

Pedestrian Protection Test and Results: Utilization for Regulations in Korea

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ABSTRACT

High death rates occur due to the frequency of vehicle to pedestrian traffic accidents. Governments throughout the world are attempting to improve the safety features of the vehicle by modifying vehicle safety standards and new car safety assessment programs. This paper introduces the pedestrian protection assessment methods that have been used in the Korea New Car Assessment Program since 2007. Assessment results obtained from 54 models, tested over five years (2008 – 2012), are examined and analyzed. This research found that the pedestrian protection features of vehicles have improved gradually but are still unsatisfactory. Therefore, much improvement is needed. In the past, car manufacturers installed pedestrian protection airbags or active hood systems to enhance the pedestrian protection features. Currently, research is being carried out to develop assessment techniques of active pedestrian protection features. Meanwhile, researches are being carried out to develop the Flexible Pedestrian Legform Impactor (Flex-PLI) to satisfy Phase 2 of the Global Technical Regulations (GTR).

INTRODUCTION

In 2011, Korea's fatality rate in vehicle to pedestrian traffic accidents reached 39.2%. This is the highest among OECD countries. Pedestrian protection technology is being researched throughout the world to provide better safety features. As a result of such endeavors, the enactment of the Global Technical Regulations(GTR) was announced in November of 2008. Member countries, including Korea, will soon

enforce the GTR to provide pedestrian safety. Korea enacted vehicle safety standards based on the GTR in December of 2008, and has enforced them with regard to passenger vehicles since January 2013. The Korean government implemented the vehicle safety regulations and the New Car Assessment Program (NCAP). The test results acquired from the NCAP were announced by the government, but although they are not legally binding, the importance of the NCAP has been recently emerging. Pedestrian safety assessment protocols were included in the NCAP in 2007, and assessments for head injury criterion were tested at that time. The leg injury criterion was added in 2008. Since then a total of 54 vehicle models was assessed for pedestrian protection features from 2008 to 2012. The test results obtained from the NCAP were announced to the general public in order to enhance customers' awareness of vehicle safety information and to encourage automobile manufacturers to make safer automobiles. As a result of such endeavors, the pedestrian protection features of vehicles have improved gradually but are not sufficient. In 2012, the average pedestrian protection rating of tested vehicles was 13.4 points (out of a maximum of 30 points) or approximately 2.8 stars on a five star rating scale. There are two major means to improve pedestrian safety features: active safety and passive safety measures.

Passive safety measures usually means designing the automobile structure to provide enough space so that impact energy is absorbed in the case of a collision with pedestrians. Currently, most of the vehicles on the market have this kind of safety feature. But it is not a sufficient measure to ensure pedestrian safety. Additional safety measures should

be considered in sections such as the lower portion of the front windshield, the A-pillar, the rear part of the hood, etc.

On the contrary, active safety measures means that protection mechanisms are activated instantaneously in the case of a collision. Well-known active safety measures include the active hood system, in which the hood is lifted upward at the moment of collision to absorb impact energy. There is also the pedestrian protection airbag systems, which are normally installed in the lower portion of the windshield and A-pillar.

This paper introduces pedestrian protection assessment methods used in Korea's New Car Assessment Program. The analysis assessment results are obtained from 2008 to 2012. Also the research plan to be carried out to achieve pedestrian safety is shown.

Pedestrian Traffic Accident Statistics(OECD)

