SUMMER
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INDIAN INSTITUTE OF TECHNOLOGY DELHI

T R I P - CENTRE BULLETIN

TRANSPORTATION RESEARCH & INJURY PREVENTION CENTRE
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Editors: Kumar Neeraj Jha, Dilip A Patel and Amarjit Singh. Pearson, 2021.

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Excerpts from: CONSTRUCTION SAFETY MANAGEMENT

Kumar Neeraj Jha, Dilip A Patel, Amarjit Singh

This book is about understanding the principles of safety science, the legal aspects of safety, managing safety, 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. Therefore, 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. We sincerely hope 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 particuJarly 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 prevention 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, tooling, 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.

Training programmes should be accurate, credible, transparent, and practical. Thus, training material and contents should be prepared by professionally qualified experts. All trainers should have the necessary expertise and field experience in safety and health management. To be effective, the language of training delivery and materials should be understood by workers. In training programmes, the relevant information, and specific skills, and ideas helpful to participants should be presented to apply in their practice.

Before starting the training session, a needs assessment should be conducted to ensure that the training contents meet the trainees' requirements. Training can be determined based on the trend of accident data, existing hazards at the project site, outputs of the safety audit feedback of other stakeholders of the project, or inputs of workers and employees. Statutory and contractual requirement of training include communication of hazards, fall from heights construction of temporary structures, first aid, disaster management, firefighting, or handling of hazardous waste. After completing the training, it should be determined whether training has delivered desired outputs, or whether any changes are required to the training programme. The effects on accident trends and behaviour of trainees, changes in production rate and quality of product, and process and feedback from workers, employees, and other stakeholders can help evaluate the effectiveness of training. Several organizations have initiated the use of digital tools and techniques such as building information modelling (BIM), virtual reality (VR), augmented reality (AR), 3D model, and artificial intelligence in physical training by developing training tools, with the pacific aim of improving safety.

In the Indian construction sector, most workers are migrants on a temporary basis on the project. Therefore, the construction organization must additionally train new workers, leading to more expensive and resource-intensive training programmes. In a big project, workers come from various parts of the country and speak different languages. The schedule constraints, common language for instruction, and education level are some of the barriers and challenges to adequate training. On the other side, young workers are well versed in the use of mobile phones, and their training can incorporate video clips and special apps.

The highest safety in projects can be achieved by addressing safety in the planning and design stages of a project. Owing to the success of these methods, the prevention through design (PtD) approach has become popular in the construction sector. Proper coordination among various stakeholders such as architects, contractors, and designers is required to identify and control the hazards in the planning and design stage of the project itself. The PtD approach is extended and conjoined with ergonomic principles to generate safe designs of construction methods, components, and materials.

Effective communication about hazards and their preventive measures among individuals can control the occurrence of accidents at the project site. Therefore, many construction organizations encourage effective communication among various groups in the project to exchange safety-related information. The communication can be via toolbox meetings or training programmes, in addition to many others possible styles and techniques. 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 operate equipment and machinery correctly and safely. It helps to check hazards to prevent accidents. Further, the 'permit-to-work' must be considered essential for contractors, especially before construction of high-risk activities such as entry into confined spaces, demolition, or underground work at the project site. They ensure whether the contractor takes proper safety precautions before executing any activity. And by implementing a Preventive Maintenance Program (PMP), the idle time of equipment and machinery can be minimized and their efficiency, productivity, and safety can be maximized. Similarly, the operators' fitness and behaviour should be controlled and maintained to prevent them from making errors that lead to accidents.

Job Site Observations GSO) examine the unsafe work behaviour of workers. The information given in the job safety observation form helps to review existing hazards, workers' behaviour, and control measures while performing tasks. Housekeeping at the project site can control certain hazards and risks by implementation of the SS (sort, set, shine, standardize, and sustain) principles. Moreover, unexpected ignition offires may cause accidents and harm to workers. Such uncontrolled fires can be prevented by proper fire management, which is easily implemented. Proper PPEs should be provided to workers and employees at the project site to protect themselves from hazards and risks. It must be noted that PPEs are required because all risks and hazards may not be eliminated, substituted, or controlled by engineering and administrative measures. The organization should review and ensure the effectiveness of accident 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 destruction activities can naturally cause accidents and injuries during the demolition of the structure. Lack of standard safely practices, absence of specialty equipment types, and in appropriat knowledge are the leading causes of such accidents. However, accidents can be prevented by proper safety planning of demolition operations in construction sites, which includes identifying hazards, pre-demoluti.on 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.

