


Bisht, L.S. and Tiwari, G., 2021. 3E. 001 Assessing the rear-end crashes characteristics on a rural multilane expressway in India. Injury Prevention, 27(2).


This book is about understanding the principles of safety science, the legal aspects of safety, management of life and implementing safety improvement techniques. The cost to the country, communities, and victims’ families are enormous, but the stories of injured individuals concerned are often unspoken. We see that we should investigate accidents, audit safety practices, and measure safety performance. Anything not measured cannot be improved. As a result, evaluating safety risks and identifying hazards take primary importance. Without a shade of doubt, each and every stakeholder in the construction process has a major role in ensuring safety at construction sites.

This book is further designed as a textbook at the senior undergraduate level as well as at the post-graduate level for those studying construction engineering management or infrastructure management. The aim of this book is that this book will be of service to the existing and newly emerging construction management programs, especially in India. The topics covered are comprehensive and particularly pertinent to what construction and safety managers encounter in their daily duties.

These programmes are essentially meant to arrest the triggering events that cause accidents or are known to have caused accidents in the past. For example, it is known that inadequacies in design can lead to accidents. To prevent such accidents from arising out of a design error, organizations have a programme that is now commonly known as preventive training through design (PTD).

‘Safe’ design is a process that can be adopted as a strategy for any organization. Christensen and Manuele (1999) define safe design as follows: “The integration of hazard identification and risk assessment methods early in the design process to eliminate or minimize the risks of injury throughout the life of the product being designed. It encompasses all design including facilities, hardware, systems, equipment, products, materials, energy controls, layout, and configuration.”

It is not advisable to assume that a worker knows how to execute his job safely and productively. Before assigning a job to any new worker, necessary training and discussions should be provided by the safety supervisor. A ‘new worker’ means a worker is new to a particular site or job even if he has experience at other sites and jobs. Before the commencement of recent construction activity, introducing the new equipment, tool, material, and related training should be provided to the crew. Qualified and well-trained workers are assets to any construction organization as their work is done safely, cost-effectively, and efficiently.

Many construction companies organize training programmes for workers only for fulfilling the statutory and contractual requirements. However, numerous construction companies have adopted training as a genuine part of their safety policy and programme. There should be a specific training department or section that can decide the training modules for employees working at various levels in the organization, workers at sites, sub-contractors, vendors, and agencies. The goal of training should be ascertained. The training an be organized at the site or in a room as per the needs. Toolbox meetings provide the necessary daily communication between workers and supervisors regarding safety. As a result, workers are made aware of existing hazards and the required preventive measures to control risks and to protect themselves at their workplace. And, training to workers and employees confirms the necessary information about the job, associated hazards, and their control measures. However, the training should be effective and fulfill its objectives.

The practice of hazard recognition must be implemented at the project site. Workers and employees should be encouraged to use the JHA, TDA and other methods effectively to identify and control any hazard. In addition, SOPs guide workers, operators, and employees to execute the work and safety practices, ensure machinery is correctly and safely. It helps to check hazards to prevent accidents. Further, the ‘permit-to-work’ must be considered essential for contractors, especially before starting construction of high-risk activities such as entry into confined spaces, demolition, or underground work at the project site. They ensure whether the contractor and the equipment are necessary to apply in their practice.

