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Factors Affecting the Road Safety Audit in Operational Stage

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ABSTRACT— Road safety audit is in the operational stage important to be conducted properly to ensure the safe operation of a road. There are several factors which might be affecting successful road safety audit, e.g. audit object, road environment, auditing method, auditor characteristics, etc. Those factors spread among either academic literature or audit regulations. This paper is intended to describe the factors in detail and at the end list the draft questionnaire which was used in the pilot survey before the main survey to determine the most important factors conducted later.

KEYWORDS: Factors, Affecting, Road Safety Audit, Operational Stage.

1. INTRODUCTION

According to [1], [2] a self-explaining road is a road that provides information to road users regarding the condition and situation of the road which will be passed by the road users to encourage appropriate road user behavior. Meanwhile, the forgiving road is a road infrastructure that can minimize road user error and fatalities. The road designer does not only comply with road geometric standards but equips the road with road furniture including a guardrail that can keep the involving vehicles within the original lanes and minimize fatalities. Road safety audits in the operational stage will ensure that both self-explaining a forgiving road is realized. There are several factors which might be affecting successful road safety audit, e.g. audit object, road environment, auditing method, auditor characteristics, etc. Those factors spread among either academic literature or audit regulations. The following chapters will describe those factors further one by one.

2. Audit Object

According to [3] road safety audit is closely related to road condition such as road surface, road geometric, and road furniture conditions. These three conditions can be considered as main road safety audit objects. [4] stated that road geometric condition that should be considered in road safety audit includes overtaking sight distance, the relative position of the road shoulder surface to the road pavement surface, curve radius, etc. Meanwhile, road surface condition in road safety audit includes the existence of defects such as rupture of the road edge, cracks (grid cracking, large crack), potholes, or subsidence depressions. Lastly, road furniture considered in road safety audit includes the availability of speed limit in curve signs, road lightings, traffic signal before the curve, etc. [5] specify further regarding road geometric condition to be audited, e.g. sharp curve with a small radius in which accident rate in average 1.5 to 4 times higher, especially when the driver operates the car in high speed as stated in [6]. Road geometric condition might be different in different road sections such as road links, junctions or flyovers/ underpasses, e.g. in term of speeds as stated in [7], or in the different geometric type of road sections such as straight road or curved road as stated in [8]. [9] even conducted a study regarding the relationship driving speed in sharp curves and driver heartbeats. The result can be used to improve road safety. [10] stated that accident probability can be predicted by lane width, road widening in the curve, shoulder width, stopping sight distance, overtaking sight distance, curve radius, maximum super- elevation radius ratio of 2 consecutive curves, maximum tangent length, availability of transition curves, maximum tangent length, slope (%), slope length, side slope, clear zone, road lighting, sign and marking, side slope and clear zone. [11] found that one of the important things considered in the road network risk index is the anomaly of the road surface.

Module 7 on the road sign, road marking and road delineation [12] in 2016 regulates the followings:

- Road sign regulation and principles of the road sign and road marking.
- Type of road sign, design, and choice of the road sign and road sign placement.
- Type of road marking, road marking as a symbol, and road marking placement.
- Harmonizing road sign and road marking and their production.
- Principles of delineation.

As part of the road furniture, by complying with all regulations on the road sign, road marking and road delineation we can ensure safer road operation.

