International Journal of GEOMATE, April., 2021, Vol.20, Issue 80, pp. 143-151
ISSN: 2186-2982 (P), 2186-2990 (O), Japan, DOI: https://doi.org/10.21660/2021.80.j2046
Geotechnique, Construction Materials and Environment

DRIVING SPEED AND HAZARDOUS LOCATION IN CONSTRUCTION WORK ZONE CASE OF HIGHWAY 2 HIN LAT-NON-SA AT

Narongdet Mahasirikul[1], *Preenithi Aksorn[2] and Wuttipong Kusonkhum[3]

[1]Department of Civil Engineering, Faculty of Engineering, Khon Kaen University, Khon Kaen, Thailand.
[2]Sustainable Infrastructure Research and Development Center, Department of Civil Engineering, Faculty of Engineering, Khon Kaen University, Thailand.
[3]Department of Civil Engineering, Faculty of Engineering, North Eastern University, Thailand

*Corresponding Author, Received: 03 Dec. 2020, Revised: 26 Jan. 2021, Accepted: 06 Feb. 2021

ABSTRACT: The construction, repair and maintenance of the highway be always operated. Those operation areas are physically inconvenient to travel; therefore, they could affect safety in driving and cause an accident. Drivers and workers in the maintenance area are risky to have such a consequence. According to the related agencies' reports, the main cause of accident on the highway is driving in high speed or higher than the speed limits. From the previous study, it is found that there are three factors which affect accidents on the highways: drivers, condition of the vehicles, and the environment. Additionally, this research study focused on studying of speed behavior in personal car driving, which capacity is not over seven passengers, on the four-lane national highway. The data collected showed that in the ordinary area of the highway, drivers were likely to drive with higher speed than the limit, but after they drove through the construction area, the drivers were likely to drive with higher speed as well. Finally, the study found that in the practically, most of the drivers do not take the safety instruction serious and even the operation staffs could not install the temporary traffic signs correctly and completely.

Keywords: Speed of Vehicle, Highway Construction, Safety Management

1. INTRODUCTION

Transportation, especially road transport is extremely important to economic growth and distribution of prosperity to the whole country. Back to the first National Economic and Social Development Plan B.E. 2504 (1961 C.E.), Thailand had a policy on highway development to connect the whole country and also with neighbor countries. The policy of road transportation has caused proportion of 87% from all categories of transportation, which has been considered as the biggest part [1]. The national highways, or so called the registered roads, have total distance of 702,210.231 kilometers [2], which have covered most area of the country. In addition, there are four agencies which are responsible for construction, repair and maintenance, which consist of Department of Highways, Department of Rural Roads, Expressway Authority of Thailand under the Ministry of Transport, and Local government organizations under Ministry of Interior. With distance and high demand of travel, it results the high risk of accidents on the highway. This is a huge problem that caught the attention and it is considered as a globally significant problem. World Health Organization (WHO) predicted that the number of deaths and injured from traffic accidents is more likely to be increasing, especially in the developing countries. Additionally, in B.E.2561 (2018 C.E.), the number of deaths in Thailand was 32.7 people per 100,000 populations, or 60 deaths per one day, the average was 22,491 deaths per year. The mentioned statistics of road accidents resulted Thailand to be ranked at number 9 of the world and number 1 of Asia [3]. Moreover, from the statistics report of road accidents in Thailand, it is found that each year the number of road accidents and damage value have been increasing continuously. In B.E.2561 (2018 C.E.), there were 79,117 people in road accidents has been official reported, the total number of deaths was 8,366 and the total number of injured was 5,380 [4]. Besides, the damage value after the road accidents in average per times has been increasing all the time. In B.E. 2561 (2018 C.E.), the total damage value for the whole country was about 328,145 million THB. In addition, from the survey of the Department of Highways, it is found that the number one cause of road accident is driving with high speed which accounted for 77.30%. For the riskiest area to have an accident is a straight road which made up for 64.59%, on the other hand, the four-lane road and the road with traffic isles were also risky to have an accident at 0.45% and 0.74% respectively. In addition, the vehicle types that has the highest number of road accidents, except a motorbike, were a private car and a pick-up truck.

