Effect of New Axle Load Regulation on Commercial Vehicle Occupant Safety

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Abstract
Commercial vehicle industry is the wheel of Indian economy and gives the maximum support to our GDP. Although safety of Indian truck drivers had been the least considered parameter till the AIS-029 regulation has forced in. with the norm came into picture OEM needs to ensure the measures for the safety of the drivers during accidents. This regulation talks about the cabin strength to absorb energy generated during accident due to impact and same depends upon vehicle gross vehicle weight (GVW), front axle weight (FAW) and vehicle payload. All the OEMs have ensured truck driver or truck occupants safety by means of cabin strength and safety measures during the regulation implementation. Now with the new vehicle weight norm, again the safety is in doubt. Government has implemented the regulation without mentioning anything about cabin crash and occupant safety. Even existing vehicles are also allowed to load up to the new maximum limit. This paper reviews in detail, the effect of new vehicle load regulation on cabin crash safety test norms and occupant safety and also recommends the methodology to save both time and cost involved in new cabin development by means of current design optimization.
Keywords: Truck occupant safety, axle load regulation, cabin crash test norm, effect of norm

1. Introduction

AIS-029 is the regulation which talks about commercial vehicle occupant safety by means of energy absorption by the cabin structure so that incase of accident, no cabin part will be intruded in the occupants body parts due to impact or crush. The parameters and specification has been defined already in the regulation mentioned and vehicle has to pass same to get certification to be sold in market. With new increased axle load and thus vehicle load notification, current design of cabin may need to be relooked. The objective of this paper is to study the effect of new axle load norm and methodology recommendation to reduce the effect so as to save the time and cost to OEMs.

1.1 Increased Axle load Notification

Overall vehicle GVW has been increased by approx 13~20% depending on the vehicle specification and number of axles in it. This increase in vehicle allowable weight will change the safety parameters of current cabins. As the weight increment is applicable for current vehicles also and vehicle manufacturer can’t make a new product just due to this regulation, requirement was to have a midway solution.

Table 1 Maximum Safe Axle Weight before and after new notification

Vehicle weight before and after new regulation (for 4X2 Truck)			
	Old Regulation	New Regulation	% load increment
Front axle load	6000 Kgs	7500 Kgs	25%
GVW (Gross vehicle weight)	16200 Kgs	19000 Kgs	17%
Payload	10000 Kgs	13000 Kgs	30%

In this paper we are trying to evaluate the impact of this mass increase on cabin strength and occupant safety by the means of case study. Same will be discussed in detail in next sections.

2. Literature Survey

As of now the effect of increased axle load and thus vehicle load has not been discussed or worked upon in any OEM or in any forum, hence getting the reference was found to be difficult but still we took certain references to study the numerical calculations of energy produced during an accident by means of vehicle load/ axle load and vehicle speed.

AIS-029 [1] has been studied detail to understand the safety norm and requirement which talks about 3 types of crash test details has been shown below

Frontal Crash Test: In This test vehicle is held firmly on ground with the help of rope and a pendulum hits the Frontal panel at particular height (more details are given below). The energy impacted by this pendulum should be 45KJ if vehicle GVW is 7000kg or more and 30 Kilo Joule if vehicle GVW (Gross vehicle weight) is less than 7000 Kg. After completion of test a 95 percentile Dummy has been put on Driver's seat and should be observed for any cab interior part intrusion in the dummy, if we could not able to put the dummy due to deformation of cab structure or steering wheel movement then we say that vehicle is not qualified in the test else it is said to be passed in frontal impact test.

Roof Crush Test: Roof of the cab should able to withstand a load equal to the front axle load which should be not more than 10T, load has been applied very slowly that is quasistatically and after the test cab deformation should be limited so as not to touch the dummy, roof deformation should not touch driver's head.

Rear Impact Test: During various study as explained previously it has been observed that injuries during hitting from rear side of the cab is also considerably larger, to safeguard occupant at rear crash event this test has been introduced. In fact it is not an impact test but a quasistatic test where a load equal to 20% of Vehicle Payload is imposed at rear cab structure and after the test there should not be any intrusion in the dummy.

Furthermore papers of different authors have been studied to understand the other parts of cabin which can be severe during accidents. Clark (2005)[2] Identified that steering wheel is the most common part which is responsible for intrusion; other major parts are Dash Board and foot leg area. It has been also observed that 2% of cases the retention system itself was the cause of injury. It has also observed that in majority of cases seat belt either not provided or if provided also driver is not using it.

Merger in 2005 [3] done various physical tests regarding crash behavior of frontal cab structure and identified ways to improve it. He also put various shapes of sheet metal structure so that energy transfer to occupant area is bare minimum.

Various educational materials through Google [4] have been studied to understand the impact energy calculation and then also the way to simulate the effect virtually.