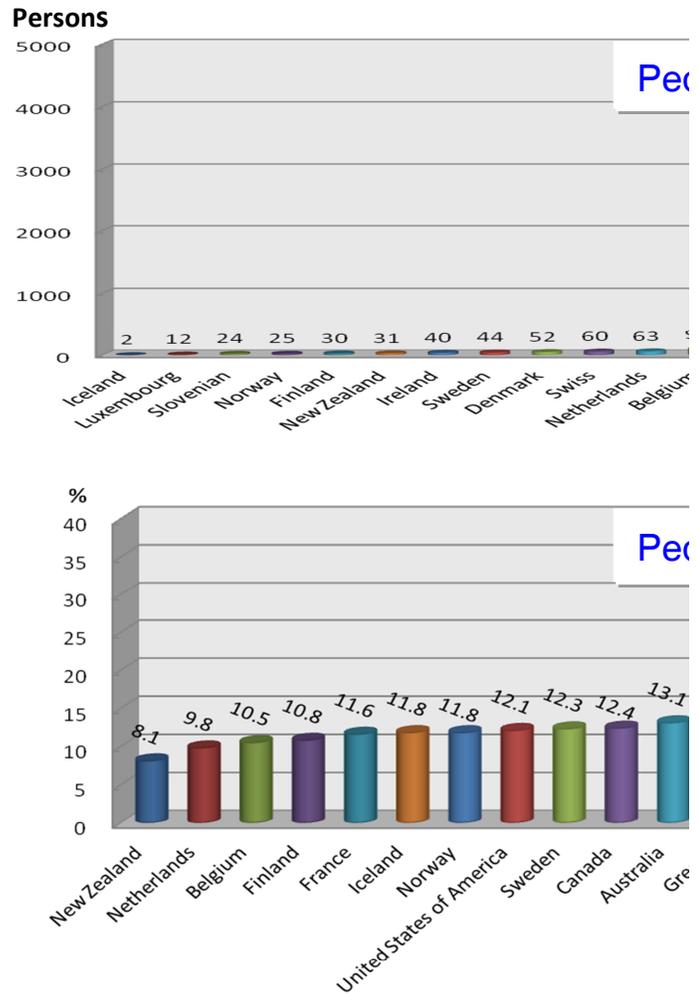


Figure 1. Vehicle to Pedestrian Traffic Accidents (OECD, 2009)

Figure 1 shows the pedestrian fatality rates of the Organization for Economic Cooperation and Development (OECD) countries(2009). 4,092 pedestrians were reported to have been killed in motor vehicle accidents in the United States, while South Korea had 2,137 pedestrian deaths, Japan had 2,012, and Poland had 1,467. However, pedestrian fatalities out of the total number of traffic accidents is different. South Korea recorded a rate of 36.6%, which is the highest among the OECD countries.

Pedestrian Traffic Accident Statistics(Korea)
Traffic Accident Occurrence

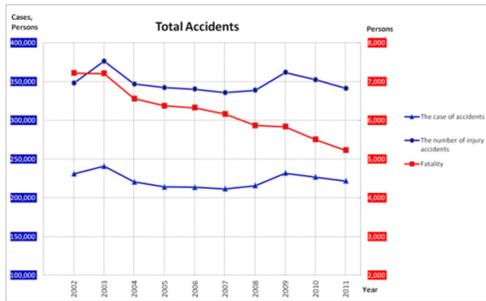


Figure 2. Traffic Accident Occurrence (Korea, from 2002 to 2011)

Figure 2 shows the number of traffic accidents, injuries, and deaths that occurred in Korea from 2002 to 2011. In 2011, a total of 221,711 traffic accidents occurred, where 341,391 people were injured and 5,229 people died. The total number of traffic accident occurrence and injuries did not change much, but the number of deaths has gradually decreased.

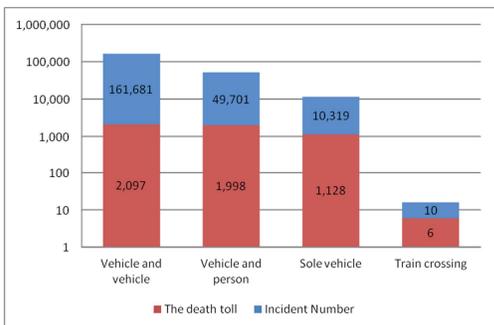


Figure 3. Traffic Accidents (Korea, 2011)

Figure 3 shows the number of traffic accidents and deaths according to the types. A total of 161,681 vehicle to vehicle accidents occurred, and 2,097 people died in these accidents. On the contrary, a total of 49,701 vehicle-to-pedestrian accidents occurred, and 1,998 people died in these accidents. The fatality rate in vehicle-to-pedestrian accidents was comparably high considering the occurrence.

Pedestrian Injury Analysis

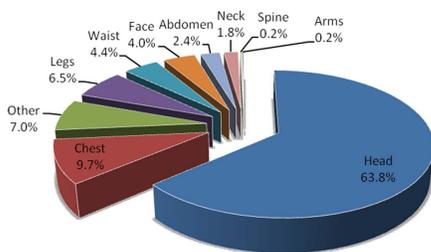


Figure 4. Causes of Pedestrian Deaths

Figure 4 shows the causes of pedestrian deaths that occurred in vehicle to pedestrian accidents. Figure 5 shows the causes of pedestrian injuries.