3. Road Environment

It is difficult to find the right term as the title of this chapter. However, here, the road environment is defined as everything related to the road, but no the road itself such as road traffic flow, road traffic load, natural/man-made hazard, and road space disturbance. [13] stated that even an improper road furniture placement might become a man-made hazard and therefore should be corrected after discovered in the road safety audit process. For example, improper installation of rumble strips although the actual objective of rumble strips installation is to reduce speed together with speed limit road sign as stated in [5]. A similar situation can be triggered by a speed hump, despite its original objective to reduce speed as stated in [14]. Furthermore, [14] describe the example of natural hazards, such as trees, rocks, etc, and other examples of man-mad hazards such as toad lightings, road signs, public transport stops, physical objects, and traffic lights. [15] reported their road safety audit of rural roads. The general public might expect that there will be fewer accidents on such low volume roads such as rural roads. However, low traffic volume naturally allows high speeds which in turn might disadvantage for road safety. [16] conducted a study in the North Corridor of Kenya. He assessed the social-economic impact of road class upgrading/ higher traffic volume on monitoring dan evaluation of road safety aspects. He also warns the potential safety reduction due to higher speed in higher road class especially potential pedestrian crossing accidents. He stated that the driver was the most frequent trigger of accidents (42%), followed by the pedestrian crossing (22%). Meanwhile, [17] stated that 92% pedestrian in major arterial and 54% in local roads. [18] found that unfamiliar driver on a certain road during summer involved in higher accident rates. [19] stated that major human contributions on accidents were incorrect observation, over- speed, lack of attention, inappropriate crash avoidance, and internal disturbance. The major environmental contribution to accidents was covered eyesight (road-based) and slippery road. Major vehicle contributions were a brake system failure, improper tire tread depth, imbalance brake, low tire inflation, and covered eyesight (vehicle-based). [20] found that the injury due to crash on the flexible barrier was more severe compared to the crash on semi-rigid and rigid barriers.

Module 6 on roadsides hazards [21] in 2016 regulates:

- General description of roadside hazards (background, definition, and roadside objects as a potential hazard).
- Strategy to face roadside hazards (clear zone concept, keeping the vehicle on road, removing hazards, relocating hazards, changing hazards, covering hazards, safe end terminal, special use of guardrails. temporary barrier, guardrail problems, guardrails maintenance, safe guardrails ends, and bridge parapet as a hazard.
- Roadside hazards implementation (roadside hazards problems, in location problems, safe roadsides for motorcyclists, etc.

4. Auditing Method

[22] define road safety audits as a formal procedure to evaluate accident potential, the safety performance of new road construction programs, and existing road maintenance. [23] stated that audit results described by calculation of risk value indicators, whether a certain part of road infrastructures was dangerous or very

dangerous which require improvement to reduce potential accidents. According to [13], all of the audited roads were given conditional acceptance status with a high accident rate still very high. [24], stated that the determination of accident-prone location can be done by using accident rate and EAN (equivalent accident number). [25] develop a model that can be used to conduct a review on the effectiveness of treatment program/ road infrastructure improvement. [26] made a model that can predict the relationship between the number of accident and driver/ vehicle and road environment conditions. A segment with more than 12 accidents per 3 years considered as a dangerous segment. [27] suggest the of use upper control limit to determine accident-prone location. According to the [28], good road safety audits should pro-actively avoid accidents before the real accident happens. They also suggest that road safety audits should be conducted in a different stage of the road life, i.e. planning, design, detailed design, determination of specification, construction, operation, etc. to avoid accidents in a different stage of road life. [29] suggests a similar approach. [30] stated that compliance with road design and construction standards does not guarantee traffic safety. The focus should be given to the weakest component in the traffic system, i.e. the driver facing congestion with stress which increases accident risk. [31] suggest safe route alternatives at a preliminary design to improve from passive audit into active audit and to improve the quality of road safety along its lifecycle. In a cost-benefit analysis, safety improvement can be considered as a benefit after accident reduction being quantified. [32] suggest a parsimony approach using minimum input but good quality of road safety audit. [2] stated that it is important to improve driver skills to make the right decision in the road. [8] made a ranking of road hazardous locations both in straight/ curve/ junction parts of the road. [33] conducted a video observation to capture the safety performance of a junction in Italia. The following parameters were observed, i.e. maximum deceleration to avoid crash (DRAC), time-to-collision (TTC), the proportion of stopping distance (PSD), and crash potential index (CPI). [17] conducted a relationship analysis between pedestrian safety, urban road type, and vehicle traffic flow. Karim et al [20] analyze personal injury risk related to a different type of road barrier. According to Guidance on Construction and Building Pd T-17-2005-B [34], a road safety audit is an effort to identify a potential hazard that can occur from the road and the environment to the traffic flow. In general road safety audit procedure between countries is typical with some exceptions due to different vehicle type composition and driving culture.

