

A Study on the severity of the proposed Korean NCAP AE-MDB side impact test.

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ABSTRACT

Since 2003, the Korean NCAP(New Car Assessment Program) has included side impact tests. In these tests, a 950 kg moving barrier is collided into the driver side of the test vehicle at 55kph, in a direction perpendicular to the longitudinal center line of the test vehicle.[1] The Korean NCAP has recently investigated using the AE-MDB (Advanced European Mobile Deformable Barrier) in their testing to better represent the population of the vehicles on the road in Korea. It is necessary to improve. side moving deformable barrier characteristics to reflect real world side collisions.

The purpose of this study is to evaluate and compare the severity of the proposed Korean NCAP AE-MDB test at both 1300 kg and 1500 kg, relative to the current 950 kg. barrier test. Large-size, mid-size and small-size cars were tested.

INTRODUCTION

The European Enhanced Vehicle-safety Committee (EEVC) and International Harmonized Research Activities (IHRA) have studied and developed a side moving deformable barrier that attempts to match the trend in front structure stiffnesses.[2] This new barrier is called the Advanced European Mobile Deformable Barrier (AE-MDB) Korean NCAP has proposed to use this new barrier starting in 2015 but has not decided whether it should be 1300 or 1500 kg. The AE-MDB barrier face was developed to have a similar shape to that of vehicles within the current fleet. The following figure shows overlays of the progressive MDB and AE-MDB barriers with fronts of the cars which are used in this study: Large-size, Mid-size, Small-size vehicles. The AE-MDB barrier face matches the shapes of these vehicles better. Refer to the following figure 1.

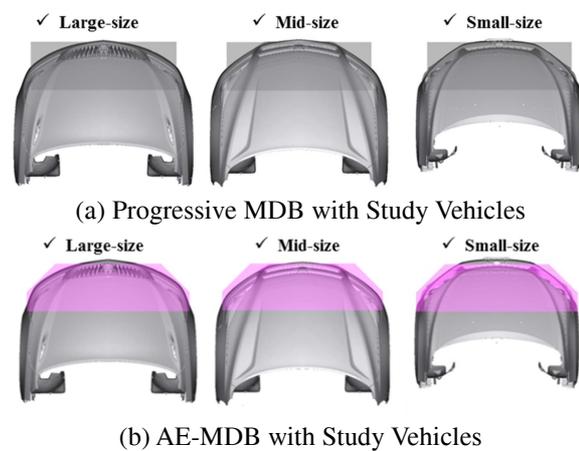


Figure 1. Barrier Overlays to study vehicles

In the previous research, the center line of the AE-MDB is perpendicular to that of the target vehicle and is aligned 250mm rearward of the target vehicle's R-point. This was set to load both front and rear seat occupants and represent a moving car to moving car side impact; where the initial contact point is aimed at the driver seat Reference Point (R-point). The same condition was adopted in this study for both front and rear seat occupant consideration [3].

Korea Automobile Testing & Research Institute (KATRI) researched the status of car registrations to investigate vehicle weight in Korea [4]. The vehicle weight has been increased continuously. 37 percent of the 2010 registered cars weighed between 1.2ton and 1.6ton and 24 percent of the cars weighed between 1.4ton and 1.6ton. Refer to the following figure 2 for 2010 car registration status in Korea.

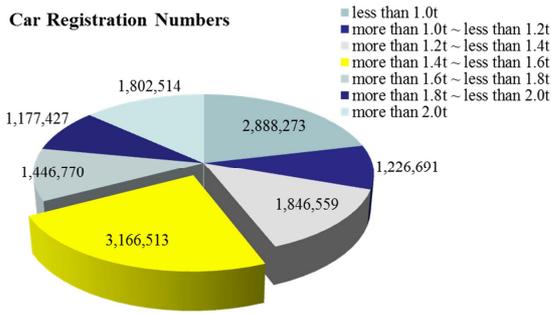
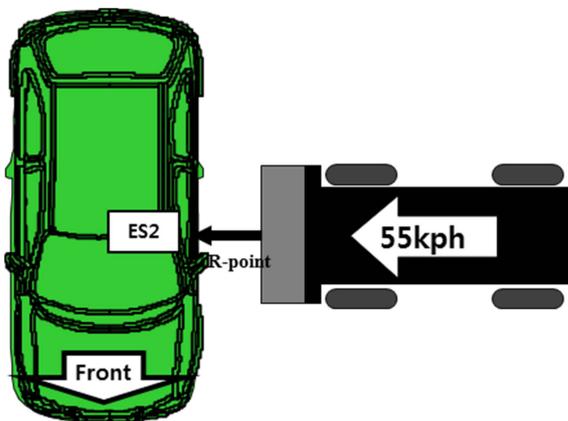