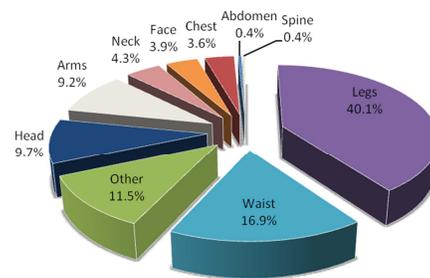


Figure 5. Causes of Pedestrian Injuries

The highest cause of death was head injury (63.8%), followed by chest injury(9.7%), leg injury(6.5%), and back injury(4.4%). The most common type of injury was leg injury(40.1%), followed by back injury(16.9%) and head injury (9.7%). As seen in the data, protection mechanisms to protect pedestrian death and injury should be improved.

New Car Assessment Program (Pedestrian Safety) Test Method

Pedestrian safety assessment measures used by KNCAP are very similar to those of EURO-NCAP. However, it does not include the upper legform impact test to the bonnet leading edge and the impact area is different with 1,700 mm with reference to Wrap Around Distance(WAD) in the case of a child headform test area. These slight differences are caused because KNCAP follows the GTR Article No. 9 “Pedestrian Safety”. As shown in Figure 6, vehicle impact assessment is performed using headforms(both adults and children) and legforms (upper or lower).

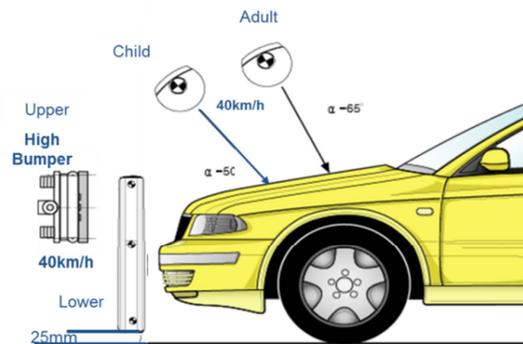


Figure 6. Pedestrian Safety Assessment Methods

The dimensions of the adult headform are 165 mm in diameter and 4.5kg in weight, and those of the child headform are 165mm in diameter and 3.5kg in weight. Impact tests are conducted at two different angles(65 and 50 degrees) and at a speed of 11.1±0.2 m/s. Six impact tests are carried out in each test area. The details of the headform impact test are shown in Table 1.

Table 1. Headform Impact Test Methods (Headform)

Speed	40km/h
Test Area	Child(1,000~1,700mm) Adult(1,700~2,100mm)
Test Method	Child : 50° (6 points) Adult : 65° (6 points)

The dimensions of the legform, used in this test, are 926mm in length and 13.4kg(lower legform) or 350mm in length and 9.5kg(upper legform). Impact tests on the front bumpers are carried out three times each at a speed of 11.1±0.2m/s, and the assessment points are measured. Unlike EURO NCAP, KNCAP does not include the upper legform to bonnet leading-edge tests. Details of the legform impact test are shown in Table 2.

Table 2. Legform Impact Test Methods (Legform)

Speed	40km/h
Test Area	Front Bumper
Test Method	Upper or Lower Leg (3 points)

Evaluation Method

Scores obtained for each assessment criterion in headform and legform impact tests are summed, and then pedestrian safety points are grouped according to injury values in three different groups. These assessment results are colored and attached to the the front portion of the vehicle as shown in Table 3. Until 2012, KNCAP used the five star rating system(the

lowest rate of one star). The maximum achievable score is 30 points(12 points each for adult/child headforms, and 6 points for legform). However, KNCAP uses the integrated rating system from this year(2013) instead of the five star rating system. Therefore it does not mark individual assessment criteria with stars.