Module 3 Accident Data [35] in 2016 regulates:

- Definition of a traffic accident, the main source of traffic accident data, the use of traffic accident data
- Traffic accident data record and description.
- Accident data analysis: weighing method, accident-prone area determination, histogram and cross-tabulation method, road accident characteristics, analysis stage.
- Traffic accident analysis (case study)

Module 4 Investigation of Accident-Prone Area and Mitigation Method [36] in 2016 regulates:

- Definition of accident-prone area, development of accident-prone mitigation priority, the procedure to conduct accident-prone area investigation,
- Development of accident-prone area mitigation and calculating cost and benefit of mitigation.

5. Auditor Characteristics

A profession as a road safety auditor may require a certain personality. As road safety audit involves field observation activities that may require gross psychomotor skills. Road safety auditors should also be meticulous to ensure accurate observation, analysis, and reports. Road safety auditors should also be responsible and honest and therefore will disclose the audit result as discovered in the field. [22] stated that there should be good teamwork between members of auditors, internally and between the auditor team and the client, consultant, and contractor. Road safety audits should produce an accurate audit report after a careful process considering the overall environment of the audited road links. Therefore, the report will be appropriate

for publication and can be accounted for. The auditors should also collect data by reading through previous audit reports in the same or nearby road links as stated in [7], [37] stated that according to European Union Regulation, all Trans-Europe road networks should be audited. Therefore, they develop the road safety course based on a survey conducted in 10 countries, mainly in Australia and Europe, i.e. Sweden, Czech Republic, Hungary, Slovenia, Portugal, Italy, Switzerland, Netherland, Germany. The survey includes the availability and the use of road safety audits, implementation of the road safety audit, pilot-training, certification of road safety auditor, road safety audit course in the surveyed countries along with expected competence from junior and senior road safety auditor. There were 6 topics of the road safety audit course. Two of them were offered in all ten countries, i.e. road safety audit process and road safety management & regulation framework. One of them was offered in all ten countries except for Italy and Portugal, i.e. human factors in road design. One of them was offered in all ten countries except for Germany and Italy, i.e. safe system approach. One of them was offered in all ten countries except for Netherland and Portugal, i.e. accident analysis. Finally, one of them was offered in Germany, Italy, Hungary, and the Czech Republic, i.e. road design. [37] also stated that, road safety auditor should at least get a bachelor degree in Civil Engineering with minimum experience of two years in road design and/ or construction and has some knowledge on road safety.

6. Questionnaires Design

We have tested our questionnaire regarding factors affecting successful road safety audit (prepared partly from 4 previous chapters of the literature review). The Pilot survey was conducted to 13 expert respondents of road safety consultant and other 13 expert respondents of road safety regulator. The respondents were asked to answer two things for each statement, i.e. regarding its importance (from 1 Not Important At All to 4 Very Important) and regarding its current level of compliance (from 1 Not Complied At All to 4 Perfectly Complied). The following is the list of the complete questionnaire (non-valid item based on pilot survey result from either consultant or regulator will be marked):

1. Knowledge of road safety audit measured by possessed training.
2. Understanding on road safety is provided from the training module.
3. Implementation of a road safety audit results in line with accurate independent recommendation.
4. Understanding of road safety audit based on the training module will result in appropriate analysis ability (not valid).
5. Continuous appropriate experience enables appropriate synthesis toward road safety audit (not valid).
6. Every stage in road safety audits requires evaluation for improvement (not valid).
7. The Auditor's ability to assess road facility standard compliance affects road safety audit quality.
8. Road safety audit requires accuracy as its nature of repetitive tasks along with a road link.
9. A road safety audit will be successful if the auditor is interested in the tasks.
10. The ability of an auditor differs from one to another due to the talent.
11. A road safety audit will be successful if the auditor can manage the audit stages.
12. Various training joined by the auditor will improve the competence of the auditor (not valid).
13. Skills obtained from the training will be evaluated based on the compliance to the standard.
14. The auditor can assess compliance with a road to the standard.
15. The auditor can conduct audit tasks quickly, correctly, and accurately.
16. Every accident has a different severity affecting the level of fatality.
17. Accident characteristic is affected by 67 accident types according to the national traffic police cluster (not valid).
18. Accident severity is affected by the appropriateness of treatment after the accident.
19. The main cause of the accident is a human being.
20. Human negligence in the traffic is the major contributor to accidents increase.
21. Accident cost is calculated from losses suffered by the accident victim.

