



Ergonomic Design of Vehicle to Improve Highway Safety

Er. C S Verma

(CHHAVI SHANKER VERMA)

F.I.E., Ex General Manger, National Highway Authority of India (NHAI)

Highway traffic accidents are the leading cause of deaths in the world especially for the age group of 15 to 49 years where it may be termed as the principal cause of death in this age group. During the year ending 2021, in India, the total fatalities due to road accidents were near about 1,54,000 in numbers and it is on increasing trend which is a serious concern of policy makers in our governments. In this very year Indian highway has witnessed, 30.6% were grievous injury accidents and in 29% of accidents, people sustained minor injuries.

It has statistically been observed that pedestrians, cyclist and motorcyclists' deaths on highways are more than 68 percent of the total fatalities. A study of traffic accident pattern in Chhattisgarh State shows that death of more than 40 percent motorcyclists are caused due to crashes either with trucks or tractors and a figure not less than 75 percent of pedestrian and cyclist deaths are caused due to crashes with either truck or tractor or due to erroneous driven motorcycles. Trucks and buses are causing fatal crashes on roads and are responsible for more than 70 percent of fatal crashes.

It is pertinent to mention here that in most of the cases, the accident happens due to non-adherence to the safety laws/parameters by the road users and it can be termed as Human error or human factor. There are three factors which have been found contributing to road accidents and these are human factors, road environment factors and the vehicle factors. It is well known that the human factors (human error) are the largest responsible factor for the road accidents, but even then, the vehicle factors cannot be taken lightly as there has been exponential increase in number of all types of vehicles on the road. The size and weight of the vehicles are also increasing day by day. At the same time, we are witnessing changing population of drivers with older drivers having an edge in numbers. It has been observed by survey for the road in Latin American countries that more than 8-10 percent accidents occur due this vehicle factor alone.

Several active safety systems are already there which is capable to alert the driver by forward collision warning signal and also helps the driver in case of a vehicle approaching a blind spot during its lane changing maneuver. To make the driver enable to comprehend these warning signals effectively in time and to enhance the safety, a thoughtful driver vehicle interface system

design is desirable. The vehicles are dependent on the human being for its control & operation meaning thereby that a system comprising the vehicle and the human is formed during the vehicle driving. Therefore, to achieve qualitative as well as quantitative performance during vehicle driving on the road, both element of the system should work in harmony and to meet this, the design of the vehicle should conform to vehicle ergonomic design criteria. The compliance of these criteria for ergonomic design of vehicle are important to avoid serious and fatal accidents on the road and loss of human lives.

The basic aim of the ergonomics is to create a proper driver vehicle interface design so that the designed equipment will facilitate the proper and timely interaction between the driver and the vehicle resulting into safety of the driver, occupants & other road users. The parameters which need to be taken care for vehicle design are speed of the vehicle; vehicle capacity and its size. Vehicle should be designed for achieving a close link between the biological and psychological behaviour of the driver and the designed physical of the vehicle so as that they can perform perfectly even in most adverse conditions.

The term Ergonomics is a combination of two Greek words; Ergo and Nomous and the word ergonomics means the natural law of doing work. Ergonomics ensures a cohesive relation between the people, their action, their interaction with the object and the environment. The Ergonomic design of vehicle consists of anthropotechnic design, interface design and the design of driver working environment. The essential parameters for ensuring that the driver may feel comfortable in adjusting posture on his driving seat after entering the vehicle are; provision of proper back support, hip lift, proper eye level, proper back lean and proper headrest position and these can be termed as elements of driver ergonomics.

The International Organization of Motor Vehicle Manufacturers (OICA) is the official designated representative at the United Nations for almost all the vehicle manufacturers in the world. OICA says that vehicle requirements vary by region and so the requirements most suitable to a given territory depending upon the people needs in that area has to be studied first. After this, the vehicle requirements and its design should be based on the Global Technical regulations under UN 1988 agreement.

The safety of a vehicle and its occupants are of prime importance and care should be taken to comply various norms of safety such as for active safety, for driving safety, for safety during operation which is inclusive of perceptibility safety, for passive safety, and for exterior & interior safety. The structural integrity of the vehicle body and its deformation behaviour during side, rear or frontal impact should be studied.

Active safety system are systems that help the driver in controlling the vehicle in case of accident and are automated for countering the human error. This system is a preventive approach which helps on the road to avoid the accidents. Antilock Braking System (ABS) and Electronic Stability Control (ESC) and Traction control system are some of the examples of active safety system. In absence of ABS the vehicle skids in case of emergency braking situations and the wheel locks & driving stability are lost.