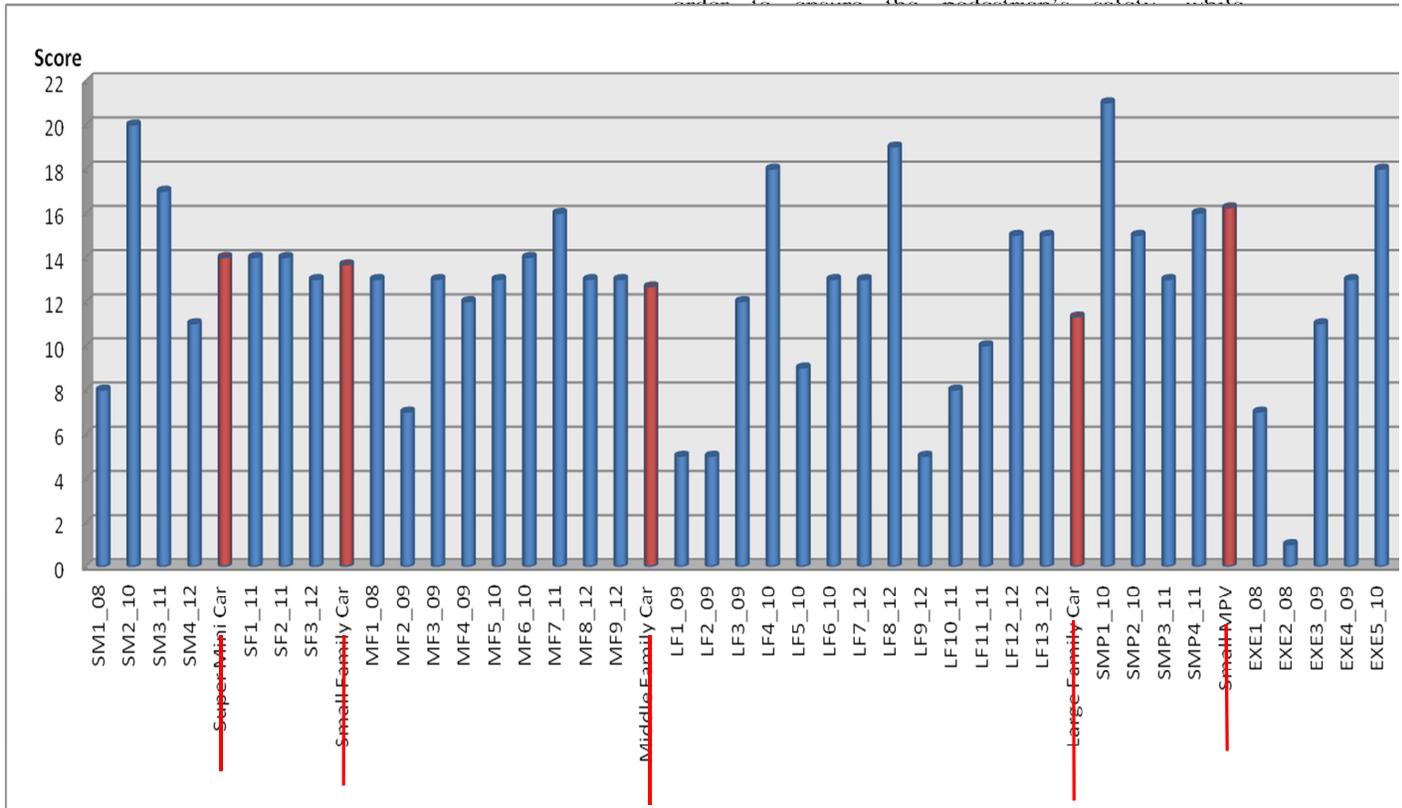
Table 3. Pedestrian Safety Assessment Standard

Section	Protection of Pedestrian			
	Color	Good	Marginal	Poor
Head Injury Criterion (HIC)	HIC	Green	Yellow	Red
	Bending Angle	Under 1,000	Over 1,000 Under 1,700	Over 1,700
Test Measurement	Lower Leg	Under 15°	Over 15° ~ Under 19°	Over 19°
	Shear Displacement	Under 5mm	Over 5mm ~ Under 6mm	Over 6mm
	Acceleration	Under 150g	Over 150g ~ Under 170g	Over 170g
	Load Value	Under 5kN	Over 5kN ~ Under 7.5kN	Over 7.5kN
	Upper Leg	Bending Moment	Under 300Nm	Over 300Nm ~ Under 510Nm

Results of New Car Safety Assessment for Pedestrian Protection

Pedestrian protection assessments have been implemented in Korea since 2007. Fifty-four models were tested over five years(2008 – 2012), and only head injury assessment tests were conducted in 2007. Eight models were tested in 2008, 10 models in 2009, 12 models in 2010, 11 models in 2011 and 11 models in 2012. The tested vehicles were all the new cars sold in Korea, and some of them were imported cars. Figure 7 shows the results of the assessment. Only two models exceeded 20 points out of the 30 points maximum scale. Therefore, overall safety performance was very disappointing.

