
MCX

Barrier Loads for Parking Garages

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1.0 Historical Background[1]

In the early 17th century, when old cannons were no longer bolfler

Many failures of vehicle barriers in parking structures have occurred because of inadequate detailing of reinforcement in the joints and connections. These failures offer tragic examples of vehicles that plunged several stories into the street, with occupants inside. Fig 2 shows a cast-in-place concrete barrier wall failure and subsequent car plunge. In this case, the edge of the concrete slab serves as the base of the wall, and the barrier is a wall-slab system. Test results have shown that concrete wall-slab barrier systems do not meet the IBC's minimum threshold.

Fig 2: Parking Structure in City of Los Angeles, Calif.[3]

Fig 2 shows the barrier-wall system failed at the joint between the vertical wall and the horizontal slab, without any visible da01 Tw [lab)2.20610.6 (v)-5.6 (is)-1.3 (i(a01 Tw [lab (t)-3 F)1.5 (i.3 (t)7.9L04 0 0)-6.6 (u-4.5 (10-6.6 (u-

5.0 Rational Method for Barrier Design[5]

In Structure magazine, October 2008, an algorithm based on energy principles and empirical car crash

Where m is the vehicle mass (=W/g, W being the weight, and g the acceleration due to gravity),

,v is the vehicle speed at impact, c, the vehicle crush, b the barrier deflection under impact.

Vehicular Speed

This is the most significant parameter affecting the impact force since the impact force increases with the square of the vehicular speed. This speed is a function of the vehicle acceleration.

Vehicle Crush

When a vehicle hits a barrier, parts of the vehicle deform, bends or crushes, and the vehicle length decreases. This decrease in vehicle length after an impact is termed "vehicle crush" i.e., term "c" in Equation 1. Based on the National Highway Traffic Safety Administration (NHTSA) vehicle crush distance "c" can be approximated by the equation:

ὦ ЍЂ / ۽ ....Equation (2)

Where, v is the car speed in miles per hour (mph) and "c" is the vehicle crush in feet (ft.).

Since vehicles are manufactured by many automakers and in many models with changes made almost every year, the equation may need to be updated accordingly.

Barrier Deflection

During an impact, part of the vehicle's kinetic energy is transferred to the barrier. For barriers exhibiting linear behavior, the deflection can be represented as:

ὦ ڗ / ڮ ....Equation (3)

Where, k is the barrier stiffness, and F is the impact force.

Combining equations 1, 2, and 3 and using some algebra, with g the gravity acceleration in ft/s^2, the following equation was developed:

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Where m, k, and v are in ft-lb units, g is in ft/s^2 units.

Impact Results

Fig. 4 below shows the relationship for a 4,000-pound car impacting against a barrier of various stiffnesses, k. The figure shows that the impact force decreases as the barrier i. 493.4p6 (u)2.3 (s2c66 (u)5 Tw 0.582 0-3.4

Fig 4: Vehicular Speed-Impact force plot for a 4000 lbs. vehicle with barrier stiffness, k.(NTS)

6.0 Barrier Force Determination in Other Jurisdictions

United Kingdom[6]

BS 6399: Part 1:1996

The horizontal force, F (in KN), normal to and uniformly distributed over any length of 1.5 m (4.95 ft) of a barrier for a car park, required to withstand the impact of a vehicle is given by:

$$F = \frac{mv^2}{c+b}$$

where m is the gross mass of the vehicle, (in Kg); v is the velocity of the vehicle (in m/s) normal to the barrier; c, is the deformation of the vehicle (in mm), and b, is the deflection of the barrier (in mm).

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The code also states, for car parks designed for a gross mass that exceeds 2,500kg., the actual mass is used with the same “v” and “c”. This impact force is to be applied at a height of 375mm (14.7 in.) above floor level for cases where the vehicle class does not exceed the 2,500 kg.

Europe

Eurocode BS EN 1991-1-1:2002[7]

Forces on vehicle barriers and parapets for car parks are given in Annex B of the code and is identical to the BS 6399: Part 1: 1996 given above.

EC 1 1-7, 2003. (Eurocode)[7]

Annex C of this code gives a simplified procedure for dynamic calculation of the problem. In the case of a hard impact, with the imN(m)-9.9 (t)-6 (,)6.92 (t)-6 n (a)-3.g 6 (d)-0.b (a)-3.j (t)t,e B dN em i,(r)-2.8 (d)-0.8 le rotae im(r ((a)-3.3 (r)-2.8 st)-637 e6.9 (w-46 (t)-6 (h)-05 Td(e)-6 (B)-3.5 .004 Tc 0.003 Tw 1110bllof-637 w.

hs c d(t)10.9 o d n (e)10.8(t)10.9 d v

References

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