

Industrial Management

Highway Safety Factor

Arismawan

Staf Pengajar Program Studi Teknik Industri Universitas Syiah Kuala
Corresponding Author: arismawan@unsyiah.ac.id

Abstract – Road safety is an important aspect of the targeted improvement of highway transportation system in addition to the smoothness, safety, reliability, efficiency and harmony with the environment. Traffic safety indicator is the main component result in whether high or low levels of traffic accidents. Traffic safety is constantly becoming increasingly urgent needs to be realized in the implementation of national transport policy. No exaggeration when safety in road is included as one indicators of public welfare as a sign of success or failure in the development of infrastructure. Copyright © 2016 Department of industrial engineering. All rights reserved.

Keywords: road, safety, highway, transportation, traffic, accidents, system

1 Introduction

In order to create safety, smoothness, and comfort in highway then the tendencies of negative attitude need to be lowered such as indiscipline, lack of knowledge about good driving habit, traffic violations, poor service to passengers, traffic jams can result in a high number of accidents and road fatalities. Highway safety aims to reduce significant victims in the street. The number of victims of land transportation accidents is much higher than those in water, rail and air transportation. Traffic safety is such program to reduce the number of accidents and all its consequences.

The attempt to improve the safety in highway is not necessarily just the responsibility of the government. It is actually our responsibility as well. The highway safety involves many agencies and many stakeholders. All parties that involves in this matter need to develop strong coordination so that highway safety can be implemented in an integrated, effective, and efficient way.

Important Factors

There are several important factors that have important roles in increasing safety in highway [1]. They are as follow:

- a. Human factor
- b. Road geometric and material selection factor
- c. Vehicles factor

- d. Policy and law enforcement factor

Human Factors

Human factor is the most dominant in accident or fatality. Almost all accidents are preceded by violation of traffic signs. Violations can occur because of intentional, ignorance and pretend of not knowing the highway rules. In addition, human factors also involved behaviour of the vehicles driver including speeding car more than maximum, consuming alcohol, violating traffic laws, less attention when driving, error in making decisions, and age factor.

Therefore to increase the people awareness as road users, there are several things need to be conducted:

- a. Introducing traffic systems to road users

Most of the time traffic accidents generated by human negligence. To enhance the people knowledge about highway safety particularly about traffic system, there are few things can be done such as through sufficient education about traffic and revision of traffic regulation.

- b. Traffic volume or road users

The emergence of risk on the highway is the impact of the increasing of road user and a growing volume of vehicles. The efforts to enhance the level of safety mainly because there is a significant increase of vehicles in highway and more people are driving at high speed [2]. Therefore, the government need to

divide lanes between pedestrians, bikers and a 4-wheel driver. It is also can be done by creating a system of open and close during certain hours so that the safety of road users could be further improved.

c. Human resources

The quality of human resources is the most important thing in providing excellent services to public in the context of improving highway safety. Research and development is one of other several ways to increase human's capacity in managing the complexity of highway problems and providing answers to solve the problem. It is expected that the development of better transportation system could reduce the number of accidents and increases the highway safety.

In creating and maintaining security, safety, and smoothness in highway as well as to decrease fatal accident, establishing a culture of obeying traffic rules is viewed essential. In addition, the improvement of highway safety cannot be handled partially and temporary. It needs professional action provided by the support of excellent resources that are reliable, modern and dynamic. All these factors must be addressed in an integrated and sustainable way.

d. Driving behaviour

There are two main factor associating with driving attitude. These are speeding more than maximum, and consuming alcohol in large quantities. Driving faster than allowed limit and/or faster than safety conditions would contribute a lot to traffic crashes. Generally speeding the vehicle would decrease a driver's ability to steer safely around objects, need extra distance to stop the vehicle and increase the distance of a vehicle to move when drivers reacting in dangerous condition.

Consuming alcohol in large dose would be very dangerous in driving vehicle. Drinking Alcohol, consuming drugs and driving vehicle simply cannot go together. Driving vehicle requires full attention and the ability to make appropriate decisions when something unexpected taken place in the street, to make speed reaction when sudden changes in the road happen. When drinking alcohol, consuming drugs, or being disturbed by any reasons, driving vehicle becoming dangerous and could potentially causing fatal accidents.