The highest safety in projects can be achieved by implementing prevention programmes from time to time. Demolition operations are one of the most hazardous activities in the construction sector. This is because improper handling of demolition activities can naturally cause accidents and injuries during the demolition of the structure. Lack of safety training and proper safety planning is the most common reason. However, accidents can be prevented by proper safety planning of demolition operations in construction sites, which includes identifying hazards, pre-demolition investigation, review of the demolition method, risk assessment, and post-demolition planning. In other words, the planning must span the entire life-cycle of the demolition process. In addition, planning for construction and demolition of structures should emphasize the protection of workers engaged in demolition operations, pedestrian safety, management of surrounding traffic, environment control, and understanding the properties, characteristics, and physical features of a demolition site.
Motorised traffic is a strong contributor to low quality of life for many people in our cities. Volumes are big and speeds are often very high. Even if safety is of prime concern in every country I dare to say that the issue to-day in developed countries has shifted from being a question about survival of the pedestrian to survival of the city, while in developing countries the question is one of pedestrian survival. One main ingredient in survival of the city is to produce liveable conditions for pedestrians, which of course includes the elimination of the physical threat. So, even though the perspective is different the main question to-day, as it "always" has been, is how to reach decent living conditions for pedestrians so that they can be safe and also feeling safe, being comfortable enough, not having to live with noise, emissions, etc. "Business-as-usual" is no longer an option. Current approaches to road safety in the world’s poorest countries are both indefensible and unsustainable. They are indefensible because they will result in millions of deaths and injuries that should be prevented through affordable investments. And they are unsustainable because no country can afford the economic and social costs associated with current speeds – that these costs are hidden from view does not detract from their devastating effects.

The vulnerability of pedestrians, cyclists and motor cyclists is finally taken seriously by the “World Convolvers” (Ishaque and Noland 2006). However that only solved parts of the problem. The other – more critical – question was how to safeguard pedestrians when crossing streets. The way to solve the problem was either to separate different road users by the help of traffic signals, or to separate pedestrians physically with tunnels/bridges. Both these solutions were tried in London in the 1870, but were turned down almost immediately and were not reconsidered until after several decades. The reason was that pedestrians were offered two long waiting times in the signal (30 seconds green on a 5 minutes) and because of that these pedestrians would not accept them and they would therefore jay walk. In a similar way tunnels/foot bridges were considered as useless because people did not use the tunnel/bridge because of the detours they had to make. A study in Delhi just emphasises the problem. A majority of pedestrian underpasses constructed recently in Delhi are not being used for their intended purpose. General observation and a pilot survey of some underpasses in Delhi indicate that pedestrians find an alternative surface route to cross the road.

Speed reducing measures that actually lower speeds is definitely the most effective solution. Meta results from Elvik et al (2010-2) clearly show this. My interpretation of the present situation is that this is a way of avoiding the critical question “How to introduce efficient speed reducing measures”, with the anticipation that this will be very unpopular. One more strong indication of the avoidance behaviour to a new strategy in Sweden, is to introduce new speed limit. For example by the year 2030, 40 and 50 km/h is added on to the former ones, 30 and 50 km/h. One of the philosophies behind this is the idea that the speed limits should better reflect the expectations of drivers. So therefore the goal is both to reduce speeds and to improve the acceptance by car drivers. In this perspective the results are not very encouraging. If the speed limit was reduced 10 km/h – from e.g. 50 to 40 km/h – the actual mean speeds were only reduced by a bit more than 2 km/h (Hyden et al 2008). This resulted in severe reductions of the compliance rate, in the case of 50 to 40 km/h from 80% compliance from 50 km/h. High speeds were reduced a little the change clearly demonstrated that drivers did not take the change "seriously enough", as the compliance rate went down.

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First attempt was to give separate space for the pedestrians, thus building foot paths (Ishaque and Noland 2006). However the only solved parts of the problem. The other – more critical – question was how to safeguard pedestrians when crossing streets. The way to solve the problem was either to separate different road users by the help of traffic signals, or to separate pedestrians physically with tunnels/bridges. Both these solutions were tried in London in the 1870, but were turned down almost immediately and were not reconsidered until after several decades. The reason was that pedestrians were offered two long waiting times in the signal (30 seconds green on a 5 minutes) and because of that these pedestrians would not accept them and they would therefore jay walk. In a similar way tunnels/foot bridges were considered as useless because people did not use the tunnel/bridge because of the detours they had to make. A study in Delhi just emphasises the problem. A majority of pedestrian underpasses constructed recently in Delhi are not being used for their intended purpose. General observation and a pilot survey of some underpasses in Delhi indicate that pedestrians find an alternative surface route to cross the road. Speed reducing measures that actually lower speeds is definitely the most effective solution. Meta results from Elvik et al (2010-2) clearly show this. My interpretation of the present situation is that this is a way of avoiding the critical question “How to introduce efficient speed reducing measures”, with the anticipation that this will be very unpopular. One more strong indication of the avoidance behaviour to a new strategy in Sweden, is to introduce new speed limit. For example by the year 2030, 40 and 50 km/h is added on to the former ones, 30 and 50 km/h. One of the philosophies behind this is the idea that the speed limits should better reflect the expectations of drivers. So therefore the goal is both to reduce speeds and to improve the acceptance by car drivers. In this perspective the results are not very encouraging. If the speed limit was reduced 10 km/h – from e.g. 50 to 40 km/h – the actual mean speeds were only reduced by a bit more than 2 km/h (Hyden et al 2008). This resulted in severe reductions of the compliance rate, in the case of 50 to 40 km/h from 80% compliance from 50 km/h. High speeds were reduced a little the change clearly demonstrated that drivers did not take the change "seriously enough", as the compliance rate went down.