22. According to national traffic police, an accident is categorized into heavy, medium, and light.
23. The availability of regulation shows the effort of the government to provide a law umbrella for road safety improvement.
24. The related government institution implements the regulation to reach the safer road.
25. The government implements public discipline to keep the traffic in order.
26. The related institution implements the regulation to reach a safer road.
27. Road safety laws containing safer roads can be the legal basis for a road safety audit.
28. Related regulation for the safer road can be the legal basis for a road safety audit to determine the deficiencies of the road link.
29. Policy on a safer road can be used to execute a road safety audit.
30. Related institutions are compulsory to be integrated as determine in the National General Plan on Road Safety.
31. Related institutions are compulsory to be integrated as determine in the government policy.
32. All road safety audit teams are compulsory to work together according to the duty of each field (not valid).
33. The accident fatality indicator is comparable with accident equivalent number (not valid).
34. Road with safety improvement can be described by a decreasing number of accidents in a consecutive year.
35. Road safety can be described by the road's ability to reduce accidents with overall infrastructure conditions.
36. A road is eligible for use after becoming a safer road (forgiving/ self-explaining/ self-enforcement road (not valid).
37. Road alignment design using safety aspects in the geometric design standard.
38. Road operational speed according to the road class is not exceeded by the driver.
39. Road design along with road elements are easy to comprehend to predict the condition of the consecutive road segment (not valid).
40. Primary data is obtained based on direct observation.
41. Secondary data is obtained from the institution owning time series data.
42. Accident data is obtained from national traffic police within 5 consecutive years.
43. Information provided in the road link will avoid the driver from a surprising factor due to hazards (not valid).
44. Driver characteristic affects accident fatality,
45. Driver disobedient on traffic rule often causes an accident (not valid).
46. Road safety is the objective of every road user (not valid).
47. A road safety audit requires an appropriate method to get the result as expected.
48. Accident equivalent number and upper control limit are the most common methods to classify accident- prone areas in certain road links.
49. The accident is affected by many factors. Therefore, to find out the most dominant affecting factor, the development of accident cause development (not valid).
50. By using a statistical model, we can find factors affecting road safety audits.
51. Road safety audits consist of several stages to provide appropriate recommendations.
52.Implementation of road safety audit recommendations will reduce accident fatality.
53. A road safety audit is triggered by a high fatality in a road link.
54. Skills to conduct a road safety audit are obtained from regular training.
55. To reach the result of road safety audit recommendation should be supported by appropriate road safety audit management.
56. Auditor has an important role in the success of the road safety audit based on training obtained from

the training process managed by training management.

57. Road safety audit management is important to manage the overall road safety audit process, from auditor team recruitment up to recommending the road safety audit result.
58. Institution related to safer road procurement is the Ministry of Public Work and People Housing, i,e, Directorate General of Highways.
59. General National Plan on Road Safety endorses integrated institutions.
60. A team for conducting road safety audits is a complete team consists of required skills.
61. The safety of road users is the objective of a safer road for all national roads in Indonesia.
62. The reduction of accident fatality in a road link is a result of the road safety audit process.
63. The change of road class/ function in the field is affected by the environment.
64. The existing lane width affects road safety.
65. The existing carriage-way width affects road safety.
66. The existing road has a median.
67. The median of the existing road is a raised median.
68. The median of the existing road complies with the standard design.
69. The median of the existing road is equipped with a barrier (not valid).
70. If the barrier in the median is in the form of a guardrail, its height and strength comply with the standard.
71. The width of the median of the existing road complies with the standard.
72. The width of the existing separator complies with the standard (not valid).
73. The width of the shoulder in the existing road complies with standard (not valid).
74. There is no gap between the surface of the shoulder and the surface of the pavement in the existing road (not valid).
75. The surface of the shoulder is lower than the surface of the pavement in the existing road.
76. The width of the shoulder of the existing road complies with the standard.
77. The height of the median of the existing road complies with the standard.
78. The height of the separator of the existing road complies with the standard.
79. The width of the sidewalk of the existing road complies with the standard.
80. The width of the shoulder of the existing toad complies with the standard.
81. The drainage dimension and design comply with the standard.
82. The width of the drainage complies with the standard.
83. The speed design complies with the road class and function.
84. The design speed complies with the standard.
85. The operational speed complies with the standard.
86. There are plantations/ trees on the roadside.
87. The trees obstruct the sight-distance.
88. There is a bus stop on the road (not valid).
89. The bus stop obstructs the sight-distance.
90. The sight-distance is sufficient to be used in the route.
91. The sight-distance given in the junction, (pedestrian, bicycle, train, etc) crossing is sufficient.
92. The horizontal and vertical alignment match to the 85% traffic speed.
93. The warning sign is required.
94. The speed limit sign is required.
95. A special curve requires a special speed limit sign.
96. Some road links are confusing.
97. Road alignment is clear and well defined.
98.Defected pavement has been replaced or repaired.