Furthermore, alcohol consumption is a significant human factor in contributing many motor vehicle fatalities. It is not permitted or illegal in most countries in the world to drive motor vehicles while the driver under the influence of alcohol or drugs in the blood in specific level of dose.

e. Age of the Driver

There is also a strong linkage between a driver's age and the possibility of being involved in an accident. Younger drivers usually driving in a reckless way and this risky driving style when combined with driving inexperience will contribute to fatal crashes. On the other hand, older drivers face even larger risk. Fatal crash rates are higher for the elderly than younger drivers.

Road Geometric and Material Selection Factor

Accidents in highway strongly connected with the width and curvature of road [3]. The visibility in highway also has major effects on the fatality. They are sensitive in psychological term on the drivers and affect their choices on the speed motion. It is therefore the policy to widen the road alignment that used to be narrow will decline the number of accidents. Moreover, roadway environment factors include the roadways' design, roadside hazard, and the condition of the roadway itself.

Super elevation repair and improvement of the road surface that made out in isolation way also has the same tendency to increase the rate of accidents. In safety view, there should be an evaluation of speed conditions that may take place after any repairing any type of road by checking the width of lanes, visibility and road surface. They all are urgent in the attempt of to decrease the number of fatality in highway.

Selection of materials for covering the road in accordance with the needs of smooth traffic and avoid accidents is no less important than the purpose of building road construction. Places that have a lower surface coefficient several times would easily cause accidents compared to the other locations that have higher coefficient. This is important when drivers braking the car or when they turn the road.

Unfavourable weather conditions, moreover, can affect traffic accidents. However, the amount of its effect could not be determined yet. Drivers and pedestrian behaviour are still assessed as the biggest factor in highway accidents. Street lighting needs to be improved significantly, both its placement distance as well as the power of its light.

The government with help from Traffic Engineer should attempt to change the behaviour of drivers and pedestrians by implementing appropriate highway regulations [4]. It is expected could diminish their harmful actions that bring danger to others. The road designers, additionally, have big responsibility to include as much safety signs as needed in their highway design in order to minimize the number of accidents in road. Environmental factor such as unfavourable weather, human factor, and street lighting should be included in Traffic Engineers' highway designs.

The roadway environment is generally considered the second most contributing factor of fatalities. Roadway environment factors that contribute to crashes include the design of the roadway, including features such as medians, narrow lanes, and lack of shoulders, curves, access points, and intersections [5].

Roadside hazards or features adjacent to the road that vehicles can crash into such as poles, trees, or embankments. Furthermore, roadway conditions such as rain, ice, snow, or fog also contribute a lot to accidents. In addition, the significance of adverse weather, including both slippery roads and reductions in driver visibility, is not fully understood because there are no measurements available to compare crash rates under various conditions

Vehicles Factor

The amount of motor vehicles in highway could be a great factor that increases traffic accident if their existence cannot be controlled as it should be. The form of control has strong relation to motor vehicles technical conditions which not roadworthy as well as the use of motor vehicles that not obey traffic regulations.

The following are some factors about motor vehicles that contribute to the incline of accident in highway:

- a. Brake failure, engine failure, bad tire condition that is not roadworthy. Bad steering loose coupling, lights off especially at night, slip, contribute to highway accidents. Thus the physical condition of the vehicle should be strongly monitored before the vehicle considered deserves to be used in highway. It is essential factor for the safety of the driver and the passengers on board.
- b. Overload use of vehicle which is not in accordance with the traffic policy and regulation. Because of that the regulation that arrange about the load capacity in every vehicle need to be determined by the traffic authority to ensure that security and safety of passengers are listed in the top priority.
- c. The design of vehicles can also be a factor that contributes to the crash severity in highway. Buttons on dashboard can injure people when passenger pushed forward in a collision. The steering column can penetrate the driver's chest at the time of crash. Front design of the vehicle can also worsen pedestrian injury if crash happens. Vehicle improvement is mainly depends on vehicle manufacturers but government regulations or recommendations are considered important to influence the designer in making new designs.

- d. Vehicle lighting system has two purposes. The first one is to enable drivers to properly see the road conditions in front of them. The second one is to differentiate vehicles from all corners without blinding.

Vehicle factors can also contribute to crashes through vehicle-related failures and vehicle design characteristics. While such recent events as the number of crashes involving tire separations have highlighted the importance of vehicle factors, data and studies generally show, and experts believe, that vehicle factors contribute less often to crashes than do human or roadway environment factors. In addition, vehicle design has been shown to affect handling in particular types of maneuvers. Recent changes in the composition of the nation's vehicle fleet, in part attributable to the purchase of many SUVs, have resulted in an overall shift toward vehicles with a higher center of gravity, which can roll over more easily than some other vehicles.