Figure 2. Car registration number and weight distribution in Korea

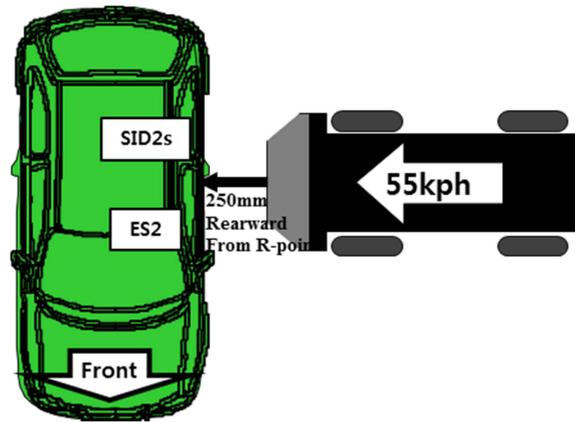
Test Condition

In this study, one large-size, one mid-size and one small-size car were used as the struck car. The striker (Progressive MDB, 1300kg AE-MDB and 1500kg AE-MDB) impact velocity was 55kph.

In the test configuration, the progressive MDB was according to current Korean NCAP test procedure with ES2 dummy placed in driver seat. In AE-MDB tests, the center line of the 1300 kg and 1500 kg barriers were aligned to 250mm rearward from the driver seat Reference Point (R-point) with an ES2 dummy placed in front driver seat and a SID2s dummy placed in rear passenger seat. Refer to the following figure 3 for test configuration.



(a) Progressive MDB side impact procedure



(b) AE-MDB side impact procedure

Figure 3. Test configuration

According to the test configuration, the progressive MDB was not overlapped to the target vehicle rear wheel house area, whereas the right corner of AE-MDB was overlapped due to 200mm wider length in barrier face and 250mm rearward position from R-point of vehicle. Refer to the following figure 4-1 & 4-2 for MDB dimension comparison and figure 5 which represents MDB positions relative to the sides of the study vehicles.

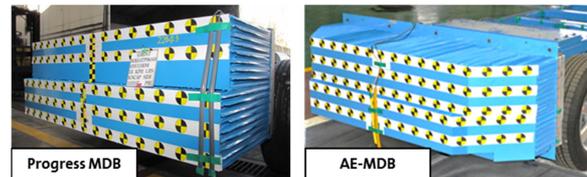
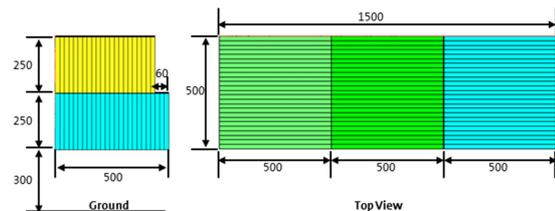
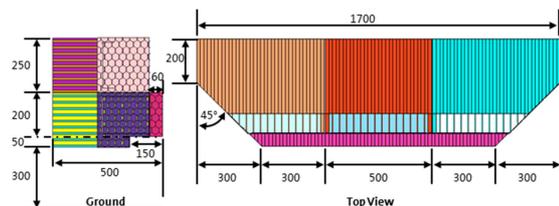