Both type of vehicles has total amount of accidents at 58.66%. (paragraph 1 or). For the factors that cause road accidents, there are three factors: human factor which accounted for 95.62%, highway or environment factor which accounted for 21.56% and vehicle factor which accounted for 27.54% [5].

In the Unites State of America, from statistical data collection of Federal Highway Administration, it pointed out that 68% of Highway budget was spent on highway maintenance, another 23% was spent on extend the current highways, and 9% was spent on the new highway construction [6]. In addition, Thailand in 2019, Ministry of Transportation received the annual budget about 183,732.54 million THB. which was considered as the 5th ministry that received the big budgets out of 20 ministries. The ministry of Transportation could be classified in department levels. In fact, Department of Highways and Department of Rural Roads were the first two departments which received most of the budgets, which were 119,091.21 and 48,089.35 million THB respectively [7]. From those number of budgets, it pointed out the direction of road transportation development in each year and the importance of the national highway construction, repair, and maintenance which the related agencies have been responsible for and it has been necessary to be in process throughout the year.

It is known and agreed that construction on the highways is dangerous for those drivers because of situations and characteristics of roads which drivers must drive differently from the ordinary roads [8]. The drivers would not be able to know traffic conditions and integrity of the front areas. Therefore, the drivers must be more aware of those conditions. Obviously, the construction areas on the highways are risky to have accidents not only for those drivers, but also the operation staffs over there as well since they need to work on the road with many equipment and machines, and especially among the traffic with high speed vehicles. The safety of operation staffs should be considered and well managed throughout the project period. Therefore, in highway construction, safety is as important as project completion [9].

Additionally, it has been encouraged to put the signs in highway constructions area. For the contractors' responsibility, design and installation system are the most important things to be considered, they must be clear for people to look at all the time, therefore they would help reducing the accidents. Even though the related people are aware of road safety regulations which helps reducing the serious accidents in highway constructions, only some of them follow the instructions [10].

Hence, considering the risk of accidents in the national highway construction, repair and maintenance where has physically inconvenient for traffic, many of equipment and machines in the area, imperfections of traffic surfaces and substandard temporary traffic signs installation that provided insufficient information can cause the high risk to have accidents. In fact, the accidents on the highway have never been recorded in statistical numbers and officially broadcasted. However, those accidents have been usually reported via various media, and there was prosecution in various cases. Although the proportion of accidents on the highway construction is less than the accidents on the ordinary roads, the loss and the damage value from it are not what the related people such as driver, operation staffs, and the agencies would expect for.

2. BACKGROUND OF STUDY

2.1 Cause of Accidents

In 1920 Herbert William Heinrich, the expert engineer in safety, had studied about causes that affect an accident in various industries. The result was found that there were three important causes which cause an accident, and the first cause was human cause, which accounted for 88% such as carelessness, disobedience the instruction and process, oversight, having a risky personality, including personality, intelligence, experience, age, level of education, and body fatigue. The second cause was mechanical failure, which made up for 10% such as no installation of the protections, equipment in unavailable conditions or damage, including inappropriate factory area design and unsafe work environment. And the third and last cause was Acts of God, this cause accounted for only 2%, the cause was occurred by nature which was out of control such as storms, floods and thunderbolts.

Later in 1931, the concept of accident cause was developed. The causes of accidents were divided into two points: Unsafe Acts and Unsafe Conditions, each of them accounted for 85% and 15% respectively.

Controlling the vehicle speeds in construction area is considered as the primary task to reduce accidents around the area, it should be done by implementing measures such as using a sign flag to inform drivers, law enforcement, signboards and various signs, narrowing the width of the lanes and rumble strip installation [12]. The studying of drivers' behavior has found that using a flag to inform those drivers could help reducing speed at 19%.

