Identification of new loadcases from the accident research

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Abstract

India is one of the leading countries reporting highest road accidents & related injuries. TMARG (Tata Motors Accident Research Group) has been recording crashes in association with M/s. Lokamanya Medical Foundation since 2011 with M/s, Amandeep Hospitals since Aug 2013.

This study has highlighted some accident types not discussed extensively in literature. Trucks to Truck impacts – Cabin interaction with overhanging loadbody structures and Offset underside impacts for passenger vehicles are seen in significant numbers. The paper discusses these in more detail including severity.

Keywords

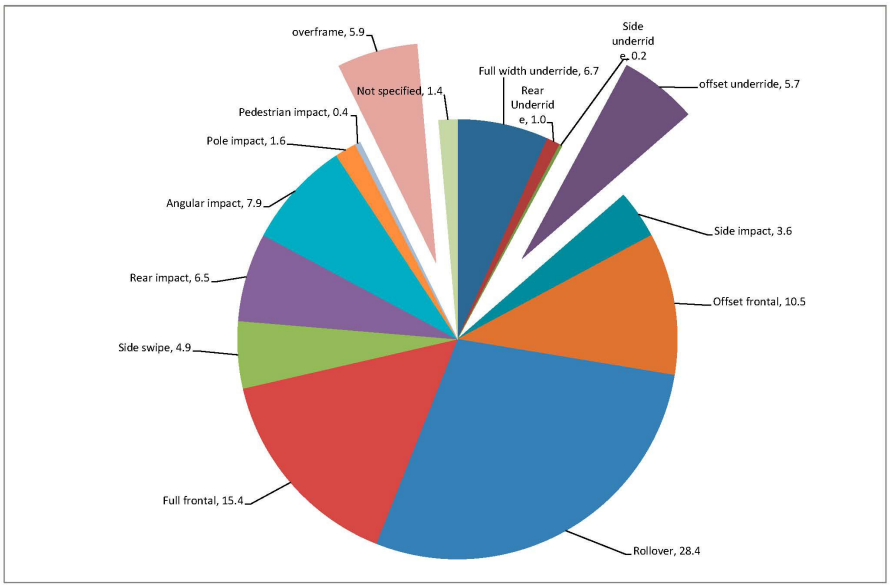
- TMARG = Tata Motors Accident Research Group
- Underride
- Overframe
- RUPD = Rear Underrun Protection Devices
- HGV = heavy goods vehicle

INTRODUCTION

Tata Motors Accident Research Group (TMARG) is recording the accident data on Mumbai Pune expressway (MPE) since 2010 in assoiciation with M/s. Lokmanya Medical Foundation, Nigdi. In Aug 2013, TMARG expanded the accident data collection domain to Amritsar Ferozpur road (AFZ) in North India in association with M/s. Amandeep Hospitals, Amritsar.

Mumbai Pune expressway is a multilane highway with traffic divided by median lane and without any crossings. It is a toll road & its

Accidents recorded by TMARG during 2010-2013



length is 94 km. Amritsar Ferozpur road is a 2 lane undivided road with crossings (a typical of rural road) & is 120km long.
This study has identified 13 different loadcases. (Refer fig …). It contained conventional (i.e. offset frontal impacts, rollovers, full frontal imapcts) as well as non conventional type of accidents. Overframe Impacts for goods carrier vehicles & Offset Underride impacts for cars were seen to be unconventional loadcases. As crash safety engineer it was important to analyse the filed data, transform it as engineering challenge & work out appropriate interventions to reduce its impact on society. This was considered to be an important contribution to the UN initiative of "Global Decade of Actions".
This paper describes the analysis of these new loadscases on road accidents and discussion about possible interventions.

There are similarities in both these types as follows –

- the long members of the bullet vehicle does not participate in the energy absorption. The overfame impact is like underride collisions of passenger cars. The passenger compartment of bullet vehicle is loaded by loadbody of target vehicle reducing the survival space critically,
- in both types, the target vehicle is a heavy goods vehicle (HGV),
- in both types the necessary intervention is required for good carrier only,

OVERFRAME IMPACTS

As seen in the fig.. This is a very grievous type accidents for HGV when one HGV impacts another HGV. In these accidents the chassis frame of the HGV does not participate in the energy absorption and the impact energy is dissipated in deformation of the passenger cabin of the bullet HGV.