Figure 4-1. Barrier shapes between Progressive MDB and AE-MDB

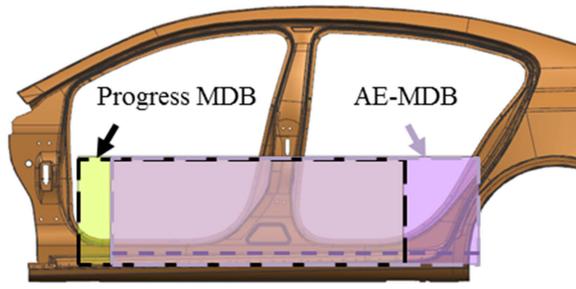


(a) Progressive MDB dimension

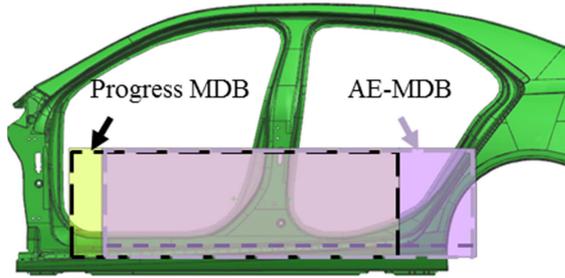


(b) AE-MDB dimension

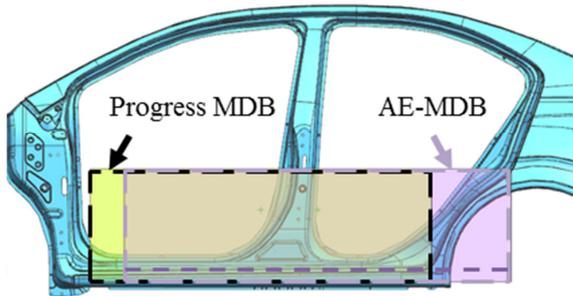
Figure 4-2. Comparison MDB dimension between Progressive MDB and AE-MDB



(a) Large-size Car



(b) Mid-size Car



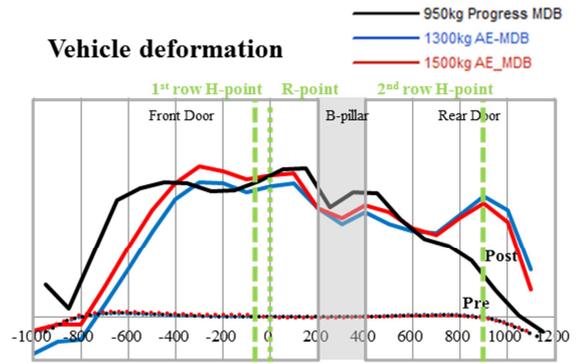
(c) Small-size Car

Figure5. Comparison MDB position between Progressive MDB and AE-MDB

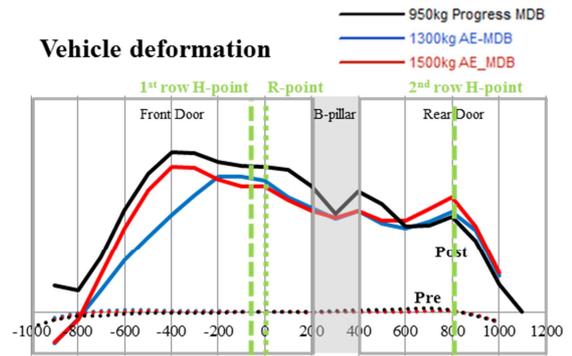
Test Result

Vehicle deformation

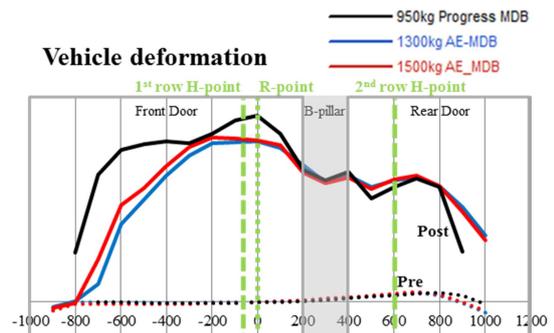
1) Vehicle side outer and B-pillar deformation
 After the barrier collision tests, the target vehicle's outer lines were measured along the outer surface of door in longitudinal direction. The deformed shape of the vehicles at the height of front driver seat reference point (R-point) was influenced by the different shapes of the progressive and AE barriers. Refer to the following figure 6 for vehicle deformation at driver R-point height.



(a) Large-size Car



(b) Mid-size Car



(c) Small-size Car

Figure6. Vehicle side door X-position relative to the R-point (0, 0)

The vehicle deformations at driver R-point height are different between the progressive MDB and AE-MDB tests, but are quite similar between 1300kg and 1500kg AE-MDB tests. The front door and b-pillar deformation were measured in outer panel and this data indicate less intrusion comparing progressive MDB test data. Refer to following figure 7 for B-pillar deformation measurement.