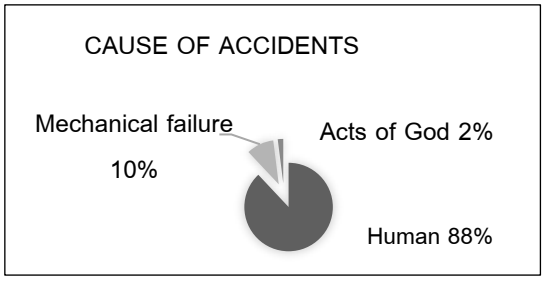

Fig.1 Cause of accidents (Herbert William Heinrich)

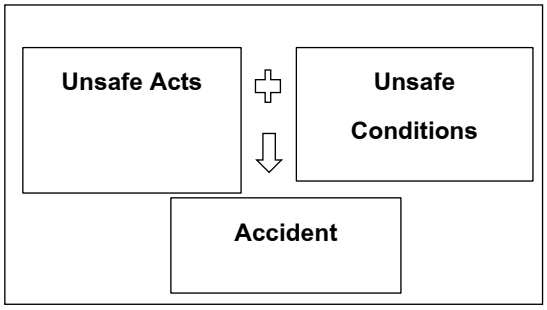

Fig.2 Unsafe Acts/Unsafe Conditions (Herbert William Heinrich)

2.2 Behavior and Speed in Driving

A driver is one of the three main factors in traffic system and also the primary cause of road accidents. Measures in traffic engineering and safety management system would not accomplished as expect without the drivers' cooperation. Hence, education and learning human factors in traffic system is considerably important and necessary [13].

Drivers' behavior has a great influence on driving safety. Human factors such as body fatigue [14], anxiety [15], or emotional conditions [16], affect drivers' potential and efficiency in driving.

In the United State of America, the statistics of accidents on highway constructions had total 642 of deaths, 28% of those cases was from driving with high speed behavior [17].

To drive a vehicle from ordinary road into the construction area, the drivers would alter their driving behavior by reducing some speeds while approaching the construction area, for example, the drivers would wait until they approach to the lane where it is closed and the vehicle could not go pass through, or until they drive through the transition area so they might reduce the speed [18]. addition, in the normal traffic conditions, the drivers have some times to reduce the speed and enough distance to control their vehicles. But on the other hand, in heavy traffic conditions, the drivers would be in the situation that out of control for vehicles and speed [19].

2.3 Temporary Signs in Construction Areas

In construction areas, it is necessary to plan the use of safety equipment such as temporary signs. This plan aims to facilitate vehicles to travel continuously, smooth and safe [20] Moreover, this could facilitate the drivers and the operation staffs in the construction areas as well. The signs in construction area in highway should have project signboard, reduce speed sign and construction zone etc. the Fig 3-7 are show example of sign of Thai policy [4].

There are a variety of safety equipment in highway construction areas depend on the purpose of use, road conditions, or surrounding environment. The road construction is detailed, complicated, unique, and dynamic. Adding or removing safety equipment could be determined by suitability, traffic condition or the supervisor's decision to warn, advise and inform drivers correctly just in time. In fact, planning and installing proper safety equipment would help reducing accidents or damage. Temporary Traffic Control Plan (TTC Plan) is a method of traffic management. In addition, safety management and safety equipment installation in highway constructions has been widely used in order to improve safety and facilitation for vehicles through various equipment such as a sign flag, a traffic signboard, a traffic barrier, a traffic cone and traffic light equipment. Moreover, the equipment must be clearly installed in the indicated areas.

The construction areas could be separated into 4 areas: Advance Warning Area, Transition Area, Activity Area, and Termination Area. Normally, the junction between the ordinary road and the construction area is traffic diversion. The traffic diversion is in transition area where is important to manage the traffic since the vehicles movement needed be bothered, the lane needed to be changed and also the speed needed to be altered. Taper Length, L could be calculated from:

Limited speed under 70 km/h

$$L = WS^2/155 \quad (1)$$

$$L = WS/1.66 \quad (2)$$

Taper length is significant in using traffic control equipment in highway constructions, it is for traffic diversion where there is a construction and a lane closed in the front. In addition, taper length is aimed to provide distance for the drivers to reduce speed and alter the road lane in construction areas.

Reducing vehicle speed just in time before approaching the construction areas is the alternative way to reduce accidents and damage [20], as driving vehicles in construction areas already increase a chance to have an accident in

the first place [21].

3. RESEARCH METHODOLOGY

In this study, the data of speed behavior in personal car driving has been collected from the construction area on the highway no.2, or so called Thanon Mittraphap, where is the junction between Tambon Hin Lat and Tambon Non Sa-at, in Khon Kaen Province, in total distance 150 meters. In addition, the physical characteristic of this highway section is four-lane reinforced concrete, straight way with traffic isles, no crossroad or intersection. Therefore, drivers could drive freely with speed on this section. However, this section is in the responsibility of Khon kaen Highway District 1 and the construction process is operated by a contractor. In addition, an announcement is always made via the agency's website, and the project board, a traffic diversion map, and temporary traffic signs are all installed in construction areas. All of those are approved to operate by the local agency.

