Gentle giants?

Crash test technology offers a solution to the danger that the size and mass of heavy trucks can pose in road traffic accidents, as well as helping to protect the driver, asserts Byron Bloch

Truck drivers are vulnerable too. Collisions with other large trucks or structures such as bridge abutments need to be simulated

■ A loaded tractor-trailer in the USA may weigh 80,000 lb, which is the upper limit according to federal law. With that heavy weight comes increased braking distances, and greatly increased danger to other motorists in collision accidents.

Large trucks are involved in about 13% of all fatal vehicle crashes in the USA. Each year there are approximately 5,000 fatal crashes involving large trucks, more than 100,000 injury crashes, and about 350,000 property damage-only crashes – out of a total of about 455,000 large trucks involved in road accidents.

NHTSA data shows that more than 95% of two-vehicle crashes involving a large truck, affect either the front of the truck and/or the front of the other vehicle. The impact point in two-vehicle collisions was the truck's front in about 66%, the truck's side in about 16%, and the truck's rear in about 18% of all truck-involved crashes. Causal factors noted include speeding, a drowsy or inattentive driver, and failure to yield.

The same basic principles, used to provide a strong safety-cage construction for passenger vehicles, need to be applied to heavy trucks as well. The cab must ensure the maintenance of the 'survival space'.

Frontal impact

For cases of frontal impact, there has to be a frontal crush zone that will absorb and distribute the forces when the truck crashes head-on, whether into another truck, a large tree, or a bridge abutment. Structurally, the frontal shroud should not be shoved rearward and impinge into the front-door hinges and door-latch system. There must not be any penetration of frontal structures rearward through the windshield, which

ought to be a tri-laminate of glass-plastic-glass, retained with both adhesives and mechanical-retaining frames.

The driver and front passengers should have the protection of a seatbelt-restraint system, preferably integrated within tough seats, with strong anchorages. The driver and passengers also need the protection of airbags, designed with internal tethers to control the shape when inflated. The windshield pillars, roof siderail, instrument panel, and under-dash must all be padded with energy-absorbing foam materials.

Side impact

For side impacts, the truck must have strong frame members and rocker sections that are at the outermost periphery of the vehicle body, or if the main structural frame members are further inboard, serve as extensions. These members should be internally reinforced with a baffle plate, or with rigid-foam filling, or both. Such reinforcement measures will typically triple the compressive and bending strength of the hollow member that it is filling.

The doors should have internal reinforcement beams, with strong hinges and door-latch system. The remote rod must not be a tension-type, where flexing of the remote rod can cause the latch to open. The driver's seat needs a wrap-around contour for additional protection in side impacts.

The cab must have side-curtain airbags that inflate in side impacts, and in rollovers.

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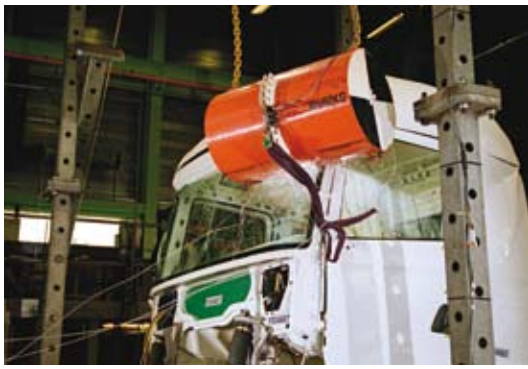


Above: A-pillar crash testing ensures safe and strong cabin design

The side windows must be of laminate glass, typically of enhanced protective-glass design that is a tri-laminate of glass-plastic-glass.

Rear impact

For cases of rear impact, the seats should be designed with high backrests and integrated head restraints to help keep the head, neck, and upper torso in safe alignment during the dynamics of a crash.

Rollover

For incidences of rollover accidents, the cab needs to incorporate a strong safety-cage construction with roof pillars, windshield header, siderails, and cross-members, all internally reinforced with baffle plates and lightweight-rigid foam, thereby increasing each member's compressive and bending strength by at least a factor of three. The roof's structural integrity should be capable of being maintained in a dynamic lateral-rollover test, at a speed of at least 50mph.

Side-curtain airbags should inflate when the sensors determine that a lateral rollover sequence is beginning, and should stay

intact for the duration of the rollover (six to 10 seconds). The side-window glass needs to be three-ply laminate, rather than tempered glass, so it will stay intact, preventing occupant ejection, acting as a life saver, and giving further support for the roof and the side-curtain airbag.

When the rollover sequence begins, the driver's and passengers' seats should automatically retract downward toward the floorpan. The seatbelt pre-tensioners should activate, giving more headroom clearance to avoid vertical loads on the occupants' heads, in cases of extensive roof crush.