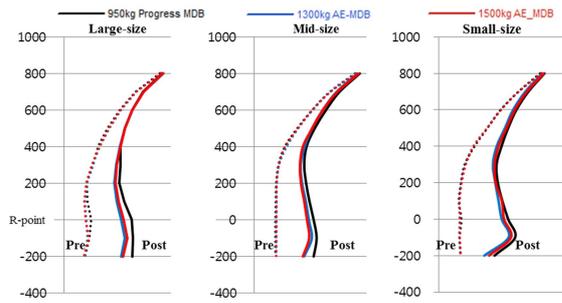


Figure 7. B-pillar outer panel deformation of all cases of the crash vehicles

B-pillar deformation was less than progressive MDB in both 1300kg and 1500kg AE-MDB despite the heavier weight and higher B-pillar velocity at beltline height of impact side. This result was caused by barrier alignment which made more overlap vehicle rear wheel house.

After the test, a B-pillar investigation was conducted and the welds remained intact and there was no tearing of the sheet metal. High strength material was used in B-pillar structure of these target vehicles and they were able to withstand the heavier barrier. Refer to the following figure 8 for B-pillar inner panel post photos..

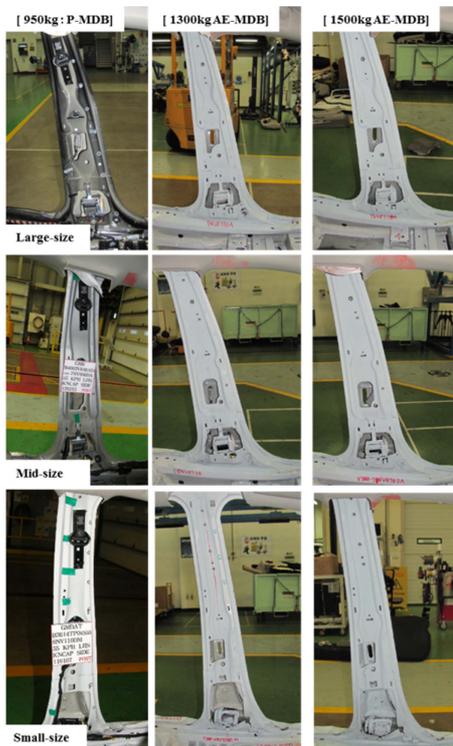


Figure 8. Struck side B-pillar inner panel (the welds remained intact and there was no tearing of the sheet metal)

2) C-pillar deformation

The C-pillar wheel house areas were investigated and the welds remained intact and there was no tearing of the sheet metal. Refer to the following figure 9 for C-pillar outer panel post photos after 1500kg AE-MDB test. The C-pillar outer panel also measured except in progressive MDB and refer to the following figure 10 for C-pillar outer panel deformation measurement in both 1300kg and 1500kg AE-MDB. There are no significant differences between them.

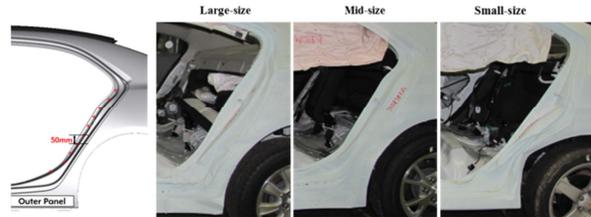


Figure 9. C-pillar outer panel measuring points and post photos in 1500kg AE-MDB test

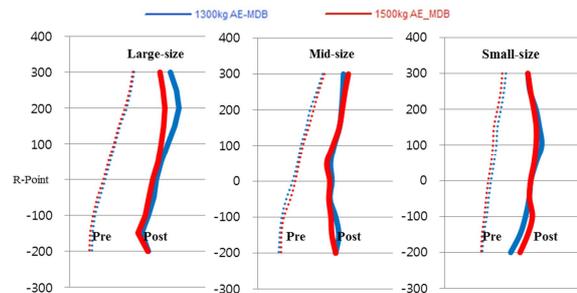
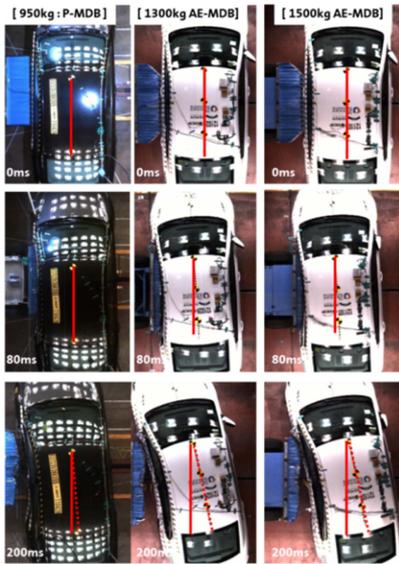