For me, the change of speed limits is yet another example of how high speeds are based on measures with minor effects at the same time as they send the message to the public that this is the kind of measures used, resulting in very little annoyance. How can decision makers be so hesitant in introducing efficient measures, in spite of the fact that the public is more in favour of these kind of measures (efficient speed reduction with e.g. UK speed limit 30 mph) and how is it possible that one city – Bergen, Norway – can use "unpopular" humps on a very large scale, while most other countries consider it almost impossible? I think one of the most important reasons is the promotion of high speeds as something important and "enjoyable" for us as drivers. This kind of promotion can be seen every day in papers and magazines. The automobile industry spends billions on advertising in different media. Ads giving messages like “Zero to 100 in a whisper” or the car industry which also produces air planes stating that “we have jet in our genes”, etc.

We have been told that strong acceleration and speeds performance are important from a safety point of view. However, we never see the counter argument that Zero to 100 km/h may not be very favourable with regards to pedestrian safety and well-being in our cities. I cannot claim that any of these stand points are “true”. However, what I can claim is that “somebody” should take the responsibility for assessing the importance of the present characteristics of automobiles from a holistic point of view, i.e. not only safety for certain groups but safety for all road users, and – particularly – the attractively and sustainability of the city’s traffic.

One important tool in the Traffic Calming tool box is the roundabout. It is defined as a roundabout with only one lane in approaches and exits as well as inside the roundabout. Originally deriding the 60 km/h through speeds to around 30 km/h at all approaches, and give all road users equal opportunity to interact with other road users, improves safety for all road users, and reduces road user noise and emissions. Thanks to the design the road-roundabout can be used for enhancing aesthetics and create an attractive environment. (SLK 2008). Elvik et al (2010-3) report a reduction of injury accidents by 41% (47–34) when changing a four-armed, non-signalised intersection to a small roundabout. There are results from the U.S. indicating that the reduction of fatal and incapacitating injury crashes can be as high as 90%. (Retting et al 2001). A small roundabout can carry at least 2,000 to 3,000 vehicles per day, and can be made quite small which make them interesting as an element in creating new streets where the speed is reduced at every equipped intersection and also between the intersections (Hyden & Våhrély 2000). The popularity of this concept is demonstrated by its rapid development. In Sweden there were around 150 roundabouts in 1980, in 2006 there were more than 1500 (Kolbenstedt et al 2007). It is important to understand that qualities of roundabouts can differ quite extensively depending on the design of the roundabout, which in turn will have large implications on the safety of the roundabout. This will be particularly true for LMIC where the experience so far is limited.

It is quite clear that there is a great potential in introducing Traffic Calming measures. And it is also necessary. However, the important thing is to ensure the low speeds that one is targeting on. There are many attempts that more or less have failed. The zebra crossing is a typical example. It has become obvious that it is not sufficient “just to introduce strict yielding rules or any other measure without ensuring low speeds at the same time. One big problem is that many measures are introduced without actually reducing speeds. Assessment of effects is lacking to a very high extent. The result is that theories on which measures are based, often are vague or non-existent. The result is that the determination of effect will be “arbitrary” in the sense that there is no guarantee that measures are targeting the right kind of behaviour.