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

Editors: Geetam Tiwari and Dinesh Mohan

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 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 could be prevented through affordable investments. And they are unsustainable because no country can afford the economic and social costs associated with current approaches. The fact 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 Community". WHO in their Status Report (2009) reaffirmed the understanding of road traffic injuries as a global health and development problem and it: "… draws our attention to the needs of all road users – including these most vulnerable groups. They too must be considered and given equal priority when policy discussions on road safety, land use and urban planning are made." My interpretation of the situation is that decision makers and others all over the globe nowadays are putting road safety quite high on the agenda. This is of course encouraging. However, it is one thing to put it high on the agenda. A completely different thing is to put relevant and efficient action on the agenda. I think that is what we still are lacking. Road safety seems to be a sensitive area for decision makers. They think that the public do not want the necessary measures. They do not know, because there has almost never been an attempt to produce a holistic view on traffic.

First attempt was to give separate space for the pedestrians, thus building foot paths (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 too long waiting times in the signal (30 seconds green once in 5 minutes) and because of that pedestrians would not accept them and they would therefore jay walk. In a similar way tunnels/foot bridges were considered as useless because pedestrians would 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 limits – in built-up areas 40 and 60 km/h in addition 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 (Hydén et al 2008). This resulted in severe reductions of the compliance rate, in the case of 50 to 40 km/h from 80% compliance to 60%. So even though 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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For me, the change of speed limits is yet another example on how the attempts to lower speeds is 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 kinds of measures (efficient speed reduction with e.g. humps) than the decision makers? And how is it possible that one city – Bergen, Norway – can use "unpopular" humps on a very large scale, while most other cities 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, etc. We have been told that strong acceleration and speed 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 small round-about, see figure 7. Small is here defined as a roundabout with only one lane in approaches and exits as well as inside the roundabout. Optimally designed it can lower 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 delay (even for car users at least when the roundabout replaces a traffic signal), and reduces noise and emissions. Thanks to the design the round-about can be used for enhancing aesthetics and create an attractive environment. (SKL2008). 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 23,000 incoming 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 (Hydén & Várhelyi 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 (Kolbenstvedt 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 safe guarding the effects. 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 therefore that the evaluation of effects 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

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NEWS

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 measures. 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 measure 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 more cars got these systems. Driver training is one of the few road safety measures for which more than one experiment has been carried out. Results consistently show no effect on accidents of driver training.

A distinction can be made between: (1) Randomised controlled trials, in which at least two groups are formed by randomisation (to make sure they do not differ systematically) and the researcher introduces a treatment in one of the groups, and (2) Observational studies, in which the researcher does not control the treatment and cannot ensure that a non-treated group does not differ systematically from the treated group. Hauer (2016) notes that there are few randomised controlled trials (experiments) in road safety and states (page 6): “Most will agree that if in road safety research experimentation and randomization were feasible, the resulting crash modification factors should be deemed trustworthy and, as a result, practitioners could make more cost-effective choices.” Hauer argues that more experiments are possible, although not all road safety measures lend themselves to experimental evaluation. In a subsequent paper Hauer (2019) discusses two experimental evaluations of edge lines made in Kansas and Ohio. The experiments were done many years after both states had started marking edge lines. The results were mixed, but did not show any clear safety benefits of edge lines. Hauer notes that the authors of the papers presenting the results of the experiments hardly mentioned unfavourable findings, as doing so might suggest that highway agencies had made a mistake in marking edge lines.

It is well-known that the results of research are treated as good or bad, not based on the rigour of a study, but based on whether we like the results or not. “Bad studies tend to be those whose results we do not like” (Rosenthal, 1991, 130). Could one of the reasons why there are so few randomised controlled trials in road safety be the fact that most of them did not find an effect of the treatment? There are many good reasons for not conducting randomised controlled trials, in particular ethical problems of introducing potentially harmful treatments. However, discontinuing the use of randomised controlled trials because one dislikes their findings cannot count as a good reason. A “favourable” effect is a reduction of the number and/or severity of accidents or injuries. This paper discusses whether “unfavourable” findings of randomised controlled trials can discourage 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.