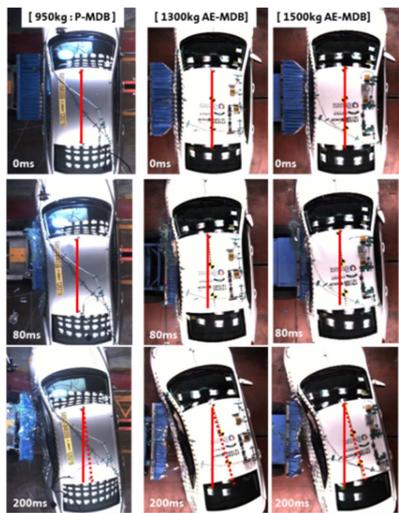
Figure 10. C-pillar outer panel deformation measurement

Vehicle dynamics

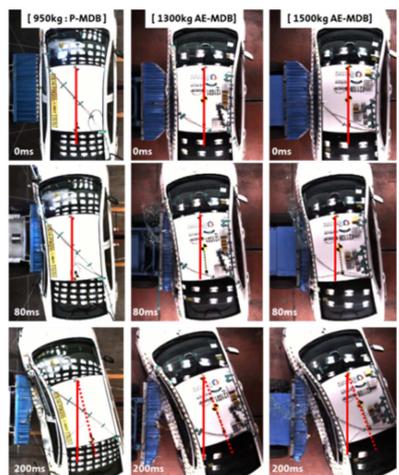
During the impact, the struck cars in the AE-MDB test were rotated more than in the progressive MDB test due to impact point change. Nevertheless vehicle rotation was not much different during injury event timing up to 80ms. Refer to Figure 11. It didn't affect the occupant injury performance.



(a) Large-size car



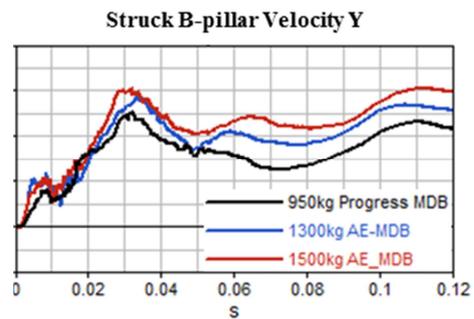
(b) Mid-size car



(c) Small-size Car

an acceleration sensor on B-pillar inner panel at beltline height. Initial velocity just after barrier impact was much higher in AE-MDB test than in the progressive MDB. It could be caused by higher barrier weight, 50mm reduction at bottom of front bumper beam which made less overlap with side rocker structure. Then the B-pillar velocity increased steeply until 30ms and at that time non-struck side B-pillar velocity almost reached 15kph which is half of struck side B-pillar velocity. After that, relative velocity between struck side B-pillar and non-struck side B-pillar was decreased. Refer to the following figure 12 for struck side B-pillar velocity at beltline height and figure 13 for B-pillar relative velocity between struck side and non-struck side at beltline height and mid height.

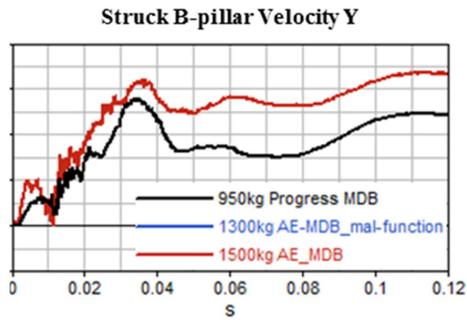
Heavier weight and the front bumper beam area which is a new and stiffer part compared to progressive MDB causes much higher initial B-pillar velocity when the barrier impacts the target vehicle during initial 10ms. After that, the struck side B-pillar velocity decreased when the barrier contacted the rear wheel house area. The B-pillar velocity then increased again, deforming the vehicle. In this situation, the rear wheel house area could help reduce the B-pillar intrusion by distributing the barrier energy.. There was no tearing of the sheet metal in B-pillar and C-pillar area.