Chapter 7: “Traffic Calming: The Way Ahead in Mixed Traffic” by Christer Hyden

Excerpts from TRANSPORT AND SAFETY : SYSTEMS, APPROACHES, AND IMPLEMENTATION

Editors: Geetam Tiwari and Dinesh Mohan
Why are there so few experimental road safety evaluation studies: Could their findings explain it?

Randomised controlled trials (also known as experiments) are widely regarded as the best design of studies that aim to estimate the effects of a treatment, like a road safety measure. However, as noted by Hauer (2016) there are few randomised controlled trials in the field of road safety. Hauer has suggested (2019) that not finding an effect of the measures being evaluated could be one reason for this. This paper provides an inventory of experimental evaluations of road safety measures. 24 different road safety measures have been evaluated experimentally. More than one experiment was reported for 8 road safety measures; for the other 16 only a single experiment was found. With few exceptions, experiments find no effect on accidents of the measures subjected to experiments. Most of the exceptions are due either to failure of randomisation or refer to measures whose effects tend to erode as they become more commonly used. Thus, the effects found in initial experiments with daytime running lights and high-mounted stop lamps have gradually eroded as mixed, but did not show any clear safety benefits of wanted to use a study design supporting causal inference and ruling out confounding. No claim is made in Kansas and Ohio. The experiments were done many years after both states randomised controlled trials presented were performed, but one may suggest that researchers were discouraged their use by providing an inventory of experimental evaluations of road safety measures. The paper does not aim to explain why the randomised controlled trials presented were performed, but one may suggest that researchers wanted to use a study design supporting causal inferences and ruling out confounding. No claim is made that the inventory of papers is complete. It does, however, include all the most quoted experimental evaluations of road safety measures.