Policy and Law Enforcement Factor

Law enforcement in traffic regulation is to protect road user to be more secure and safer which in consequence will support their activity that can result in high productivity. High productivity will as well improve people quality of life. Law enforcement in field traffic, moreover, is to rescue, prevent and educate people in order to develop their awareness and obey law about highway safety.

The highway circumstances and traffic conditions these days are becoming increasingly complex. If conventional ways still applied to manage highway matter, then it will certainly no longer solve the problem. It is likely may create new problems instead. The authority currently developed its law enforcement by electronic system (Electronic Law Enforcement). Thus the integrated system with TMC (Traffic Management Centre) needs to be developed to support better highway management.

Registration and identification of driver and vehicle is the part of police duties. It is to make sure there is a control function in relation to forensic. By performing these duties, the police are expected could manage the way people driving their vehicle in highway. It is also to encourage people to be responsible for not only for their own safety but also for others. The police function in the area of registration and identification will control security services that accurate and accountable.

2 Methods

Methods that used to examine highway safety factor is by doing an Analysis of Traffic Safety Factors. Table 1 indicates on how to evaluate safety factor by using index criteria ranking. In addition, the result of the analysis based on the theory is presented in Table 2. The parameters y_1 , y_2 , y_3 and y_4 , respectively, are the number of accidents (events per year), the number of dead victims (people per year), the number of injuries (people per year) and the amount of loss expenses (million USD per year). According to the index performance, criteria factors are x_{11} , x_1 , x_2 , x_5 , x_7 , x_9 and x_{12} classified as very high, while x_8 , x_6 , x_{10} , x_3 and x_4 including high criteria

Table 1 Ranking for Traffic Safety Index

No.	Performance Criteria	Index (P)	Rangking (r)
1.	Very High	$0,8 < P \leq 1$	(r=5)
2.	High	$0,6 < P \leq 0,8$	(r=4)
3.	Normal	$0,4 < P \leq 0,6$	(r=3)
4.	Low	$0,2 < P \leq 0,4$	(r=2)
5.	Very Low	$0 \leq P \leq 0,2$	(r=1)

Table 2 Sequence Index Traffic Safety Factor for Overall Parameter (Y_i)

Notation factor	Variable/factor	Parameter				Means Ri (Rangking)	Proportion X_j
		Y_1	Y_2	Y_3	Y_4		
X11	Age ratio 16-30 yr for all victims	0.820	0.877	0.816	0.790	0.8258 (r=5)	8.76%
X1	The population (millions)	0.793	0.882	0.810	0.784	0.8173 (r=5)	8.67%
X2	Passengers factor	0.788	0.881	0.808	0.790	0.8167 (r=5)	8.67%
X5	Road length (x 1.000 km)	0.792	0.878	0.809	0.782	0.8153 (r=5)	8.65%
X7	Motorcycle ratio of total vehicle	0.804	0.854	0.816	0.765	0.8098 (r=5)	8.60%
X12	Number of traffic violations	0.809	0.836	0.830	0.762	0.8094 (r=5)	8.59%
X9	Student ratio towards all victims	0.821	0.815	0.789	0.776	0.8004 (r=5)	8.50%
X8	Private ratio to all victims	0.785	0.791	0.792	0.784	0.7881 (r=4)	8.37%
X6	Number of vehicles (x 1.000 vehicle)	0.782	0.751	0.749	0.837	0.78 (r=4)	8.28%
X10	Civil servant ratio towards all victims	0.774	0.719	0.762	0.718	0.7431 (r=4)	7.89%
X3	Vehicle factor	0.719	0.670	0.716	0.729	0.7085 (r=4)	7.52%
X4	Road Factor	0.747	0.637	0.746	0.700	0.7073 (r=4)	7.51%
Proportion Y_i		25.0%	25.5%	25.1%	24.5%		100%

Source: Data Analysis

The Necessity of Highway Safety Manual

The safety management of highway requires manual which identifying sites or roads with potential for safety development. In addition, the manual provides information on how to diagnose condition on the sites, evaluating it, and identifying both potential crash and potential treatment [6]. In Highway safety manual there is a predictive method to estimate crash frequency and the level of its severity. This predictive method can be used for making such decisions

throughout the project development process. The necessity of highway safety manual is highly required. It is because the manual consist beneficial information including design, planning, maintenance, operations, and overall for highway safety management process.