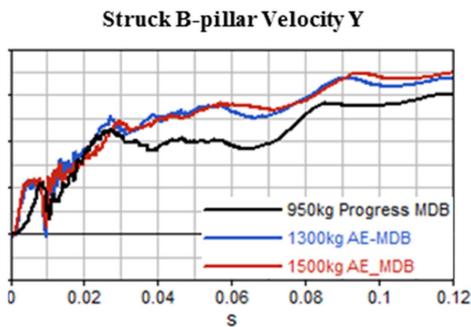
(a) Large-size car

Figure 11. Vehicle dynamic movement

The struck side B-pillar velocity was measured using



(b) Mid-size car



(c) Small-size car

Figure 12. Struck side B-pillar velocity at beltline height of all cases of the crash cars

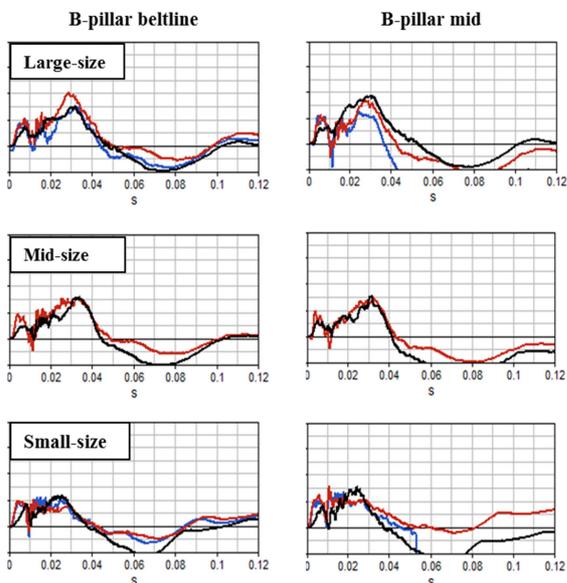
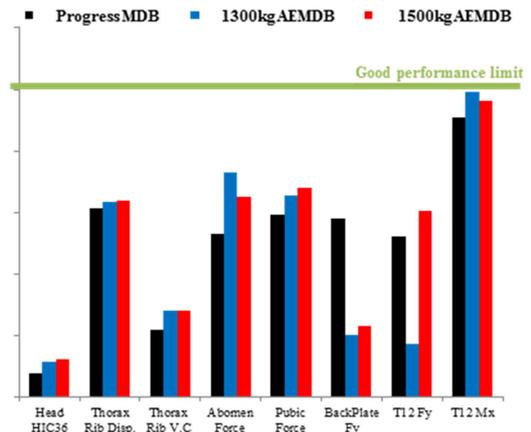


Figure 13. B-pillar relative velocity at beltline and mid height between struck side and non-struck side of all cases of the crash cars

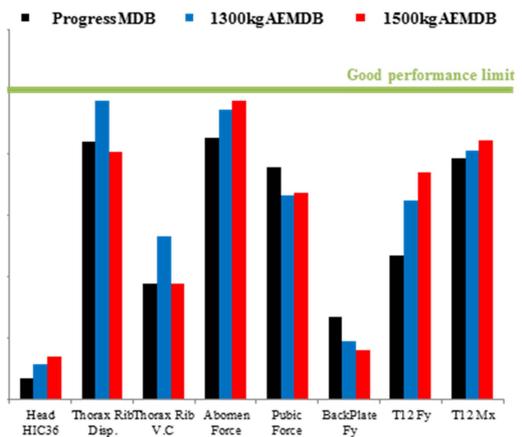
Dummy injury criteria

1) Front driver seat dummy

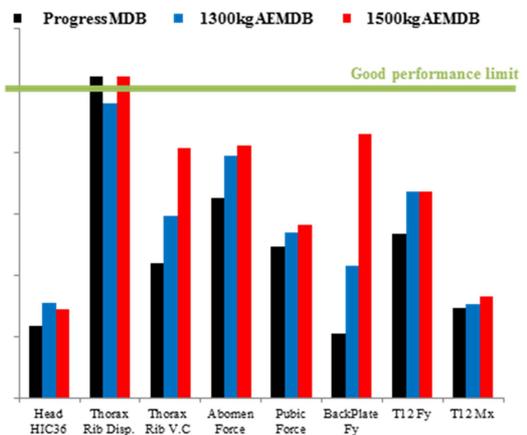
In the front driver seat, an ES2 dummy was positioned. Among the tests, the AE-MDB test injury result was more severe than the progressive MDB. Based on Korean NCAP high performance value as 100% (which is 5% probability of AIS 3 injury) [5], individual relative injury percent values were charted in figure 14.



