**For discussion**
**on 10 July 2012**

# Legislative Council Panel on Transport
# Use of Crash Cushions in Hong Kong

## Purpose

This paper gives a brief account of the installation of "crash cushions" at suitable road locations by the Highways Department (HyD) with a view to reducing the severity of injuries to drivers and passengers of errant vehicles during collisions with fixed objects on roads, thus enhancing road safety in Hong Kong.

## Background

2. There are a number of fixed objects, such as bridge columns, support gantries of directional signs and ends of barriers, etc. installed on expressways. During traffic accidents, vehicles may collide with such fixed objects, resulting in injuries to drivers and passengers. In general, corrugated beam barriers, thrie-beam barriers or concrete profile barriers are installed near the fixed objects by HyD to reduce the severity of damages to vehicles and injuries to drivers and passengers during collisions. However, depending on different road circumstances and conditions, for locations of fixed objects with high risk of head-on impact, crash cushions will be installed to strengthen the protection to the drivers and passengers concerned. (See **Figure 1**).

3. According to the "Roadside Design Guide" from the U.S.A., crash cushions have been proven to be an effective highway protective measure. The use of such cushions can effectively reduce the annual casualty rate of highway accidents.

## Operating Principles of Crash Cushions

4. The major significance of a crash cushion is its ability to absorb the kinetic energy of a vehicle during collision, thus quickly decelerating an errant vehicle to a stationary condition within a short time and distance.

"Dissipation of energy principle" or "conservation of momentum principle" is commonly employed in the design of crash cushions to reduce impact of vehicles. By "dissipation of energy principle", kinetic energy is mainly absorbed through the deformation of crash cushion components and friction generated by sliding components during collision of objects. The "conservation of momentum principle" involves the transfer and distribution of momentum from the impacting vehicles to the impacted objects.

5. Currently, most of the crash cushions on the market are patented products. Manufacturers, during the research and development stage, have completed necessary safety tests according to international standards and requirements in respect of different speeds and types of vehicles.

**Safety Requirements of Crash Cushions**

6. All approved crash cushions shall meet the safety test criteria of the National Cooperative Highway Research Program (NCHRP) Report 350 of the U.S.A., such that the cushions shall be able to withstand head-on, side-angle and reverse-angle impacts of specific speeds, types of vehicle and impact angles, and to comply with internationally recognised safety standards. In general, the crash cushions should be equipped with the following safety functions:

(i) **Non-gating function:** To avoid chain-reaction crashes by errant vehicles during traffic accidents, crash cushions have to be of a certain degree of rigidity, which means that the cushions must not allow the vehicles to pass through under head-on or sideway impacts, thus avoiding dangers to drivers of the opposite carriageway. Although non-gating function is not a basic safety requirement in some countries, it is required for the crash cushions installed in Hong Kong because of the narrow roads and congested traffic conditions;

(ii) **Redirective function:** Same as the safety requirements of typical barriers, crash cushions must redirect errant vehicles to its original lane when being impacted, so as to prevent setting off a chain reaction of collisions with other vehicles of the adjacent

carriageway. According to international standard on redirective function, crash cushions must be able to prevent errant vehicles from passing to the adjacent carriageway if the crashing angle does not exceed 20 o. Furthermore, a redirected vehicle must leave a crash cushion at an impact angle of not more than 60o;

(iii) **Anti-climb function:** Launching is likely to occur when a vehicle impacts on an object in high speed, resulting in dangers to other road users. The design of a crash cushion should therefore prevent errant vehicles from jumping and losing control during impacts. Furthermore, the height of most vehicle bumpers should also be taken into account during the design of crash cushions, such that the impacting vehicles will not vault over the cushion during an impact due to the overly low level of cushions, thus ensuring proper buffering function; and

(iv) **Durability:** Crash cushions are mostly installed on highways and are under prolonged exposure to stringent environment and weather conditions. Therefore, components of crash cushions must be suitable for the road environment in Hong Kong and be able to maintain its safety capability under high temperature and exposure to the sun as well as high humidity.

**Types of Crash Cushions Adopted in Hong Kong**

7. Two major types of crash cushions are being used in Hong Kong. One type makes use of energy absorbing cartridges (EACs) to dissipate impact energy, whilst another type achieves energy absorption through friction as the steel components interlock with one another.

8. Crash cushions with EAC design consist of crushable EACs surrounded by a framework of thrie-beam steel fender panels. When being impacted by a vehicle, the front EAC will be compressed; and energy will then be transferred to other rearward EAC through the diaphragms in between to reduce the severity of the impact. Under normal circumstances, the impacted cushions can be easily repaired to full functional state only by replacing the damaged EACs (See **Figure 2**).

9. Another type of crash cushions consists of a series of W-beam fender panels supported by diaphragms in the middle, with anchoring bolts locking the components to the ground. During impacts, the interlocking components will telescope rearward. At the same time, friction generated among the components as well as pulling force of the ground anchor can effectively stop the errant vehicles and absorb the impact energy (See **Figure 3**).

10. The two types of crash cushions mentioned above have obtained attestation of conformity to the safety test of the NCHRP Report 350 of the U.S.A. They have also fulfilled the requirements stipulated in the Transport Planning and Design Manual published by the Transport Department, and is allowed to be used on roads in Hong Kong.