Highway safety manual provides information and examples of typical transportation performance measures including recognizing sites with the most potential crash situation and on how to reduce its severity consequences [7]. Moreover, it also provides information on identifying factors that contributing to crashes and associated potential countermeasures to recognize the problems. Then following by to evaluate crash reduction benefit of applied treatments, and the last one is to estimate potential effect on frequency of crash and severity of planning, operation, the design, and policy from the authorized parties.

The methods of integrating quantitative and qualitative crash frequency and severity into planning, project alternative analysis, evaluation, program development are also can be found in highway safety manual. It can be used for adding quantitative safety analysis into multidisciplinary transportation projects. Furthermore, the highway safety manual can also be used for projects that are focused on to respond safety-related question. It is beneficial to be utilized in conducting quantitative safety analysis on projects that have not traditionally included in this type of analysis, such as corridor studies to identify capacity improvements and intersection studies to specify alternative forms of traffic controlling.

From a legislative aspect, the highway safety manual will contributes in local safety goals to reduce fatalities and severe injuries. As it is popularly known that many drivers are attributes to victims of fatal crashes and serious injuries. It is then the highway safety manual are viewed very important to be socialized not only among land transportation authority but for the common drivers as well. As public agency works towards their safety goals, the quantitative methods in highway safety manual can be applied to evaluate which program and project developments are achieving planning, and as the result the agency can allocate more funds towards the programs that result in the greatest benefits for enhancing safety management in highway. It is also to reduce the number of fatal accidents in road which mean to decline the rate of victims every year.

Safety Management Software Tools

There are some software tools have been developed to support practitioners in using highways safety manual methodology [8]. These are:

1. Safety Analyst. It is a set of software that used by government and local highway authorities to

increase the quality of highway safety management. It incorporates state-of-the-art safety management process into computerized analytical tools for guidance of decision-making process to identify safety improvements needs and develop a system program of specific improvement projects.

2. The Interactive Highway Safety Design Model is a suite of software analysis tool for evaluating safety and operational effect of highway geometric design. The Interactive highway safety design model executes predictive method for the public facilities such as two lanes highway, two-way rural roads, rural multilane highways, urban and suburb arterials. This tools is also summarize the capabilities and applications of the evaluation modules and provide a library of research reports documenting the improvement.
3. The Crash Modification Factors Clearinghouse. It is a tool web-based database along with supporting documentation to help engineers identify the most appropriate countermeasure for their safety needs. By using this kind of tool, users are expected could enhance the safety and security in highway regarding to minimize the number of fatal accident to happen.

Specific Design of Safety Highway

In highway the most severe situation is in intersection. Usually in the intersection the traffic so crowded and high demands. It requires the expertise of transportation engineers to design that can answer the problems. The most severe safety problems in the intersection including driver's vision, comprehensive traffic signs, attention of the drivers, reactions, and the judgment as well as appropriate decision making in precarious situation. Signs, signal, pavement marking that can be easily seen and understood by at a glance by entire road users including the most vulnerable group of drivers – elderly population – that usually becoming more careless in the highway. The highway designers and transportation engineers should include sound element in the traffic infrastructure to service all taxpayers with high quality design and most secure and safe from avoiding the fatalities in highway.

Some factors that should be taken into account in designing secure and safety highway including measuring the visibility, legibility of highway signing, delineation. Furthermore, it is also beneficial to determine message characteristic to avoid information be overloaded. Identifying the most important sources of driver distraction should be learned too by the transportation designers.

Other factors contribute to safety design of highway such as to observe and analysed driver's

behaviour in representative laboratory. Simulator-and instrumented vehicles studies are samples that should be viewed very crucial as well in designing high safety land transportation. A focus on design for an aging population of road users are especially counted important. Because the elderly population one of the most vulnerable drivers in highway.

Along with highway design, the vehicle design should be modified to improve driver's performance and to decrease unsafe behaviours of some segmented drivers. The transportation engineers should evaluate driver's capabilities to benefit from existing or new vehicle technologies. Consumer information and deep knowledge of variety of driver's behaviour will help engineers in enhancing performance that can be implemented in the development of representative saver vehicle technologies.