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Transportation is the lifeline of a country. Road transportation holds a vital significance as it serves as an ecosystem of an inter-related system for all other transportation modes ensuring the last mile connectivity for road users. Still, safety remains a common challenge for transportation. The fast-growing population, increasing motorization, and rapid urbanization has made the road users more vulnerable to accidents which have proved to be a critical challenge globally. The World Health Organization uses the term road traffic injury (WHO Violence and Injury Prevention, 2004), motor vehicle accident fatalities caused by U.S., Census Bureau (Statistical Abstract: Motor Vehicle Accidents and Fatalities, 2008) for road accidents. Countries have been planning and designing solutions to prevent accidents and to ensure road user’s safety. The victims, e.g., post-accident trauma, property damage, and wastage of resources. Past researches reveal that deaths in traffic accidents are second highest after cardiovascular diseases (Crundall, 2005). Accidents occur by vehicle(s) crashing on a road user or vehicle(s) or static fixture such as a pole or tree or road divider. Vehicles in a road accident are categorized as the impacted vehicle or victim vehicle and impacting vehicle or accused vehicle. In general, details of the vehicle(s) involved in accidents are available. However, there are cases where one does not know the impacting vehicle as the driver flees from the accident scene. These types of accidents are hit-and-run incidents. Hit-and-run accident types, where impacting vehicles are not known, become a bigger problem. Lack of information in an accident is the missing information that has a significant impact. The impacting vehicles in hit-and-run vehicles are referred to as “unknown”. For an efficient safety system for road accidents, knowledge of unknown vehicles becomes essential. There are two possible cases when an impacting vehicle after the crash flees away. In one case, information about impacting vehicle type is known. In other case, no such impacting vehicle’s information is available. In which case, a method is required for finding unknown vehicles. A process-based approach using six machine learning models on accident data is used to identify an accurate model. A hit-and-run accident is a matter of global concern for the safety of road users. As per the National Highway Traffic Safety Administration, U.S., hit-and-run accidents and fatalities in U.S. hit-and-run crashes increased by 13.7 %, from 1274 in 2009 to 1449 in 2011. In India, 57089 hit-and-run accidents were reported in 2015 and figure rose to 65000 in 2017 with 25 % increase in fatalities from 2079 to 2600 in 2015 and 2017 respectively (MoRTH TRW, 2015; MoRTH Accident Trends, 2018). The increase shows the vulnerability of road users to hit-and-run accidents. Many S. countries have declared hit-and-run accidents as criminal offenses. Much research has been published to understand the dynamics of hit-and-run accidents. Vaz et al. (2013) identified a model combining logistic regression and rough sets to identify factors affecting hit-and-run crashes in Hawaii. Qin (2013) studied factors contributing to hit-and-run crashes in China. The researchers also proposed to control the ways in which hit-and-run accidents can possibly occur. Macleod (2012) concluded that driving under the influence of alcohol in the early morning increases the probability of hit-and-run accidents. Tay (2009) proposed that education, awareness campaigns and traffic enforcements can reduce hit-and-run accidents and is complemented by Aidoo (2013). USA and EU countries have improved accident recording mechanisms (Jha et al., 2020) and data is used in various studies on causes. However, not much research is done in finding the unknown vehicles. The knowledge of unknown vehicles of hit-and-run accidents has been found to have a vital relevance in understanding the dynamics of road, road users, environmental conditions, or any other related parameters and plan precautionary measures and reduce the vulnerabilities to road users. However, this subject is a matter of utter importance. We have proposed an approach to identify the best model to predict the unknown vehicles. An unknown vehicle is a missing value in accident record in hit-and-run accidents. There are three types of missingness (Jha et al., 2018) in accident data viz. missing completely at random (MCAR), missing at random (MAR), and not missing at random (NMAR). MCAR is an unsystematic missingness where the probability of the value being missing is a random event and unrelated to other records in the data. MAR is a systematic missingness where the probability of being missing is justifiable by variables recorded in the data. It is not random at all, and missing data can be correlated and predicted. NMAR (or NMAR) type is neither MAR nor is MCAR; the value of the variable is directly related to the reason for its missingness. The accident data recorded with missing impacting vehicles is an MAR (missing at random) (Jha et al., 2018) variable. A supervised learning-based predictive analysis is followed for the prediction of these missing unknown vehicles. Six models have been tested for the prediction of missing data viz. (A) Logistic Regression (or LR), (B) Linear Discriminant Analysis (or LDA), (C) k-nearest neighbor (or KNK), (D) Classification and Regression Trees (or CART), (E) Support Vector Machine (or SVM), (F) Naive Bayes (or NB). LR is a regression-based statistical model to predict the dependent variable. KNN is based on nearest values of existing labels in class and used for the test sample data. SVM finds a separating hyperplane or line between data of two classes and takes data as an input and output. LDA searches in a given data set for a linear combination of predictors and model them in two targets. NB uses Bayes theorem of probability and predicts the class of unknown data set. CART follows a recursive partitioning approach for prediction. Several independent studies have been done on these supervised learning models; however, we are working on cross-pollination of these models with the road accidents and evaluate the best model that can be further used to predict unknown vehicles. This paper employs a process designed using applied prediction models on accident data from six Indian cities, i.e., Agra, Bhopal, Amritsar, Ludhiana, and Vizag (or Vishakhapatnam). The most accurate model is ascertained using the prediction accuracy of six models. Road accidents are one of the major causes of deaths and injuries. There are property losses and other irreversible direct and indirect impacts. It is a well-identified global problem, and many international bodies have been working in designing policies, technologies to prevent these accidents. For the prevention of road accidents, knowledge of participating vehicles i.e. victim vehicles and impacting vehicles, is essential. Hit-and-run type of accidents has no information on impacting vehicles, as, after the accident, impacting vehicle flees the accident scene. These are the most dangerous type of accidents. The vehicles responsible for accidents are unknown and quoted as ‘unknown vehicles’ in recording any accident. Knowledge of impacting vehicle(s) is crucial to set up prevention plans. There are several models for prediction, and therefore identification of the most accurate model is important. The vulnerability of hit-and-run accidents on road users is described and an approach is proposed to identify the best way that may be used to predict unknown vehicles. The approach created a process cycle and implemented various learning models over accident data using K-fold cross validation technique to get the best performing models. A 10-fold cross validation is used in the analysis. Support Vector Machine (SVM) had the highest accuracy for the five cities except Amritsar whereas Classification and Regression Trees (CART) had the highest efficiency. The difference in the accuracy of the models depends on data size, total number of variables, and variable values. The model finalized by theprocess shows that non-parametric methods are most suitable for predictions. Data size is insufficient for proper learning, and hence performance is justified with such limited learning scope. With this much-limited data set, that is the best accuracy that can be achieved in the study. One possible way could have been to scale up the data with a random function. However, the purpose was to use real data from a city, and hence this scaled-up quantity would not have fulfilled the objective. The type of data, e.g., continuous or categorical also has an impact on the performance. The distribution of vehicles causing the accident in the city plays another vital role. The work can be extended by applying other classification and regression models, such as self-organizing maps, random forest, neural networks, clustering techniques, rough sets and deep learning techniques. The information of the unknown vehicle(s) predicted with the best performing model will be very useful in preventing the hit-and-run accidents and designing better road user safety plans.
Quality and safety are essential parameters for the successful execution of a construction project (Ogwueleka 2013). Nonadherence to contractual specifications on quality and safety measures often leads to remedial work and accidents, respectively. Rework shortens the time available for execution of the project and has an adverse effect on the completion schedule. This may create a situation in which safety has to be compromised to achieve the planned schedule of the project (Wanberg et al. 2013). Lack of quality and safety measures may also lead to a reduction in the motivation of the workers and this can ultimately affect productivity and quality of workmanship (Li et al. 2012). Compromise in these two parameters has the potential to increase the time and cost of projects (Doloi et al. 2012), which is undesirable and affects a project’s success. Therefore, these two parameters cannot be treated in isolation and attention being paid to one at the cost of the other is not desirable (Ogwueleka 2013). Although quality and safety evaluative models, they are often found to be overlooked in quantitative models (Wanberg et al. 2013).

