THE SAFETY PERFORMANCE EVALUATION OF POLYETHYLENE BARRIERS

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Abstract: "All drivers have the right to be prevented from accidents in driving." In this paper, I focus on longitudinal PolyEthylene Barriers because they are the typical and common type of roadside safety feature. I consider two types of PolyEthylene Barriers named as "Green Safety Box" and "Guard Box". I achieved several full-scale crash test on the two features to evaluate crashworthiness and safety according to the "Installation and Maintenance Criteria of Roadside safety features (MOCT, 2001)". In crash test, I used a passenger car which weigh about 1,300kg as a test vehicle to evaluate the safety performance of the features, impact speed was set up 80km/hr, and impact angle was 20degrees. As a result, THIV (Theoretical Head Impact Velocity) and PHD (Post-impact Head Deceleration) was calculated below the criteria 9m/s, 20g's each. I confirmed the safety performance of them not only through the safety indices but also through the post-impact trajectory of the test vehicles. In this paper, I'm going to describe the characteristics of the two longitudinal PolyEthylene Barriers, show full-scale crash test criteria, and explain test results of them.

Key Words: longitudinal barrier, crash test, polyethylene, safety, performance

1. INTRODUCTION

"Drivers on the road have the right to be protected from the accidents." The cause of traffic accidents are largely classified due to the drivers, road condition and geometry, and vehicles' malfunction. Traffic accidents data which are reported in Korea reveal that over 80% of the traffic accidents are mainly influenced by the drivers' judgment errors and inattention, etc. Thus, it is clear that continuous research and efforts to prevent such traffic accidents are definitely needed although such accidents can not be completely avoided. Considering that the annual loss on the lives and properties due to traffic accidents is so serious problem to the nation, it is asserted that research on and development of road safety facilities, which can greatly reduce the impact of the accidents, are necessary.

This research deals with polyethylene barriers, which are commonly used at the roads. The performance evaluation of polyethylene barriers has been carried out on the safety of the riders in accordance with the revised "Handbook of the Road Safety Facilities Installation and Maintenance - Vehicles Protection and Safety Facilities Section" of the Ministry of Construction and Transportation. After several failures and restructuring, a satisfactory product was obtained that met the above specified standards. This paper intends to present the characteristics of the polyethylene barriers by subjecting them to the safety performance evaluation procedures and the analyses of the results. "Handbook of the Road Safety Facilities

Installation and Maintenance- Vehicles Protection and Safety Facilities Section" reads as follows concerning "development monitoring."

This "Handbook of the Road Safety Facilities Installation and Maintenance- Vehicles Protection and Safety Facilities Section" applies in all cases including the design stage currently in progress except in special circumstances (the case of having difficulty in applying the standards due to the impending deadline for construction in near-the-completion). For the case of feasible evaluation of the safety facilities by real object collision testing, it is allowed to follow pre-existing guidelines by the end of the year of 2002 simultaneously considering the time required to develop the satisfactory product. However, this revised "Handbook" supercedes in the application.

Thus, it is mandated that a safety performance evaluation in accordance with the performance evaluation standards as specified in this revised "Handbook" has to be carried out beginning in 2003 in order to install vehicle protection/safety facilities on the roads. This revised directives of the national policy is interpreted as a thoughtful decision after accepting the new performance-oriented paradigm, which requires the safety verification only instead of the past requirement for the appearance and size in the name of the "standardization" and for its sake only.

2. THE STANDARD FOR THE SAFETY PERFORMANCE EVALUATION

2.1 Testing Criteria

Vehicle guard-rail barriers should satisfy both conditions of adequate strength to deter the vehicles' momentum to break away and adequate impact absorption to ensure the safety of the riders. These barriers are graded in 7 steps in accordance with their strength (impact grade) and further specified by the performance requirements for each grade. The design for these barriers considers the impact resistance strength by performing the structural strength computation, computer simulation, prototype (simple) experiment, and real object collision tests. However, the final verification of the barriers' safety performance is based in principle on the real object collision test for the obvious reason.