In data collection of the speed, the researchers have separated the construction areas into 4 areas according to the standard for determining construction area of Department of Highways. The areas consist of Advance Warning Area, in position 1-2, Transition Area, in position 2-3, Activity Area, in position 3-4, and Termination Area, in position 4-5. Additionally, 5 Speed Gun have been installed from the beginning to the end of each section. Data was collected from the active fields to avoid failures in speed measurement which was affected from drivers' misunderstanding: when drivers drive closer to the speed measurement area, the drivers would notice Speed Guns and consider it as a police's speed camera, so they would reduce speed intentionally. Therefore, the Speed Guns were placed at an angle of 45 degrees to the vehicle's direction, this affected the inexact data: the speed collected was less than the real speed about 70.72% [22]

In addition, the data has been collected from Monday to Sunday in 3 periods of time: at 09.00-11.30, 13.30-16.30 and 19.00-22.00 o'clock, those periods are in normal traffic conditions and not in a rush hour [23]. In the real construction areas, it was quite difficult to collect the data after sunset since there was no street lamp, so this was such an obstacle for data collection. Therefore, this research study would only use the data collection from 2 periods which included 09.00-11.30 and 13.30-16.30 o'clock instead.

The samples in this research were private cars, which in this study would be separate into 3 categories: sedan, SUV, and pick up. Each category consisted of 10 cars per each period of time, thus the total amount would be 60 cars per one day and the total of example is 420 cars. The samples were selected randomly: the first car among a group would be selected because there were no other cars in the front. Additionally, the data of each car needed to be collected completely from 5 positions before collecting the data from the next car. The process has been repeated on and on until the data collection was completed for each category.

Fig.3 Example of project signboard

Fig.4 A reduce speed sign at the construction area 50 km./hr.

4. RESULT

From data collection, The Table 1 and 2 show that both periods at 09.00-11.30 and 13.30-16.30 o'clock have similar average values. The Advance Warning Area, or position 1-2, where was 680 meters in distance, there was a reduce speed sign suggested driving at 50 km/hr. However, all sedan, SUV, and pick up were driven with higher speeds than 90 km/h in both periods of time. Additionally, when all category of samples approached to Transition Area, or position 2-3, which was 60 meters in distance, the speed was reduced. Nevertheless, the speed reduced was still higher than 40 km/h, which was a recommended speed for transition area in both periods of time. When those cars approached to the Active Area, or position 3-4, where was 150 meters in distance with the recommended speed of 30 km/h, the speed was increased in both periods of time. And

the last one, Termination Area, where was 100 meters in distance, the speed of all vehicle was increased to similar level of driving in ordinary surface.

From Fig.1-2, when calculating the collected speeds in each area to find rate of speed change or acceleration, the result has found that at position 1-2 and position 2-3, Sedan, SUV, and Pick up have negative acceleration, which means the speed was reduced. For the position 3-4 and position 4-5, all category has positive acceleration, which means the speed was increased. When considering the accelerations, it is found that position 2-3, or in Transition Area, is the position that has the highest acceleration level from all area.

Fig.5 A traffic diversion sign

Fig.6 A traffic diversion area

Fig.7 The recommended speed before a traffic diversion area 40 km./hr.

Fig.8 Temporary traffic signs before a traffic diversion area

Additionally, Fig.9 and Fig.10 are comparing this acceleration with another acceleration from driving vehicles on the highway construction areas with recommended speeds on the traffic signs of Thai government. The result has found that the acceleration level from the collected speeds is higher than from the recommended one 9.9-11.4 times as show in the Table 3.

The Transition Area where data has been collected was 60 meters in distance. The recommendation speed was at 40 km/h with taper length of 30 meters. However, In the Table 4-5 show the data collection, the result has found that those sample vehicles exceeded the speed limit, which is 90 km/h, and exceeded the recommend speed which is only 40 km/h. It resulted in insufficient taper length, which would not be enough for a vehicle to slow down its speed before approaching safely to the Active Area. Moreover, this would cause the sudden change of speed and the chance of having accidents.