Underride

All large trucks, including tractor-trailer combinations, should be equipped with underride-protection devices, or structures that will prevent passenger vehicles from crashing beneath trucks and trailers.

There are about 250 rear-underride fatalities per year in the USA alone, although the USA and EEC and have safety standards that require rear-underride guards. There are also annually 225 side-underride fatalities in the USA, indicating the hazard is substantial and equivalent for both scenarios – yet only the rear underride guards are required.

As yet there is no international regulation to mandate rear- or side-underride guards on large trucks and trailers. Consequently, South American and African nations lag behind in ensuring that such basic safety features are on their trucks and trailers.

Apart from many European nations, the USA, and Japan, many countries do not have any legal mandate to require both rear guards and side guards on all trucks and trailers. The EU regulation for side-underrun guards has been in effect since the late 1980s, but was primarily intended for protecting pedestrians and cyclists from getting trapped and crushed by rear wheels.

However, these European side guards have also been shown to be effective in helping deflect passenger cars, but they need to be made even stronger, such as the full-panel integrated side guards on the Krone Safeliner trucks, which provide underride protection around the entire truck.

Mismatch

In truck-versus-car collisions, severe injuries and fatalities occur 98% of the time to the driver and passengers in cars, SUVs, vans, and pickups. This is a serious vehicle-mismatch issue that needs dealing with now, as the quantity of large trucks continues to increase within the traffic mix. Frequently, the smaller and lighter passenger vehicle (2,800-5,000 lb) is completely demolished by the larger and heavier truck (20,000-80,000 lb).

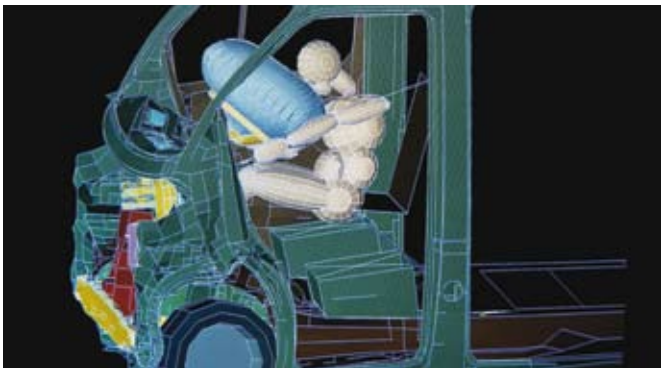
Although smaller vehicles are relatively strong and equipped with airbags and other safety features, the huge mass and size of a heavy truck, often fully loaded, will overwhelm the ability of any passenger vehicles to withstand the impact. The truck's much-greater size and weight, that simply overwhelms the smaller and lighter cars, vans and SUVs, must not be an insurmountable problem. Creative measures have to be taken to help mitigate and reduce the mismatch hazard. The frontal design and structures of the large truck, should not override smaller vehicles. The frontal portions of the truck should extend downward sufficiently to engage a smaller vehicle, such as a car, requiring engagement at 16-18in height above ground.

The frontal structures could be designed and constructed to minimize impact damage and abrupt deceleration, by use of energy-absorbing cushion structures and devices, such as hollow sections that are filled with energy-absorbing, rigid-but-lightweight foam and/or energy-absorbing Belleville spring washers, stacked within pistons. When a crash is imminent, as detected by forward-looking radar-type sensors and computer algorithms, the truck could deploy a shaped airbag presenting a large rectangular barrier (with internal compartmentalization for energy-absorption in progressive stages) enabling a longer deceleration ride-down stroke by the other impacting vehicle. ■

Truck-into-truck collision

At the intersection of two roads, a tractor truck A without any trailer crashed into the side of another tractor-trailer combination, truck B. In the collision, the driver's door of tractor A separated from the cab and the seatbelted driver was forcibly ejected out onto the highway, and suffered fatal head injuries. In my analysis, I pointed out why tractor A was unreasonably dangerous and defectively designed, and was well below the state-of-the-art.

The defective design included the lack of effective front crush zone structures. It had only a molded fiberglass plastic shell that disintegrated, opening the way for excessive damage to the poorly-attached door hinge pillar. This now tore away from the cab body, causing the driver's door to separate from the cab body. The door-latch system remote rod easily flexed and foreshortened, causing the latch to pop open. The seatbelt, with its unsafe, protruding release button was actuated in the accident. There was no driver's airbag to help prevent the driver from going diagonally forward, and being ejected through the door opening.



Left: Simulated and physical crash tests can ensure the cabin protects the driver in rollover accidents