However, current situation allows temporarily the practices as specified in the guidelines of "protective barrier section" and "bridge-area protective barrier section" of the Handbook of the Road Safety Facilities Installation and Maintenance of the 1997 and 1999 edition, respectively, until all the necessary conditions for the real object collision testing such as the establishment and expansion of the national performance evaluation centers as well as the establishment and execution of the national performance verification system are satisfied.

Nevertheless, the real object collision tests are the only tests with unsurpassed validity that can assess the performance of the protective barrier following the collision with the vehicles in real situation. Thus, the monitors of the road would apply such proven barriers after passing the real collision tests with the first preference.

2.1.1 Strength Testing Standards

The protective barriers are classified in 7 grades as shown in Table 1, and a testing of the barriers' protection performance is carried out in each condition to ensure the appropriate strength of the barrier for each grade.

Table 1. Strength Test

Grade	Collsion Speed (km/hr)	Vehicle Weight (kg)	Collision Angle (°)	Impact Criterion (kJ)
SB1	55	8,000	15	60
SB2	65			90
SB3	80			130
SB4	65	14,000		160
SB5	80			230
SB6		25,000		420
SB7		36,000		600

2.1.2 Testing Standard for the Protection of the Riders

Testing conditions for the evaluation of the riders' safety are as shown in Table 2, and each testing is executed in the condition appropriate for each grade.

Table 2. Rider's Safety Test

Grade	Collision Speed (km/hr)	Vehicle Weight (kg)	Collision Angle (°)
SB1	60	1,300	20
SB2, SB4	80		
SB3	100		
SB5, SB6, SB7			

2.2 Evaluation Criteria

Protective barriers for the vehicles should satisfy all the performance criteria in terms of structural strength, riders' protection, vehicles' safety, etc. after real vehicle collision testing is carried out in the conditions appropriate for each grade based on the degree of impact.

2.2.1 Structural Strength

The adequate structural strength to prevent the breaking away of the vehicles is one of the most important features of the protective barriers. The verification of the satisfactory structural strength of the barriers is routinely carried out by the visual inspection for the breaking off of the barriers and/or the degree of the damage to the joining section of the barrier as well as the ultimate concern for the breaking away of the testing heavy vehicle.

Deformable barriers are protective barriers, which can be anticipated at the design time of the change in elasticity and plasticity of major components after a collision. They are excellent impact absorbers by changing the shape of both themselves and the colliding vehicle at the moment of collision impact. However, the maximum allowable reshaped distance must be specified because of the danger of excess deformable to cause the colliding vehicle to be pushed toward the pedestrian walk area or outside of the roads or bridge. Here, the maximum allowable reshaped distance indicates the maximum pushed distance of the barrier from its original position (the vertical distance to the traffic lane) as the colliding vehicle pushes the barrier.

It is specified to be below 1.1m for the stakes of the deformable protective barrier driven into the ground and below 0.3m for the stakes driven into the concrete foundation. Thus, the deformable protective barrier must satisfy both the requirements of maximum allowable reshaped distance and the limiting value delineated by the particular characteristics of the installation site. The strength requirement for such high-strength protective barrier as the concrete barrier specifies that no change in the plasticity of the major components of the barrier should occur. The protective barriers for the vehicle are subject to a heavy load being applied during the collision. Thus, it should be carefully avoided that their major components fly above or outside the road to injure the riders or other third party.

2.2.2 Protection of the Riders

A regular sedan is used as the testing vehicle to evaluate the protection of the riders. Different testing conditions are applied for each grade, and the performance of the barriers in protecting the riders is assessed by the criteria as shown in Table 3.