The standard deviation of car's speed is show in the Table 6 -7. The result show that the validity of average is more different between cars.

5. CONCLUSION AND DISSCOSSION

From data collection of total 420 cars which travelled through the highway construction areas from 09.00-11. 30and1 3.30-16.30 o'clock for a week, the result has found that the three categories of cars in this study have exceeded limited speed in normal traffic on the highway. However, when they approached to the construction areas where the temporary traffic signs and safety equipment were installed according to safety standard of the local agency, those cars have reduced the speed. Nevertheless, the speeds have still exceeded the recommended speed for highway construction areas. Additionally, the riskiest area of having accidents is Transition Area.

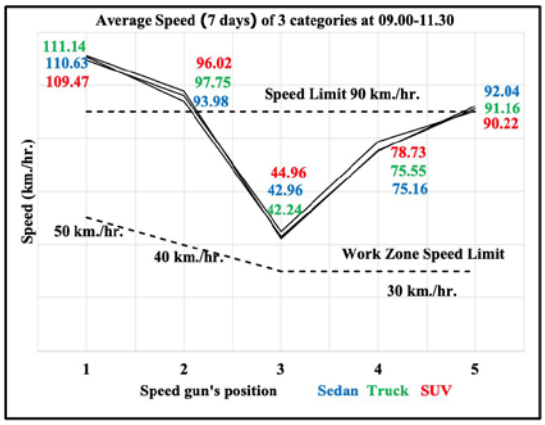

Fig.9 Average speed of 3 categories at 09.00-11.30

The Transition Area is extremely significant since it is where traffic is altered, and the surfaces of the roads would be disturbed. The speed that all samples have while approaching the Transition Area was negative acceleration, or retardation, in higher level than the acceleration in the recommended one 9.9-11.4 times [5]. This resulted the risky area to have accidents among vehicles since there are traffic diversions and merging of two lanes into one, and accidents between vehicles and the operation staffs in construction areas as the vehicle speed could not be reduced in time or ceased safely. In addition, narrowing a traffic lane is such a way to reduce vehicles speed efficiently and this way would help reducing vehicles' average speed up to 7%. However, the most efficient way to reduce speed when vehicles are approaching to the Active Area is using the flag to inform drivers [13].

6. RECOMMENDATIONS

This study of speed behavior in personal car driving on construction area of the four-lane highway with lane transition still could not indicate the related cause or factor in driving with high speed clearly. For the further studies, there should be the study of designing data collection to study about causes that result speed behavior of drivers. Additionally, considering of temporary traffic signs and safety equipment installation follows the standard, the positions of installation were calculated by the recommended speed in construction areas. Practically, most of the drivers do not take the safety instruction serious and even the operation staffs could not install the temporary traffic signs correctly and completely. Therefore, the alternative way to reduce a chance of having accidents is to extend the time for recognition for drivers, so they could acknowledge the constructions toward the highways and travel through the construction areas safely.

Table 1 Acceleration in each area of the three categories of cars at09 .00-11.30 o'clock

	Period 09.00-11.30				
	Position	Distance (S) meters	Initial velocity (U) m/s	Final velocity (V) m/s	Acceleration (A) m/s^2
SEDAN	1-2	680	30.73	26.11	-0.19
	2-3	60	26.11	11.93	-4.49
	3-4	150	11.93	20.88	0.98
	4-5	100	20.88	25.57	1.09
SUV	1-2	680	30.41	26.67	-0.16
	2-3	60	26.67	12.49	-4.63
	3-4	150	12.49	21.87	1.07
	4-5	100	21.87	25.06	0.75
TRUCK	1-2	680	30.87	27.15	-0.16
	2-3	60	27.15	11.73	-5.00
	3-4	150	11.73	20.99	1.01
	4-5	100	20.99	25.32	1.00

