel housing, the B-pillar rockers is likely to be torn and the dummy behavior occurred by the contact of driver seat frame. On the 75degree oblique side pole test, the concentrated load of collusion energy generated at the side sill, underbody frame and the B-pillar rockers through CAE analysis(See photo14). Therefore it is necessary to optimize B-pillar rockers, side sill stiffness and underbody frame to reduce dummy injury value from the collusion energy of moving barrier.

3) In case of AE-MDB test, the C-pillar deformation characteristic increased to maximum 315%, compared to R 95 MDB test. Also the deformation increases of the rear door and C-pillar cause to increase the injury values of the chest and pelvic of 2nd seat passenger dummy. Therefore the optimization of vehicle structure is required to increase the stiffness of rear door side impact beam as well as C-pillar.

4) The dummy head injury value increased slightly both the AE-MDB test and 75° oblique pole test, but it is difficult to judge as increase because the dummy head injury value is lower compared to the injury performance limit values. The dummy head injury values of the test are not high because the dummy head has been well protected by the curtain airbag.

5) In case of AE- MDB test, the driver dummy chest injury value were increased the maximum deflection 17% than R95 MDB, and 75degree oblique side pole test increased the maximum 96% and 460% respectively for chest deflection and VC than 90degree side pole test. The dummy chest injury value of the tests are high because the dummy behavior occurred by the contact of seat mounting frame and B-pillar lower panel. Therefore the lower panel is required to increase the stiffness and structure of B-pillar lower panel to prevent the behavior of driver dummy. And in the case of the 2nd seat dummy, AE-MDB test will necessary to optimize deployment of the side airbag and vehicle structure to reduce chest injury value.

6) Focusing on the pelvic injury value of the dummy on the driver seat, Even though the injury values from AE-MDB test are comparatively higher than the injury values of R95 MDB test. However, the increase is regarded as not big change with respect to injury performance limits. The pelvis injury of 75degree oblique pole test was reduced to 44% due to the large movement of the dummy(See Table5, 8). On rear seat passenger dummy, pelvic injury value from AE-MDB test increased to 79% more than R95 MDB Test results, but the pelvic injury value of the driver dummy is lower than the injury performance limit values due to the dispersion of crash energy by the 250mm rearward movement of impact base line and contact of rear wheel housing. In sum, on AE-MDB test, the rear

door impact beam, the C-pillar, the side sill and the rear wheel housing, of which position and stiffness should be optimized. On 75degree oblique side pole test, the methods to reduce of the pelvic movement are following
a. geometric dimension and stiffness of the vehicle body should be optimized.
b. side & curtain airbag should be finely tuned.

As a results, to reduce dummy injury chest value for the newly amended NCAP(New Car Assessment Program), the manufacturers should investigate to the preceding interpretation and optimizer work such as door trim materials, the position of door trim & impact beam, the stiffness of C-pillar & door impact beam, passengers resident spaces etc. Through this work propose SUV side structure optimization plan.

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