Table 3. Evaluation Criteria for the Protection of the Riders by the Barrier

Evaluated Characteristics	Unit	Limiting Value
(lengthwise·crosswise) THIV	m/s (km/hr	9 (33)
(lengthwise·crosswise) PHD	g (=9.8m/s2)	20

Here, THIV (Theoretical Head Impact Velocity) is one of the index numbers to evaluate the safety of the riders when colliding to safety facilities such as the barriers on the berm. Regarding the head of the riders as free flying objects, it is the moving speed of the head of a rider until it hits some interior object of the vehicle.

PHD (Post-impact Head Deceleration) indicates the maximum deceleration value of the second collision, i.e. the colliding of the head of a rider to some interior object of the vehicle caused by the initial collision of the vehicle. In addition, this value could signify that the structural components of the protective barrier did not cause any harm to the driver or the passenger.

2.2.3 The Behavior of the Vehicle After the Collision

When a vehicle collides against the protective barrier, the influence of movement behavior the colliding vehicle on the following vehicle can vary with the distance between the two vehicles and also the availability of the escaping space. At this time, the colliding vehicle should neither suddenly stop nor be deflected to stop on the traffic lane. Additionally, the detrimental movement behavior of the colliding vehicle to seriously influence on the vehicles moving on the opposite direction or parallel direction should not occur. After the collision, the safety evaluation of the colliding vehicle should be executed regardless of the type of the vehicle. In the testing involving heavily loaded vehicle, the evaluation of the strength of the protective barrier and the safety of the vehicle should be performed always. In the testing situation involving smaller passenger vehicles, the evaluation of the safety of the riders and safety of the vehicle should always be carried out likewise.

3. ANALYSIS OF RESULTS FOR COLLISION TESTS

3.1 Real Object Collision Tests

The subject of this research, the polyethylene protective barrier, is widely used in highway, national roads, and city streets as temporary protective barrier. Recently, it is the trend to use them as median protective barriers on the national roads for their convenience in installation and maintenance. The polyethylene protective barriers are formed as the structure that can be filled with water while polyethylene is used as the main material. During the production process, it has the advantage of controlling the its strength at will by adjusting the thickness of the main body. In addition, it is possible to rapidly install or replace the damaged parts of this protective barrier due to the simplicity of its structure without seriously hindering the traffic flow. The green safety box used in this research was 1.5m in the unit length, and each units were connected by inserting iron pipes in the strut style. The guard box was 2.0m in length per unit, and the connection method was to insert iron pipes in the top connecting hole in parallel to the ground. Iron wires were then inserted inside the iron pipes. The opinions of the producing companies were considered in the selection of the product materials, forming method, the structural configuration and installation method as well as considering the characteristics of the field site.

The strength of the polyethylene protective barriers was not analyzed in this research. Considering the materials and structure of polyethylene protective barriers, it was determined that they would not have adequate strength to withstand the collision against large cargo trucks. Furthermore, it was decided that applying the same performance criteria for temporary protective barriers to permanent protective barriers was not reasonable. Thus, only the safety of the riders was evaluated after the collision against the polyethylene protective barrier.

This decision was seconded by the responsible department of the appropriate agency. It is hoped that this decision on the evaluation policy of the temporary facilities would be considered and upheld again in the future. The evaluating conditions for the riders' safety after the collision against polyethylene protective barrier are shown below.

Table 4. Testing Condition

Classification	Collision Speed (km/hr)	Vehicle Weight (kg)	Collision Angle (°)
Green Safety Box	80.38	1,310	20
Guard Box	83.99	1,320	20

The real collision tests against these two types of polyethylene protective barriers are depicted in Figure 1 and Figure 2 below.

Figure 1. Real Collision Testing Against Green Safety Box

Figure 2. Real Collision Testing Against Guard Box

3.2 Evaluation of Safety Performance

3.2.1 Evaluation of Protective Performance for the Riders

As previously described, the performance of the protective barriers on the protection of the riders is evaluated by a comprehensive assessment on THIV (Theoretical Head Impact Velocity), PHD (Post-impact Head Deceleration) and the damage caused by flying of dismantled structural components. For the case of green safety box, THIV and PHD were measured at 5.22m/s and 5.37g, respectively, within the limits of safety standards set forth.