MPVs have more space in the engine compartment in order to ensure the pedestrian's safety while



(2008 - 2012)

Figure 8 below shows the assessment results by year. In the graph, one can notice that pedestrian safety performance has improved slowly over the years. In 2012, the average number of points of the assessed models was 13.9(out of a possible 30 points), and in terms of the star rating system, the average was 2.8 stars (on a five star scale).

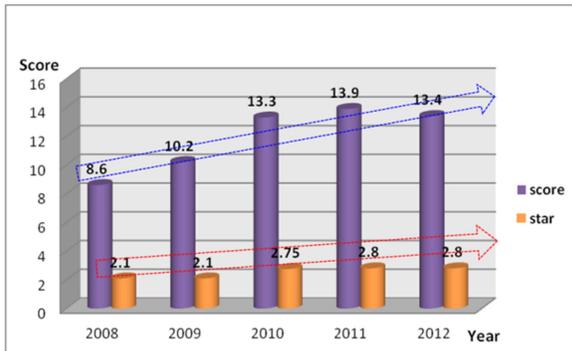


Figure 8. Pedestrian Safety Assessment Results (Points and Stars)

Figure 9 shows the assessment results by the type of the vehicle. Small MPVs(Multi Purpose Vehicles) and superminis recorded relatively higher scores in pedestrian safety assessment. Most of the small

factor is higher than the score acquired from the adult headform factor.

The reason for this is that the adult head test area is normally located close to the safety hazard sections of a vehicle such as a lower portion of the windshield or A-pillar.

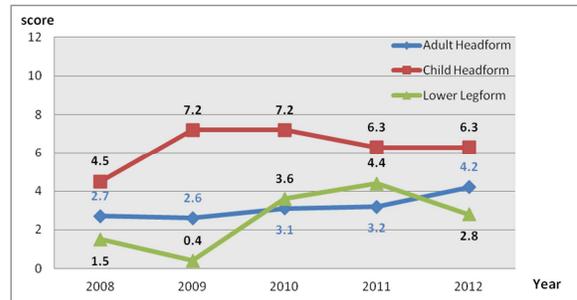


Figure 10. Pedestrian Safety Assessment Results (by Impact Area)

Figure 11 shows the assessment results of Korean manufacturers' models and imported models. Generally, imported models scored lower compared to Korean manufacturers' models. This can be explained by the origin of the vehicles. Most of the imported models were manufactured in North America. Due to the bumper regulations implemented in that region, vehicles manufactured

there tend to have lower pedestrian protection capabilities.

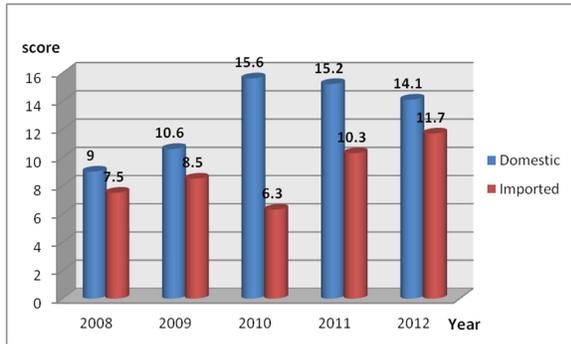


Figure 11. Pedestrian Safety Assessment Results (Korean Manufactured Models and Imported Models)

Figure 12 below shows the assessment results obtained from the vulnerable sections such as the bottom area of the front windshield(A2 – A5) and A-pillar(A1, A6) of both Korean manufactured models and imported models. The bottom area of the front windshield is considered as an unsafe section for pedestrians because the crash pad is attached to it. Impact tests on the bottom area of the front windshield have been implemented from 2008 to 2012 and the results have been analyzed. The analysis showed that this section produced high injury values. Particularly, the head injury criterion (HIC) was mostly between 1,000 to 3,000. According to the analysis of test results, this area should be improved by installing pedestrian protection airbags.