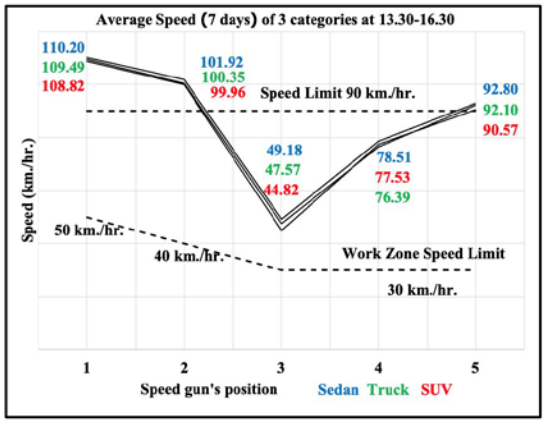

Fig.10 Average speed of 3 categories at 13.30-16.30 o'clock

7. COPYRIGT

Copyright form signed by all authors is necessary for GEOMATE. It should be submitted along with the paper submission. Copyright form can be downloaded from geomate web site.

Table 2 Acceleration in each area of the three categories of cars at**13**.**30**-**16**.**30** o'clock

Period 13.30-16.30					
	Position	Distance (S) meters	Initial velocity (U) m/s	Final velocity (V) m/s	Acceleration (A) m/s^2
SEDAN	1-2	680	30.61	28.31	-0.10
	2-3	60	28.31	13.66	-5.12
	3-4	150	13.66	21.81	0.96
	4-5	100	21.81	25.78	0.94
SUV	1-2	680	30.23	27.77	-0.10
	2-3	60	27.77	12.45	-5.13
	3-4	150	12.45	21.54	1.03
	4-5	100	21.54	25.16	0.85
TRUCK	1-2	680	30.41	27.87	-0.11
	2-3	60	27.87	13.21	-5.02
	3-4	150	13.21	21.22	0.92
	4-5	100	21.22	25.58	1.02

Table 3 Acceleration in each area when driving with the recommended speed.

Position	Distance (S) meters	Initial velocity (U) m/s	Final velocity (V) m/s	Acceleration (A) m/s^2
1-2	680	13.9 (50)	11.1 (40)	-0.05
2-3	60	11.1 (40)	8.3 (30)	-0.45
3-4	150	8.3 (30)	8.3 (30)	0
4-5	100	8.3 (30)	8.3 (30)	0

Note: () It is average velocity with legal.

8. ACKNOWLEDGMENTS

We would like to thank College of Local Administration, Khon Kaen University for their funding support.

Table 4 Shifting Taper follows the actual speeds collected from **09**.**00**-**11**.**30** o'clock

Period 09.00-11.30			
Category	Speed in construction area (km/h)	Width of Offset (m)	Taper length (m)
SEDAN	93.98	3	170.95
SUV	96.02	3	184.94
PICK UP	97.75	3	178.45

Table 5 Shifting Taper follows the actual speeds collected from 13.30-16.30 o'clock

Period 13.30-16.30			
Category	Speed in construction area (km/h)	Width of Offset (m)	Taper length (m)
SEDAN	101.92	3	201.05
SUV	99.96	3	193.39
PICK UP	100.35	3	194.91

.

Table 6 The Standard Deviation of car's speed from 09.00-11.30 o'clock

Period 09.00-11.30					
Point	1	2	3	4	5
	S.D.	S.D.	S.D.	S.D.	S.D.
Sedan	16.75	21.92	16.88	11.07	14.05
Truck	16.80	22.57	16.70	11.06	14.03
SUV	16.47	22.02	16.50	11.08	13.83

Table 7 The Standard Deviation of car's speed from 13.30-16.30 o'clock

Period 13.30-16.30					
Point	1	2	3	4	5
	S.D.	S.D.	S.D.	S.D.	S.D.
Sedan	16.75	21.92	16.88	11.07	14.05
Truck	16.80	22.57	16.70	11.06	14.03
SUV	16.47	22.02	16.50	11.08	13.83

9. REFERENCES

[1] Parliamentary Budget Office., The Secretary of the House of Representatives, Guidelines for the Development of the Country's Transportationsystem, 1st edition, 2019.

[2] ministry of Transport operation center (MOTOC)., Division of Statistics and Information, 2017.

[3] World Health Organization., Global status report on road safety 2018: Summary. World Health Organization, 2018.

[4] Office of Transportation and Traffic Policy and Planning., Office of Highway Safety, Division of Highway Safety Standard, Road Accident Situation Analysis Report, Department of Highway, 2018.