Rune Elvik, Accident Analysis & Prevention, volume 163, December 2021, 106467

INTERNATIONAL COURSE

An International Course on Road Safety Audit, Road Construction Safety, Biomechanics and Crashworthiness was organised by the Transportation Research & Injury Prevention Centre (TRIP Centre), Indian Institute of Technology, Delhi, on 22 November – 10 December 2021. The course was supported by the Ministry of Road Transport and Highway, Govt. of India, Ministry of Housing and Urban Affairs, Govt. of India, Indian Road Congress, National Highway Authority of India, TATA Sons Ltd., Independent Council for Road Safety International (ICoRSI) and South East Asia Region, World Health Organisation. A total of 84 participants including faculty attended the course, six faculty members were from four countries, fifteen participants who attended the course were sponsored by the Border Roads Organisation and Ten of the participants were from the Kerala Transport Department. This fifteen day Course brought together professionals working in the area of transportation planning, safety promotion, biomechanics of impact and vehicle crashworthiness, road construction safety and acquainted them with state-of-the-art information. The course was especially designed for an interdisciplinary audience of traffic and road engineers, behavioural scientists, mechanical and automotive engineers, law enforcers, and police officers. It focussed on a global perspective to the road safety problem. The first two weeks of the course were conducted online and the final week was attended in person. The course was divided into three modules. Module 1 was compulsory for all participants followed by three parallel sessions on Road Safety Audit, Road Construction Safety and Biomechanics and Crashworthiness. Faculty members from IIT Delhi were from Prof. Geetam Tiwari, Prof. K.N Jha, Prof. K.R. Rao, Prof. Nezamuddin, Dr. Rahul Goe, Prof. S.B. Paul, Prof. Ravi Shankar; Mr. A.K.(Dunu) Roy, Hazard Centre, India; Prof. Dilip Patel, SVNIT, Surat; Prof. Girish Agarwal, O.P. Jindal Global University, India; Mr. Jigesh N Bhavsar, ADB, iRAP, India; Dr. Mathew Varghese, St. Stephens Hospital, Delhi, India; Dr. P.D. Nayar, SEAR, WHO, India; Dr. Sadhu S L N Sarma, Safety Expert, India; Prof. Hermann Knoflacher, University of Technology, Vienna, Austria; Prof. Shrikant I Bangdiwala, McMaster University, Canada; Dr. Sylvain Lassarre, IFSTTAR, France; Prof. Amarjit Singh, University of Hawaii, USA; Prof. Kavi Bhalla, Bloomberg School of Public Health, USA.

The Transportation Research and Injury Prevention Programme has been operational for two decades. On May 21st 2021 it was established as TRIP Centre. It is based at the Indian Institute of Technology (Delhi) and is an interdisciplinary academic unit focusing on the reduction of adverse health effects of road transportation. Researchers at TRIP Centre seek to integrate all issues concerned with transportation to promote safety, active mobility, cleaner air, and energy conservation. They are involved in planning safer urban and inter-city transportation systems and developing designs for vehicles and safety equipment.

Endowments for perpetual Chairs
CONFER, India: TRIPP Chair for Transportation Planning
Ford Motor Co., USA: Ford Chair for Biomechanics and Transportation Safety
Ministry of Urban Development India: MoUD Chair for Urban Transport & Traffic Planning
MoUD Chair for Urban Transport and Environment
MoUD Chair for Urban Traffic Safety
VREF: Volvo Chair for Transportation Planning for Control of Accident and Pollution

Establishment funds have been received from
Ministry of Industry, Government of India
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Tata Motors Limited, India
Volvo Research and Educational Foundations (VREF), Sweden

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Excerpt from: A PERFORMANCE ANALYSIS OF PREDICTION TECHNIQUES FOR IMPACTING VEHICLES IN HIT-AND-RUN ROAD ACCIDENTS

Alok Nikhil Jha, Niladri Chatterjee, Geetam Tiwari

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 onnectivity 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 accidents (MVA) is used 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 traumas, 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 a 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 accidents. Hit-and-run accident types, where impacting vehicles are not known, become a bigger problem to solve. Lack of information in an accident is a challenge as this missing information 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, USA (NHTSA, 2012), fatalities caused by 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 20709 to 26000 in 2015 and 2017 respectively (MoRT&H TRW, 2015; MoRTH Accident Trends, 2018). The increase shows the vulnerability of road users to hit-and-run accidents. Many countries have declared hit-and-run accidents as criminal offenses. Much research has been published to understand the dynamics of hit-and-run accidents. Kim et al. (Kim et al., 2008) 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 a 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. MNAR (or NMAR) type is neither MAR nor is MCAR; the value of the variable that is missing 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 KNN), (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 unknown vehicles 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 the process 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 have 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 vehicles predicted with the best performing model will be very useful in preventing the hit-and-run accidents and designing better road user safety plans.