99. Old pavement marking is replaced according to the standard.
100. Road lightings and a strip of trees match to the road alignment.
101. There are overtaking lanes that comply with the standard.
102. The width of overtaking lanes complies with the standard.
103. There are overtaking road marking and road signs available and comply with the standard in the overtaking lanes.
104. There is a special lane for heavy vehicles and buses at the climbing alignment.
105. The length and the width of the special climbing lane comply with the standard.
106. The length and the gradient of the special climbing lane comply with the standard.
107. There are available road marking and road signs to indicate climbing lane comply with the standard.
108. The lane width, pavement width including bridge width, consistent without constriction.
109. The shoulder width complies with the standard.
110. The shoulder can be passed by the vehicles and road users.
111. The crossing in the shoulder is sufficient for the drainage according to the standard.
112. The placement of electrical and telecommunication poles safe for traffic.
113. Constriction road sign should be provided when necessary.
114. There should be a road sign and facility to control speed before the road constriction.
115. Road lightings are functioning well.
116. Road lightings are located sufficiently at junctions, roundabouts, pedestrian/ bicycle crossing.
117. Road lighting poles types comply with the standard in all locations.
118. There is no area with conflicting lighting between road light or sign.
119. There are lightings for road signs that comply with the standard, especially additional road signs.
120. In two-ways roads, there are disturbing road-lights causing glare at night.
121. There are glare lights from the sun in the morning and in the afternoon.
122. Availability of glare screen in the required area.
123. The traffic light is available and appropriately located.
124. The traffic light is working well.
125. The traffic light is clearly seen (not obstructed).
126. The warning and the guidance signs are located according to the standard and therefore not confusing (not valid).
127. There is an over-placement of road signs.
128. Road signs are installed in the right place, correct height, and with appropriate side free space.
129. Road sign placement does not obstruct the sight-distance, especially for turning vehicles (not valid).
130. Every road signs are effective for all conditions (day/ night, rain, low intensity of light, and glare) (not valid).
131. Road signs are according to the manual/ standard (not valid).
132. Other equipment/ road signs are obstructing the eye-sight of pedestrians.
133. There is a special sign for the elderly and people with disabilities who walk.
134. There are no serious defect on the road surface causing safety problems such as vehicle out of control
135. The safety barrier is installed pada important locations such as bridges according to the standard.
136. Crash barrier system has been installed according to the standard and the objective of the installment.
137. The length and the placement of the barrier at each installed location are according to the standard.
138. There is box control nearby the billboard according to the standard.
139. The position of box control, box culvert, direction sign, and the billboard safe from traffic lanes.
140. The position of objects in the left- and right-hand sides of the road do not obstruct the driver's eye-sight.
141. The pavement skid resistance is sufficient, including at the curve, downhill, and near the junction

segments.

142. The pavement skid resistance is tested regularly.
143. The pavement is free from inundation causing a safety problem.
144. The pavement is free from landslides.
145. Routine maintenance will ensure a safe road infrastructure.
146. The completeness of road facilities is causing a safe road.
147. The defect of road surface causing accidents especially at high speed.
148. Road operation speed is affected by the geometric condition.
149. The long road segment affects the level of difficulty to determine the accident area.
150. Road segment containing accident-prone location affecting the mitigation method.
151. Accident fatality affecting the determination of accident-prone location.
152. To localize accident-prone location, segmentation of road link is conducted.
153. Accident location becomes an accident-prone area if the accident exceeds the limit.
154. The accident environment affects accident fatality.
155. On the left and right sides of the road, objects are obstructing the driver's sight-distance which may cause an accident.
156. In the road median, there are objects obstructing the driver's sight-distance which may cause an accident.
157. Variation, number, and type of vehicles passing the road are affecting road safety conditions.
158. Road furniture infrastructure is affecting road safety characteristics.
159. Speed gun measures driver spot speeds.
160. All equipment should be maintained and calibrated regularly.
161. The equipment condition affects audit field observation results.