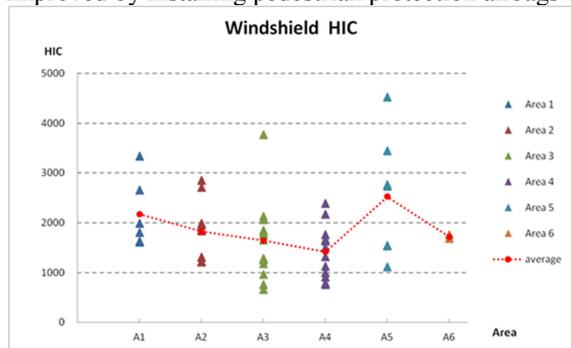


Figure 12. Pedestrian Safety Assessment Results (Bottom area of the windshield)

Figure 13 shows the assessment results of the top area of the hood. The top area of a hood is considered to be hazardous to pedestrians because of a secondary collision with the internal engine structure and its closeness to the cowl top. Therefore, this section generates higher pedestrian injury values. The head injury criterion mostly ranges from 1,000 to 1,500. An active hood system should be installed to

enhance pedestrian protection capabilities of this section.

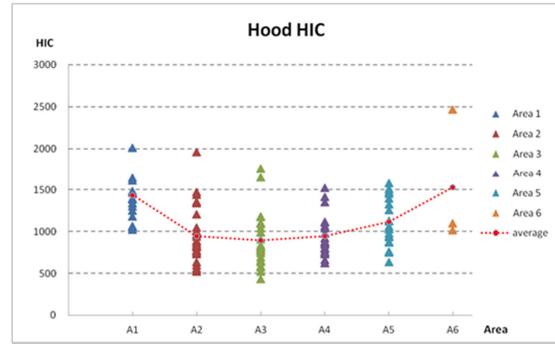


Figure 13. Pedestrian Safety Assessment Results (Top area of the hood)

KNCAP has used an integrated rating system since 2013 instead of announcing the ratings of each assessment criteria individually. Particularly, pedestrian safety related assessments were enhanced so that tested models could not receive a five star rating if a certain levels of pedestrian protection capabilities are not achieved, unlike previous years. Moreover, the percentage of the pedestrian-related balance limit will be increased by 50%(2013), 60% (2015), and 65%(2017). Details are shown in Figure 14 below.

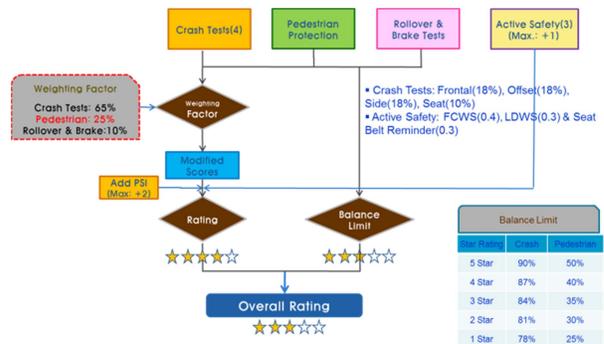


Figure 14. Pedestrian Safety Assessment (Integrated Rating System)

Discussion

In 2011, Korea's fatality rate from vehicle to pedestrian traffic accidents reached 39.2%. This is the highest among OECD countries. The Korean government has been endeavoring to improve pedestrian protection features. In 2007, it started the head injury criterion assessment for pedestrian safety assessment through its Korea New Car Assessment Program. It extended the assessment categories to leg injury risk assessments in 2008. A total of 54 vehicle models were assessed for their pedestrian protection

features from 2008 to 2012. Over the years, pedestrian protection capabilities of vehicles have shown noticeable but slow improvement, but they still remain unsatisfactory. In 2012, the average pedestrian protection rating of tested vehicles was 13.4 points (of a maximum of 30 points) or appropriately 2.8 stars on a five star rating scale. The Korean government has adopted a new integrated rating system for pedestrian safety assessment in its New Car Assessment Program in order to encourage vehicle manufacturers to install a certain level of pedestrian protection features in their vehicles in order to receive a five star rating.

Future Works

Some vehicles are already equipped with active hood systems to enhance pedestrian protection abilities. In 2012, a new vehicle model with a pedestrian airbag system was launched. The Korean government is developing assessment methodologies in order to assess active pedestrian protection systems installed in vehicles. Once this research is completed, the assessment techniques will be announced, included and implemented in KNCAP.

In the meantime, research is being carried out to develop the Flexible Pedestrian Legform Impactor (Flex-PLI) to satisfy Phase 2 of the Global Technical Regulations (GTR). Since Korea is a signatory to the GTR, once it amends its Phase 2, the Korean government will reflect and announce the changed technical requirements for its KNCAP.

Acknowledgements

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