[5] Pongpullponsak A., Laosirihongthong T. and Kuakasemboon K., The Study of Factors Component Relating to Road Accidents. KMUTT Research and Development Journal, Vol. 27, Issue 3, 2004, pp. 333-356.

[6] Holtz R., Barry C. and Berg R., Federal Highway Administration, 1998.

[7] Chohan and U. W., Independent budget offices and the politics–administration dichotomy. International Journal of Public Administration, Vol. 41, Issue 12, 2018, pp. 1009-1017.

[8] Al-Bdairi., N. S. S., Behnood A. and Hernandez S., Temporal stability of driver injury severities in animal-vehicle collisions: A random parameters with heterogeneity in means (and variances) approach. Analytic methods in accident research, Vol. 26, 2020, pp. 100-120.

[9] Cho C., Park J., Kim K and Sakhakarmi S., Machine learning for assessing real-time safety conditions of scaffolds. In: ISARC. Proceedings of the International Symposium on Automation and Robotics in Construction. IAARC Publications, 2018, pp. 1-8.

[10] Gannapathy V. R., Subramaniam S. K., Diah A. M., Suaidi M. K. and Hamidon A. H., Risk factors in a road construction site. Proceedings of the World Academy of Science, Engineering and Technology, Vol. 46, 2008, pp. 640-643.

[11] Penkey., S. P., and Siddiqui N. A., A Review on Accident Pyramid and its Empirical Interpretation in Oil & Gas Industry (Upstream). International Journal of Scientific and Research Publications, Vol. 5, Issue 1, 2015, pp. 1-3.

[12] Richards, Stephen H., Robert C. Wunderlich and Conrad L., Field evaluation of work zone speed control techniques. Transportation Research Record, Vol. 1035, 1985, pp. 66-78.

[13] Office of Transportation and Traffic Policy and Planning., Office of Highway Safety, Division of Highway Safety Standard, Road Accident Situation Analysis Report, Department of Highway, 2017.

[14] Filtness., Ashleigh J., Louise A. Reyner and James A. Horne., Driver sleepiness—Comparisons between young and older men during a monotonous afternoon simulated drive. Biological psychology, Vol. 89, Issue 3, 2012, pp. 580-583.

[15] Regan, Michael A., Charlene Hallett and Craig P. Gordon., Driver distraction and driver inattention: Definition, relationship and taxonomy. Accident Analysis & Prevention, Vol. 43, Issue 5, 2011, pp. 1771-1781.

[16] Rhodes., Nancy., Kelly Pivik., and Marnie Sutton., Risky driving among young male drivers: The effects of mood and passengers. Transportation research part F: traffic psychology and behaviour, Vol. 28, 2015, pp. 65-76.

[17] Schattler K., Vadlamudi N. and Riemann, A., Safety evaluation of red light running camera intersections in illinois. Illinois Center for Transportation/Illinois Department of Transportation, 2017.

[18] Benekohal., R. F. and Wang L., Speed change distribution of vehicles in a highway work zone. Transportation Research Record, Vol. 1409, 1993, pp. 42-51.

[19] Sorock., G. S., Ranney T. A. and Lehto M. R., Motor vehicle crashes in roadway construction workzones: an analysis using narrative text from insurance claims. Accident Analysis & Prevention, Vol. 28, Issue 1, 1996, pp. 131-138.

[20] Office of Transportation and Traffic Policy and Planning., Office of Highway Safety, Division of Highway Safety Standard, Road Accident Situation Analysis Report, Department of Highway, 2018.

[21] Whitmire II J., Morgan J. F., Oron-Gilad T. and Hancock P. A., The effect of in-vehicle warning systems on speed compliance in work zones. Transportation research part F: traffic

psychology and behavior, Vol. 14, Issue 5, 2011, pp. 331-340.

[22] Wang J. S., Knipling R. R. and Goodman M. J., The role of driver inattention in crashes: New statistics from the 1995 Crashworthiness Data System. In: 40th annual proceedings of the Association for the Advancement of Automotive Medicine, 1996, pp. 392.

[23] Office of Transportation and Traffic Policy and Planning., Urban and City Traffic Management Standard Development Planning Project, Traffic Survey and Analysis, 2016.

Copyright © Int. J. of GEOMATE. All rights reserved, including the making of copies unless permission is obtained from the copyright proprietors.