(a) Large-size car



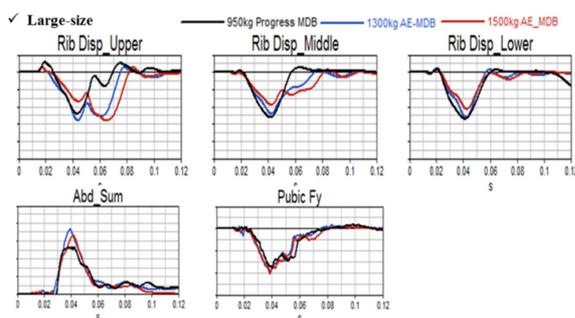
(b) Mid-size car



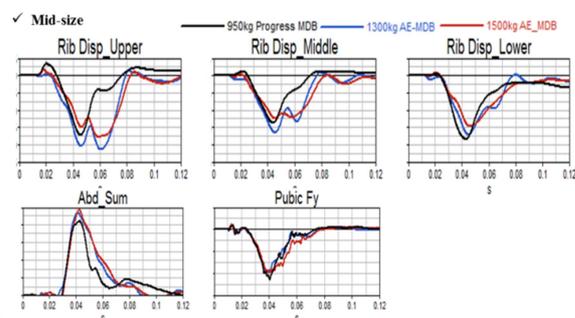
(c) Small-size car

Figure 14. Front driver ES2 dummy relative injury value based on Korean NCAP high performance value as 100%

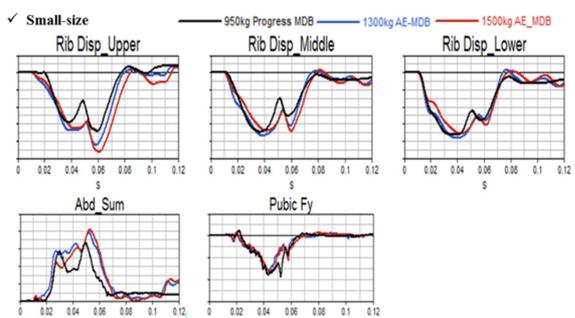
In chest injury, lower rib deflection was the worst case value in progressive MDB but upper rib deflection is the worst case value in AE-MDB. Moreover it has 2nd peak during the time between 50ms and 70ms and maximum injury value was occurred at that time. It was caused by the side airbag bottoming out due to higher vehicle speed and intrusion at initial impact time. A side airbag that stayed inflated longer could potentially improve occupant performance.



(a) Dummy injury in large-size car



(b) Dummy injury in mid-size car



(c) Dummy injury in small-size car

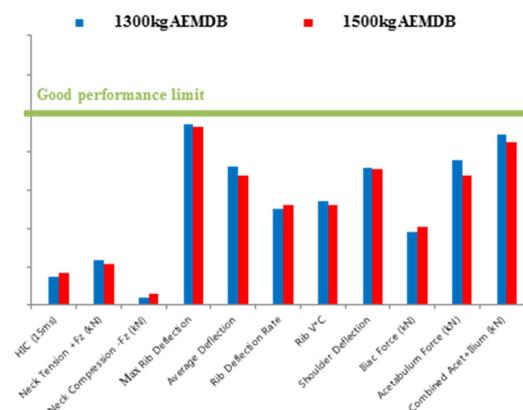
Figure 15. Front dummy injury pulse

In abdomen and pelvis, the AE-MDB test result was more severe than the progressive MDB especially in the abdomen area. The heavier weight of the AE-

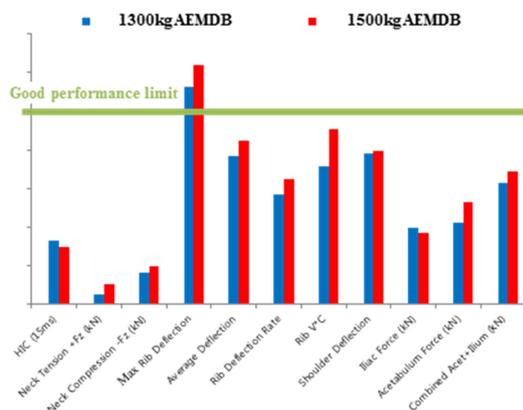
MDB and the stiffer AE-MDB bumper, which is 50mm shorter than the progressive MDB bumper, produces a faster initial B-pillar velocity and leads to earlier contact and bottoming out of side airbag. It causes higher abdomen, pelvis and 2nd peak rib deflection injuries.