Crash Data Assessment

The agency or highway authorized parties should assess the crash data to see if there is an assistance needed to prepare it for the rigor of highway safety manual analysis. The highway authorization parties will provide technical assistance and support the local government in evaluating their data system against data requirement of the manual. Moreover, there is a technical support staff with high knowledge will also available to answer the question regarding geometric design of the highway.

To incorporate the highway safety manual into an agency's processes will take a rigorous effort that can begin with a plan of action. It is could be executed by developing agency-specific training programs.

Some Challenges in Building of Achieving Saver Highways

There are some points that need to be addressed regarding to incline the safety environment in highways. Some of the point that matters are as follow:

1. Continuously changes in vehicle design and the high demands of some specific utility vehicles make it hard for highway authorities to design road and roadside keep compatible with the vehicle fleet.
2. Demographic changes also raise a number of issue that relate to drivers performance and their ability to survive from crash.
3. There is a continuously increase of older drivers who are more susceptible to injury in fatalities and the opportunity to survive less likely in their accidents. The elderly population may suffer from declining vision, quick response in hazardous situation, and cognitive skills associated with the

performance of complex tasks. Moreover, the increase of fatalities could also come from younger population who are not gained many experience in driving performance.

4. New vehicle technologies absolutely have positive benefits in enhancing the ability of vehicle. However, if the new technology not go together with adaptability of drivers in using vehicle could result in negative effect that consequently add the number of crash.
5. Even with the new technology, driver's behaviour are constantly changing related to safety riding. It could be seen from the drivers that are willing to take shorter distances between vehicles for a number of given speed.
6. Highway safety problems are both very serious and full of complexity. It requires tools as part web-based technology to identify problems and provide variety of solution that can be used by highway experts regarding reducing the number of fatal crash in road or highways.

4 Results and Discussion

There are some results and discussion as follows:

- a. The transportation system should be planned integrated between land modes, water modes and air modes.
- b. Increase public participation in the planning and supervision of transport system development that in accordance with applicable standards such as British Standard ASTM or AASHTO.
- c. Provincial policy should be encouraged in the era of local autonomy.
- d. Transparency and decision about route permits license.
- e. Transport operators should have business entity.
- f. Improve monitoring function in every weighbridge.
- g. There should be the age limit of vehicles roadworthy.
- h. It is expected that the vehicle manufacturers to make changes to the physical automotive vehicle design, including the addition of vehicle lights that enhance the quality of vision of the drivers.
- i. Provide highway safety manual as an approach to increase and enhance safety management that consequently will reduce the number of victims in fatal accident in highway.
- j. Specific design of more safety highway should be viewed by the local authorities as prioritize

to increase the convenient of road users and help them to avoid from unnecessary fatalities that could be happen in highway.

5 Conclusions

The conclusions are as follows:

1. Human factors are generally viewed as the most significant one that contributing most in fatality in highways. Then followed successively by road geometric and material selection factor, policy and law enforcement factor, vehicle factors at the last.
2. There are multiple factors that produce circumstances which lead to vehicles crashes. It is rarely that one single cause lead to the fatalities.
3. Highway safety manual is a very beneficial tool as a science-based technical approach that guide users to increase safety and security management in land transportation especially highway transportation mode. The highway safety manual provide tools to conduct quantitative safety and security analysis, allowing the safety and security analysis to be quantitatively evaluated alongside other transportation performance measures such as traffic operation, environmental effects, and cost of the construction.
4. The highway safety analysis can be applied to some transportation projects that is specifically focused on the safety and security necessity.

References

- [1]. Cariawan, U. et al, *Vehicle and Traffic Accidents on The Toll Road*, Transport Safety Bureau, 1990.
- [2]. Amelia Handayani, *Environmental Management in Tool Road Sector Towards Sustainable Urban Transport, A Study of Jakarta Intra Urban Toll Road, Indonesia*, Erasmus University of Rotterdam, 2008.
- [3]. McShane W.R & Roess R.P , Prentice Hall Inc, *Traffic Engineering*, Traffic Engineering 4th Edition, 1990
- [4]. Ezra Hauer, *Safety in Geometric Design Standards*, University of Toronto, 1999
- [5]. Fachrurrozy, *Traffic Safety*, Gadjah Mada University, Yogyakarta, 2001.
- [6]. AASHTO, *An Introduction to the Highway Safety Manual*, Highway Safety Manual User Guide, 2003.