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Excerpt from: INTEGRATING QUALITY AND SAFETY IN CONSTRUCTION SCHEDULING TIME-COST TRADE-OFF MODEL

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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 are referred to in qualitative 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 project. To do so, 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 similar 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 consider 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 performance, profitability, and productivity during project implementation (Ogwueleka 2013), notable research that uses these two parameters together in an optimization model for MOSP has not yet been undertaken.

Further, most of the scheduling problems have concentrated on two or three objectives in trade-off problems, the results of which are straightforward to visualize in low dimensions. However, in real-life scenarios, there are several objectives that affect a project and should be included in a construction schedule, which makes it a many-objective problem. For a higher-dimension problem, most of the existing scheduling models lack effective research in terms of dealing with large populations, computational complexities, and visualization (Jain and Deb 2014).

This study takes the aforementioned two issues into consideration for setting the research ground and considers (1) integration of quality and safety into scheduling model, and (2) developing a many-objective scheduling model. Hence, this study makes an attempt to develop many-objective scheduling model by considering quality and safety together along with essential scheduling parameters, time and cost, in a construction scheduling problem.

The construction industry is recognized as being the most hazardous (Patel et al. 2016). Traditionally, time, cost, and quality were the three prominent parameters required to ensure the success of a project. However, health and safety measures were not given due importance in the time-cost-quality trade-off models but have slowly gained appropriate roles in the trade-off models. Afshar and Dolabi (2014) incorporated safety measures, considering the risk-based health and safety analytical model developed by Hallowell and Gambatese (2009). Afshar and Dolabi (2014) quantified the safety risk on the basis of an activity-based safety risk method. This method involved three basic steps: (1) identification of significant safety risks, (2) determination of the likelihood of the occurrence and evaluation of the severity of safety risks, and (3) determination of overall safety risk score.

In the first step, significant safety risks for all the activities were compiled, based on the data available from different government reports and literature (Afshar and Dolabi 2014). After identification of the safety risks, the method evaluated the probable likelihood and severity of each identified safety risk. The method sought comments and opinions from domain experts. The process involved seeking opinions on a 1–6 scale for both likelihood and severity. In the case of likelihood, 1 denoted remote likelihood occurrence and 6 denoted a highly probable occurrence, with the intermediate gradations lying in between. Similarly, a severity of 1 represented minor injury and 6 represented fatality. After getting all the scores from the experts, the overall safety risk score was calculated using following equation

$$S^{j}_{R_i} = \sum_{k=1}^{K} (L^{j}_{k} \times S^{j}_{k})_i$$

Where S_{RS} = total safety risk score of the project; $S^{j}R_{i}$ = safety risk associated with the jth execution mode of ith activity; K = total applicable safety risk in the ith activity; L^{j}_{k} = likelyhood of kth safety risk occurring in jth execution mode; and S^{j}_{k} = 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. Incorporation of these parameters into a MOSP provides decision makers with a holistic construction schedule. Still, the integration of these two parameters in trade-off models of MOSP was not observed in past studies. This was mainly because the complexities and intricacies involved in solving these problems increase exponentially with an increase in the number of activities, their possible execution modes, and the number of project objectives. To make it manageable, a many-objective optimization model was developed based on NSGA-III. The model carries out the trade-off between four key project objectives, namely time, cost, quality, and safety risks. To indicate the comparability and dominance of the developed model, a comparative study was carried out on two multiobjective scheduling problems (TCQ and TCS) taken from the literature. The obtained solution for both examples indicates that the model has better capabilities for dealing with MOSPs. Fur ther, the proposedmodel has the ability to deal with more than three objectives and provides opportunity for the construction stakeholders to incorporate the parameters of their interest. The generated Pareto front solution shows the superiority of the developed model when compared with the models available in the literature on all four objective TCQS.

The developed model is illustrated for many objectives with the help of a case study example. The results obtained from the model reveal the benefits of the inclusion of quality and safety with the other project management objectives. To study the influence of these two parameters, various trade-off graphs are analyzed and discussed. The analysis results highlight the new and unique capabilities of the scheduling model in generating optimal tradeoffs between construction time, cost, quality, and safety risk. An interesting insight is that by examining sets of Pareto optimal solutions, additional quality and safety performances can be obtained without putting additional cost. Further, the trade-off pattern shows that the quality performance increases with an increase in project cost and safety risk score decreases with increasing time duration. Correlation analysis has also been conducted to verify the trade-off pattern between the objectives. An optimal schedule with regard to all these four essential construction objectives proves to be useful for construction planners and can lead to significant improvements in the safety and quality performance of constructed facilities at the planning stage itself with time and cost. Sensitivity analysis was performed to check the impact of these inputs on output parameters.