2) Rear passenger seat dummy

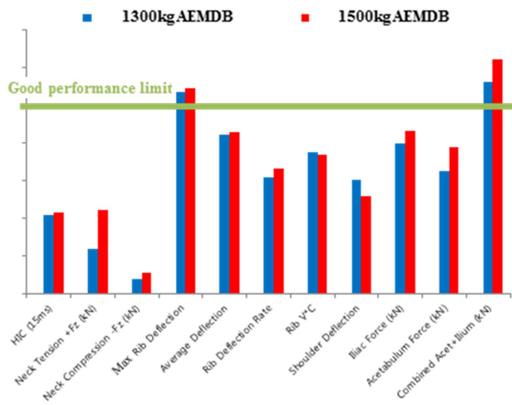
In the rear passenger seat, a SID2s dummy was positioned. Among the tests, there is no comparable data so the AE-MDB test injury results were evaluated by using IIHS injury limit[6] in figure 16 except femur injury which is not considered in this present study.



(a) Large-size car



(b) Mid-size car



(c) Small-size car

Figure 16. Rear passenger dummy injury value based on IIHS good performance limit as 100%

In the thorax area, IIHS considers only average rib deflection as 34mm for a good performance rating but this study considered not only average rib deflection but also maximum rib deflection value with a good performance limit of 34mm. In large-size and mid-size vehicles, maximum rib deflection was the highest injury value and in small-size vehicle maximum rib deflection and combined acetabulum and ilium force were the highest injury values. In mid-size and small-size vehicles rib deflection, deflection rate and viscous criteria were increased, especially in maximum rib deflection in thorax ribs, but still had a good performance rating in average rib deflection. Shoulder rib deflection also increased significantly in all of the cars; mid-size and small-size cars.

In pelvic area, iliac and acetabulum force increased with small-size vehicle. Iliac injury is the most increased value and then the total pelvic force was largely increased. This result made small-size car rating downgraded to acceptable in 1300kg and marginal in 1500kg AE-MDB although mid-size car still had good performance without a rear side airbag. This result could relate to the mid-size car being more spacious and having a larger seat bolster which is better to protect pelvic area.

DISCUSSION

- 1) In AE-MDB tests, the injury values measured in front driver ES2 dummy was higher than progressive MDB. AE-MDB brings the vehicle structure higher intrusion speed although B-pillar and outer door measuring data indicate less intrusion than progressive MDB. It caused airbag

bottoming out and chest, abdomen and pelvic injury area increased. The target vehicles used in this study have high strength material for the B-pillar structure which can help reduce the B-pillar structure intrusion.

- 2) In rear passenger SID2s dummy, there was no injury data from the progressive MDB testing to compare to the AE-MDB test results. Thorax and pelvic injury area were higher than good performance limit of IIHS injury in the AE-MDB tests of the small-size vehicle. C-pillar intrusion in the AE-MDB tests was much higher than in progressive MDB tests. As well as the B-pillar structure, The target vehicles which were used in this study have high strength material for C-pillar reinforcement and also have no ruptures in this area.
- 3) In this study, the target vehicles are mid-size and small-size segment cars. The smallest vehicle had the highest injury values for both front and rear seat occupants. But mini-size cars have not yet been studied and more study considering the mini-size car is needed.

CONCLUSIONS

The AE-MDB barrier is heavier and positioned 250mm rearward in than the progressive MDB and contacts the vehicle rear wheel house area. The further rearward impact point reduces B-pillar deformation assuming that the B-pillar, C-pillar and rear wheel house area do not rupture. The heavier weight of the AE-MDB increases deformed structure velocities leading to higher injury values. Nevertheless, the test results showed similar front driver occupant injury values. The 2nd peak in the driver chest deflection curves in the AE-MDB tests(50ms~70ms) is caused by bottoming out of the side airbag due to the higher intrusion speeds. To improve this performance, the side air bag should potentially have a longer deployment duration or additional energy absorption capability. For the rear passenger dummy, the AE-MDB produces a more severe impact to the thorax and pelvic areas due to higher intrusion speeds. In the large-size and mid-size vehicles, occupant injury values met the IIHS "Good" occupant performance criteria, but not in the small-size vehicle. A rear side airbag or energy

absorbing system could be helpful to improve rear passenger's thorax and pelvic injuries, especially in small-size vehicles.

Globally, the trend is that the ES2 dummy will be replaced with the World SID dummy. World SID dummy has wider chest and pelvic area, which could reduce the space that the side airbag has to absorb the impact energy. A future study using the World SID dummies in these test configurations is recommended.

ACKNOWLEDGEMENT

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