Another safety requirement is that the damage caused by flying of structural components of the barrier above and outside the traffic lanes after the collision should not seriously effect the riders or other third party such as pedestrians. This requirement was again satisfactorily met by the visual inspection, which revealed seriously damaged 4 units and slightly scratched 8 units. It was determined that this damage after the impact was not enough to have some structural components of the barrier dismantled and flown in the air. The damage assessment revealed that 4 units of 1.5m were to be replaced, attesting to fairly satisfactory performance of the barrier. The lengthwise and the maximum crosswise distance of deformity of the barrier were measured at 14.45m and 0.62m, respectively.

The collision test by a real vehicle against the guard box exhibited 6.41m/s and 8.52g for THIV and PHD, respectively. These values meet the standards satisfactorily. It also showed serious damaged units of 3 and slightly scratched units of 7, thus, indicating that the damage caused by possible flying structural components would not be enough to be concerned. Three units of 2.0m were to be replaced, a rather satisfactory result. The lengthwise and maximum crosswise deformed length were measured at 23.2m and 1.09m, respectively.

Table 5. Performance Evaluation of the Riders' Safety

Classification	THIV (≤9m/s)	PHD (≤20g)	Evaluation
Green Safety Box	5.22	5.37	Pass
Guard Box	6.41	8.52	Pass

3.2.2 The Trajectory of Test Vehicle

The movement behavior of the colliding vehicle was then analyzed and evaluated. It is stipulated that breaking away of the colliding vehicle should not occur, and the deflected angle of the vehicle should be less than 12°, which is 60% of the assumed colliding angle. There was no breaking-away observed, and the deflected angle was regarded as 0° because the colliding vehicle ran alongside the barrier. The testing vehicle stopped after 35.6m from the point of impact.

Figure 3. The testing vehicle and barrier before and after the collision test - Green Safety Box

Likewise for the guard box, the colliding vehicle did not indicate any possibility of breaking away, and the deflected angle was regarded as 0° for the same reason that it ran just alongside the barrier. The testing vehicle came to stop after running 28.7m from the impact point.

Figure 4. The testing vehicle and barrier before and after the collision test - Guard Box

Therefore, it can be seen after a comprehensive evaluation of the test results that the two types of polyethylene protective barriers satisfactorily met the performance standards for the safety of the riders and the movement behavior of the colliding vehicle.

4. CONCLUSION

"Drivers on the road have the right to be protected from the accidents." The quoted remark on the introductory section is stated emphatically again here. In order to better protect the drivers and passengers from the accidents, the building of roads, which not only anticipates drivers' mistakes (misjudgment, inattention, etc.) but also allows it to happen without serious consequences, must be provided. In other words, not only the proactive system, which anticipates drivers' mistakes to redirect their attention preventively, but also damage-minimizing system, which minimizes the damage after the accidents, must be established. The road safety facilities are the typical exemplar of this paradigm, and the subject of this research, polyethylene protective barrier, can be regarded as the typical exemplar of the road safety facilities. In this research, we have chosen the widely used polyethylene protective barrier and evaluated its safety performance on the riders and the movement behavior of the colliding vehicle.

As the conclusion, the subject of this research, two types of polyethylene protecive barriers (green safety box and guard box), met satisfactorily the safety standards set forth by the Ministry of Construction and Transportation as stipulated in the 2001 revised "Handbook of the Road Safety Facilities Installation and Maintenance- Vehicles Protection and Safety Facilities Section."

It's been our hope that the future practices involving various performance evaluations of road safety facilities, i.e. protective barriers, consider the case findings of this research in building such evaluated and verified safety facilities at appropriate capacity and places. Then, it's been our intention that we get closer to our tasks of building the safe roads, which can afford to allow the drivers' mistakes without serious consequences.

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