In case of unavoidable crash, the passive safety system helps to protect from injuries to the driver and the occupants in the vehicle. The most glaring example of passive safety system is airbags which helps to protect the occupants from serious or grievous injuries. Other features of the passive safety are seat belts and roll over bars.

Smart airbags, Crash Sensor System, Breakaway engine, rollover protection bar, engine immobilizer are the salient safety elements of a smart & safe LMV.

For controlling the chassis effectively during motion, Anti-lock braking, Traction control system, electronic damping control and Power assisted steering systems are employed. The braking system efficiency is dependent on available amount of traction at the tyre-road interface. The effectiveness of braking differs as it is different in case of slippery and wet roads than that in case of dry roads. Braking behaviour of the vehicle is different in case of laden vehicles than that in case of unladen vehicles. Straight line braking and braking on a curvature differs. Speed sensors and brake force modulators are the part of electronic brake force distribution systems. The factors like wheelbase, vehicle mass and height of center of gravity in case of laden or unladen vehicle, maximum allowable speed of the vehicle, its tyre & rim configuration and braking standards should be studied before the design of the vehicle. It is pertinent to mention here that vehicles brakes, steering and suspension systems are crash avoidance system especially in case of potholes and surface irregularities on the road.

There exists various UN regulation for vehicle safety standards. UN regulations 94 & 95 stipulates the standards for frontal and side impact protection and about vehicle crashworthiness in crash test. The regulation 140 of UN stipulates about the electronic stability control system which includes ABS. For two wheelers such as for motorcycles, the UN regulation 78 is there which explains the antilock braking and control of skidding. To prevent or to reduce the severe injuries to pedestrians, UN regulation 127 is there.

Here it is again important to mention that by installation of ABS in the motorcycles & in the car, loss of steering control due to skidding can be prevented. It also helps in eliminating rotation and shorter stopping distance is achieved. ESC (electronic stability control) helps in controlling the vehicle as it facilitates to monitor the speed of all the wheels individually and brakes can be applied to individual wheel. It has been found in survey in the Latin American countries that ABS and ESC has been useful in averting accident death rates by approximately 9 percent and 20 percent respectively. Motorcycle with ABS would add safety to the motorcyclist in case of accident and fatalities would be substantially lower in case of motorcycles having ABS. Similarly, by using ABS in four wheelers, the pedestrian death rate can be controlled. To minimize the adverse effect of side impact, side airbags are desirable. Side Structures can be strengthened by use of energy absorbing padding cushion.

Now comes the question of evaluation of vehicle safety i.e. whether their safety design is complying with the international standards or not. Crash test methods are employed to check the vehicle safety design standards in terms of the protection of the occupants. Vehicle crashworthiness is ensured so that risk of severe or fatal injury to the occupants are minimized. At the global scenario, U.S. National Highway Safety Administration (NHTSA) and Economic Commission of Europe, China etc. have developed their standards for vehicle safety regulations. For evaluation of safety performance of car in India by assigning star ratings, government of India has introduced new car assessment program known as Bharat NCAP. It has 16 points for front impact test and 16 points for side impact test. The testing speeds in the Bharat NCAP protocol for various impact assessment categories are lower than in the Global NCAP. The safety regulations and rating systems in various parts of the world lack harmony.

Based on research, it has been found that the current vehicle safety standards including rating systems in the U.S. regulations are not able to protect the people outside the cars especially in the current situation of ever-growing multimodal vehicular traffic on the road.

Due to ever increasing size and weight of vehicles, the fatalities of the pedestrians and the cyclist have increased to an alarming level. In this year 2023, NHTSA (National Highway Traffic Safety Administration) issued proposed regulations that Cars, SUVs and light duty trucks are required to be fitted with Automatic Emergency Braking (AEB) so that pedestrian fatalities may be contained.

References: -

Road accidents in India-TRW of MoRT&H;
TRIP Centre, IIT Delhi- Road Safety in India, Status report 2021;
Effects of vehicle safety design on road traffic deaths-----in the Latin American region; a modelling study-
Kavi Bhalla;
Ergonomics in the Automotive Design Process—Vivek D. Bhise;
An introduction to Modern Vehicle Design—Julian Happian Smith;
National Association of City Transformation Officials-NACTO-Vehicle Design