This type of accident is similar to the underride crashes of cars. However there is no "underriding" of any bodyshell because of which it can not be classified as "underride". Therefore TMARG had termed it as "Overframe" accident.

The accident statistics have shown total 3 sub types of the accident scenario as follows :

- full width overframe impacts,
- offset overframe impacts – this has more reduction in survival space and cab mount failures are quite frequent. This is a scene of failed attempt to avoid accident.
- ultra overframe impact – in this the impact is oriented above the beltline. This sub type forms a minority of the accidents,

Full width

Offset

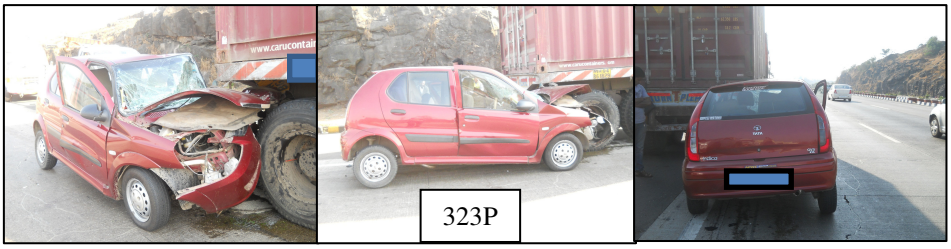
Ultra

The statistics of this accident type is –

- 5.9% were “overframe” type of accidents. Out of which 41% were of full width type & offset type each. The Ultra overframe type were 19%,
- 24% of the overframe accidents were fatal (of that 22% were full width overframe, 44% were ultra overframe & 66% were offset overframe).

OFFSET UNDERRIDE CRASH TESTS

This loadcase was created out of the total underride crash tests because of its severity & challenges involved in the interventions. When a small vehicle impacts a heavy vehicle wherein part width of smaller vehicle & of heavy vehicle is involved in the energy absorptions.



The statistics of this type of accidents is as follows :

- 11.5% accidents were reported to be of underride. Half of these accidents had the heavy vehicle fitted with rear underrun protection devices (RUPD),
- 5.2% of them were of full width underride & 6.3% were of offset underride collisions.
- 14.6% underride accidents were fatal with 3:4 distribution between offset underride & full with underride.
- 17.6% persons were fatally injured in underride accidents. 7.4% fatalities were in full width underride & 10.2% fatalities were in offset underride type accidents,

Discussions

Both these crash cases were studied and following are details of the analysis -

Overframe impacts -

The loadcase is similar to ECE R29 pendulum impact test however it is more severe for the following reasons –

- The impact energies are quite high,
- Widthwise or heightwise offsets results into load concentration leading to severe deformation of the passenger cabins and reduction in survival space,

Some of the key observations on this type of accidents are –

- Provision of RUPD (on bullet vehicle) and FUPD (on target vehicle) does not prevent these accidents. A probable reason could be the difference in level of UPD interaction and centre of gravity (COG) of the vehicle. In fact the inertia forces & the UPD reaction would produce a couple that will promote the interaction of the passenger cabin as shown.

- Breakage of cab mounts :
    - The front cab mounts are under higher stresses & in many cases they were found broken. However breaking of cab mounts found to be desirable as it retains the survival space (provided there is adequate space for movement of the cab).
    - In case of offset type of overframe impacts, the cab is under rotational moments which also lead to breakage of cab mounts.
    - Subsequent to the front cab mount failure, the cab tilts about the rear mounts. Such tilting helps to reduce the cab deformations & thus improves survival space.
    - When can tilts, there is a dissociation of steering linkage (either due to breakage or due to disconnect the spline joint) which is also desirable as it prevents the steering wheel intrusion.
- When the cab deforms, the A pillars are under higher stresses & in some extreme cases they have lost their integrity with the roof structure.