M. J. Bayarri,[5] has presented a very useful paper on Predicting Vehicle Crashworthiness, Validation of Computer Models for Functional and Hierarchical Data in 2009. In this paper he has presented CRASH computer model simulates the effect of a vehicle colliding against different barrier types. It is of great significance in various aspects of vehicle design, such as the setting of timing of air bag releases. The aim of this study is to address the difficulty of validating the computer model for such design goals, based on utilizing computer model runs and experimental data from real crashes.

3. Numerical Analysis

The kinetic energy of the vehicle must be dissipated to stop it and this energy has to be absorbed by the cabin structure. The Kinetic energy dissipated during frontal crash before and after the new regulation implementation has been evaluated here

Here we have taken a case study of 16 tonner vehicle wherein the crash is happening at the speed of 20KMPH.

So the old vehicles GVW was 16 ton i.e. 16000Kg and after new regulation came into force the vehicle GVW may rise up to 19ton i.e. 19000 Kg

Hence the kinetic energy is given by $K.E. = 0.5 * M * v^2$

$KE_{old} = 0.5*16000*[20(0.28)]^2 = 250.88$ KJ

$KE_{new} = 0.5*19000*[20(0.28)]^2 = 297.92$ KJ

It's very clear from the above calculation itself that the impact energy during crash will be increased by approx 19%.

Similarly the effect on rollover crush i.e. roof crush test and rear impact test will also be significantly increased. Fig 1 shows the simulation results.

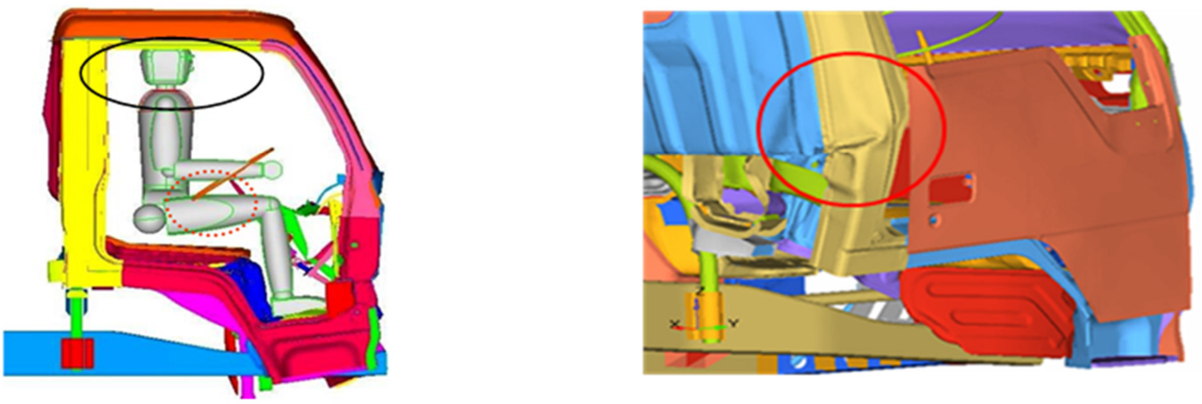

Fig 1 Cabin part intrusion in human dummy due to frontal impact, roof crash and deformation of cabin due to rear impact test

All these effects has been checked in virtual simulation using software Ls-Dyna and observations of the same has been tabulated below

AIS 029 TEST	Simulation results		Remarks
	Old Vehicle/axle load	New vehicle/axle load	Intrusion in human dummy observed in all the 3 tests after applying increased loads
Frontal impact test	Min 38mm	0mm – Intrusion on leg and torso	
Roof crush test	Min 69mm	0mm – intrusion on head	
Rear impact test	Min 38mm	0mm – seat dislocated	

The observations has provided the insights that the increased load will definitely going to effect the vehicle occupant safety and same needs to be worked out very seriously by all the OEMs.

4. Results and Conclusion

We have evaluated the effect of increased vehicle/axle load on crash safety. The simulation result shows it very clearly that the increment in axle load will hamper the occupant safety. Even if it will enhance the profitability of the vehicle owner and also the economical growth of the country still same should not be done by compromising the human safety.

OEMs/ vehicle manufacturers should immediately worked upon the solution to cater the safety norms. Although with reference to the results, it seems that the cabin needs to undergo a severe surgery to meet the safety regulation that may lead to a new cabin design which may not be very feasible for the OEMs to do at this point of time as most of them have recently developed and launched their new range of products with new cabin. Hence the optimization of current cabin is the only solution remains. And optimization also will need huge time and cost of investment in design, development and validation.

By using virtual simulation software, time and cost can be saved and an optimum solution can be obtained which will need very less modification in current cabin.

5. Future scope

Current cabin design optimization by using virtual analysis tool to be done and recertification can be obtained on the existing cabins also. If government came up with safety norms applicability on existing field vehicles also then service kit solution can also be provided.

Acknowledgement

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