It is essential for project managers to ensure that a project should be done right the first time. Further, there should be no major accidents and rework during the planning phase. Therefore, it is important to engage quality and safety parameters in the planning stage along with the primary objectives such as time and cost in quantitative modeling. There are a number of planning and scheduling models available in the literature and in practice. Some of these practical models give a project schedule dependent to one generated by software such as Microsoft Project and some are more advanced and can build an optimized scenario-based project management model considering multiple-objectives such as the one generated by the software Project Team Builder.

From the literature, it is evident that significant numbers of researchers have developed optimization models to solve construction management problems, ranging from layout planning to schedule preparation. Several attempts have also been made to solve multiobjective scheduling problems using optimization models, in which genetic algorithms (GA) are most commonly used. In the past, various researchers have also made efforts to develop different optimization algorithms, such as particle swarm optimization (PSO), ant colony optimization, and so forth. Although adequate work has been carried out in the field of multiobjective scheduling problems (MOSP) that considers quality as one of the parameters, only a few studies have been reported on safety, while also solving MOSP. Afshar and Dolabi (2014) were the first to work with a GA-based optimization model for time-cost-safety (TCS) tradeoff. Although safety and quality play a crucial role in improving all these four essential construction objectives proves to be useful for construction planners and project team builders.

Where $S_n = total safety risk score of the project; S_R = safety risk associated with the jth execution mode of ith activity; K = total applicable safety risk in an optimization model for MOSP; S_{L_j} = likelihood of kth safety risk occurring in jth execution mode; and S_{L_j} = severity index of the kth safety risk in jth execution mode.

The following constraints were considered in the instant model: (1) all the activities represented in the activity network are executed, (2) each activity must be executed using only one of the available executing modes, (3) decision variables must be positive integers subject to the boundaries of upper and lower limit (which varies with each activity execution mode), and (4) the project schedule must maintain the relationships between the activities. Quality and safety are the two performance parameters that directly or indirectly affect the project time and cost. Nonadherence to contractual scenarios, there are several objectives that affect a project’s success. There are many objective scheduling models lack effective research in terms of dealing with large populations, computational complexities, and visualization (Jain and Deb 2014).