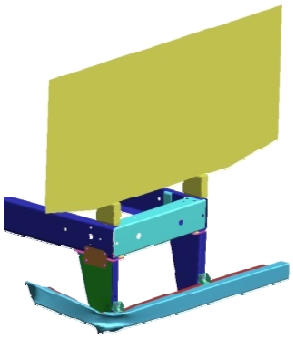
In a possible solution, there is a need to provide protective structure at the level of COG of bullet vehicle which would engage with impacting structure & prevent an undesirable cabin loads. However it appears to be unpractical. Therefore a more emphasis to “accident avoidance” seems to be the best possible intervention

Offset underride impacts -

The data show that the RUPDs are effective in mitigating the full width underride collisions, however they are not effective in offset underride crash tests. The following accidents show that the overhanging portion of the RUPD bends under impact & does not avoid

underride. The severity is more with vehicles with shorter bonnets/flat front/forward control vehicles.

The same situation was reproduced in CAE environment & the behavior was confirmed :

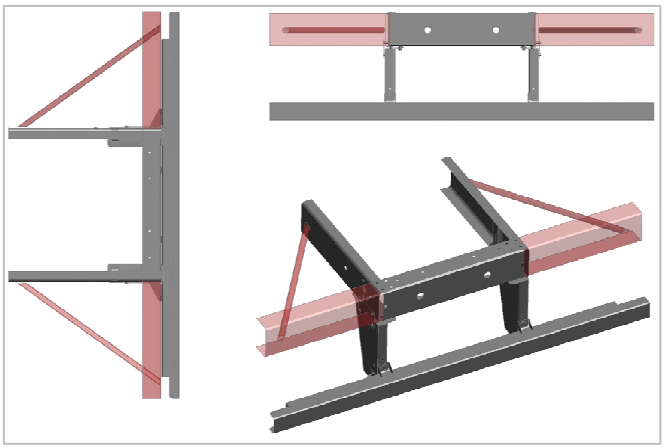


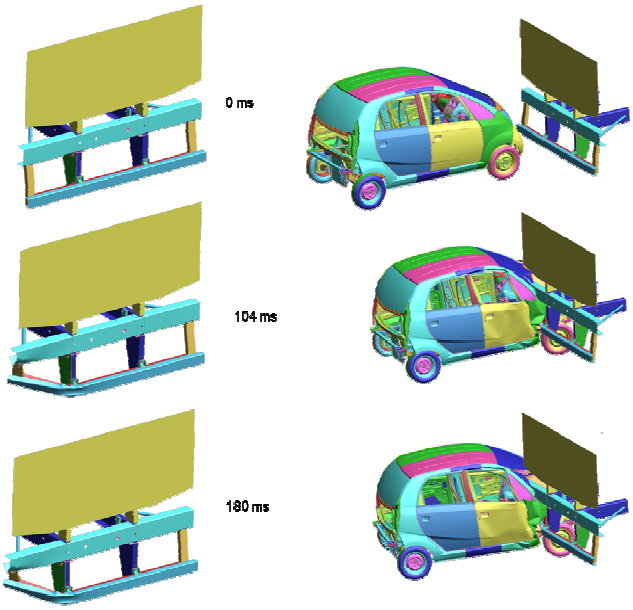
the generalized sequence of this type of accident is as follows :

- The smaller vehicle structure hits the end of the RUPD ,
- Bends it & continues to move ahead,
- The loadbody installed on HGV interacts with either of the A pillar and/or the windshield of the small vehicle. At times the loadbody interacts with the roof structure as well. This is particularly observed when the ground clearance of the bottom end of the chassis frame is ≥1000mm.
- The smaller vehicle comes to halt when its structure (A pillar, roof etc.) are adequately deformed & the kinetic energy is completely absorbed.

Increasing strength of the RUPD is quite challenging & adds up excessive material since supporting the unsupported end is a challenge and there is no vehicle structure available which would provide the additional strength.

An alternate solution was worked out by extending the end cross member of the cassis frame of a goods carrier as shown[1]. It “wedges” the sloping bonnet & stop the smaller vehicle from underrunning. The following sketches explain the same.





[1] This concept has been applied for patent vide Indian Patent Application 610/Mum/2014.

CONCLUSIONS

- Accident research provides inputs which are beyond any conventional safety strategies.
- Overframe impacts for good carrier & offset underride impacts for passenger cars are important loadcases on Indian roads that require attention for improving the road traffic injuries (RTI),

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