**Use of Crash Cushions in Hong Kong**

11. As early as in 1998, HyD introduced the first crash cushion for trial use with a view to enhancing road safety in Hong Kong. After more than one year of observation, HyD confirmed the suitability of using crash cushion in Hong Kong in view of the smooth operation of such cushion. Subsequently, HyD installed more crash cushions at different locations in Hong Kong. According to operational experience, crash cushions have been proven to be effective in absorbing impact energy and reducing casualties during traffic accidents, and reducing the severity of injuries to drivers and passengers when vehicles crash on fixed objects. As at mid-2012, HyD has installed 173 sets of crash cushions at various locations in Hong Kong. The regional distribution is shown in the following table:

| **Region** | **Number** |
|---|---|
| Hong Kong Island | 22 |
| Kowloon | 39 |
| New Territories | 112 |
| **Total** | **173** |

12. HyD will continue to keep itself abreast of the latest technological development of crash cushions overseas, and continue to install crash cushions in Hong Kong where necessary. To enhance road

safety, HyD has planned to install approximately nine sets of crash cushions on fixed objects where necessary in Hong Kong in the coming years.

**Highways Department**
**July 2012**

**Annex**

Figure 1: Moment when crash cushion was impacted

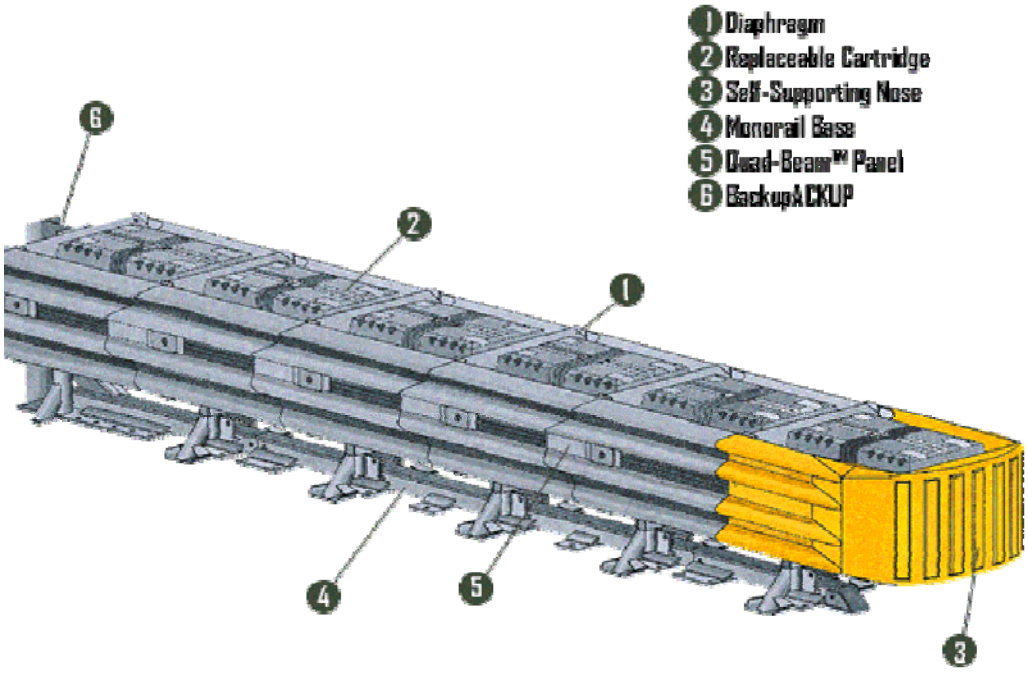


Figure 2: Crash cushion adopting EAC

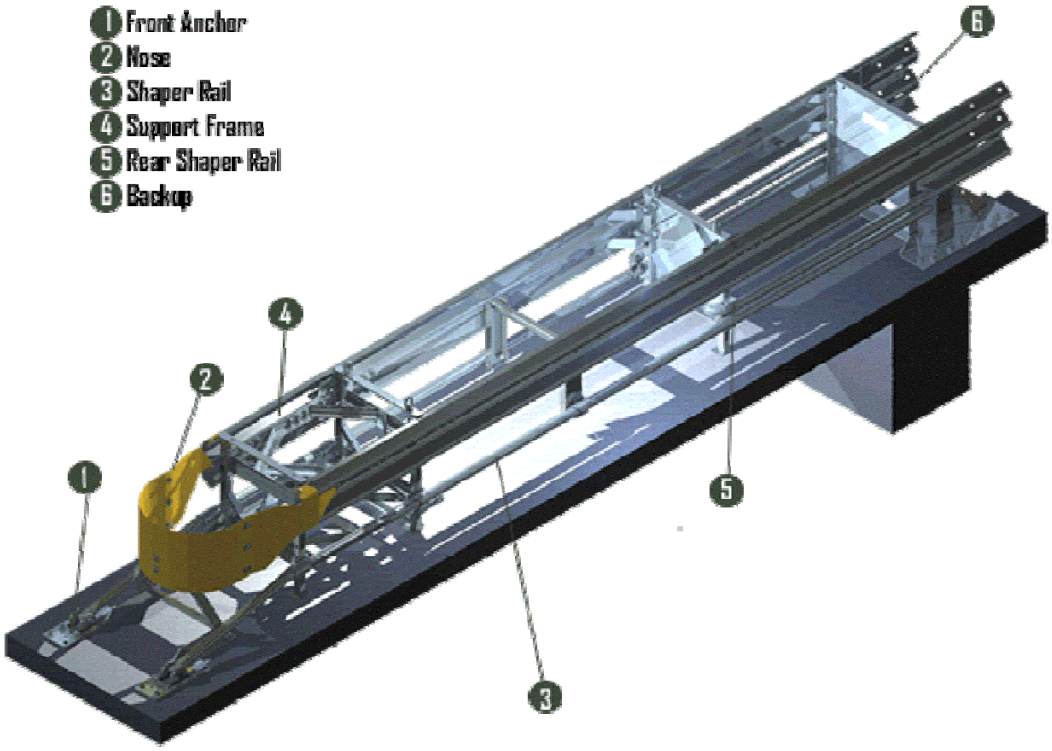


Figure 3: Crash cushion adopting friction principle