7. Conclusions and Recommendations

Based on the above literature review and item validation tests, there were 140 valid items and 21 invalid items in the questionnaire. These items were spread into four groups, i.e. audit object, road environment, auditing method, and auditor characteristics. Besides statistical tests using responses from 26 expert respondents in the pilot survey, further refinement on the instrument to check the consistency of wording and whether all valid items are suitable for both importance and compliance responses should be conducted in the further work before the instrument is used in the full sample.

8. References

[1] Herrstedt, L. (2006). Self-Explaining and Forgiving Roads – Speed Management in Rural Areas. ARRB Conference, (October), 1–14.

[2] Dudziak, M., Lewandowski, A., & Śledziński, M. (2017). Uncommon Road Safety Hazards. Procedia Engineering, 177, 375–380.

[3] Sutandi, A. C. (2014). Integrated Road Safety Approach Towards Safer Road in Indonesia. Jurnal Transportasi 14(2), 97–106.

[4] Mulyono, A. T., (2009), Sistem Keselamatan Jalan untuk Mengurangi Defisiensi Infrastruktur Jalan Menuju Jalan Berkeselamatan, Prosiding Konferensi Nasional Teknik Sipil-3 (Konteks-3), ISBN 927- 979-15429-3-7, Jakarta.

[5] Manggala, R., J, J. A., Purwanto, D. & I, A. K. (2015). Studi Kasus Faktor Penyebab Kecelakaan Lalu

Lintas Pada Tikungan Tajam. Karya Teknik Sipil, 4(4), 462–470.

[6] Purwanto, D., Kusuma Indriastuti, A., & Hari Basuki, K. (2016). Hubungan antara Kecepatan dan Kondisi Geometrik Jalan yang Berpotensi Menyebabkan Kecelakaan Lalu Lintas pada Tikungan. Media Komunikasi Teknik Sipil, 21(2), 83.

[7] Suwarto, F. and Nugroho A., (2019). Audit Keselamatan Jalan sebagai Dasar Implementasi Perencanaan Karakteristik Jalan. Jurnal Proyek Teknik Sipil, 2 (1), 20 -24, E-ISSN-2654-4482.

[8] Agarwal Pradeep, K., Patil Premit, K. & Mehar, R. (2013). A Methodology for Ranking Safety Hazardous Locations Using Analytical Hierarchy Prosess. 2nd Transport Research Group of India., Procedia Social and Behavioral Sciences 104, 1030-1037.

[9] Qiao, J., Wen Ying, Y. & Zhou, R. (2011). Curved Section of Road Safety Audit Model Based on Humanization on the Mountain Two-Lane Highway, First International Conference on Transportation Information and Safety (ICTIS).

[10] Idalin, F., Malkhamah, S, & Suparma Latif, B. (2018). Pengembangan Metode Prediksi Probabilitas Kecelakaan Pada Suatu Ruas Jalan Antarkota Berdasarkan Kondisi Geometrik Jalan Dan Karakteristik Lalu Lintas. Jurnal Transportasi 18(2), 145-152.

[11] Rosolino, V., Teresa, I., Vittorio, A., Carmine Festa, D., Antonio, T., Daniele, R. & Claudio, Z. (2014). Road Safety Performance Assessment: A New Road Network Risk Index for Info Mobility. Procedia Social and Behavioral Sciences 111, 624-633.

[12] Modul 7-Rambu, Marka dan Deliniasi (2016). Kementerian Pekerjaan Umum dan Perumahan Rakyat.

[13] Tjahjono, T. (2016). Upaya peningkatan keselamatan pada jalan nasional indonesia. Jurnal Transportasi 16(2), 143-150.

[14] Usman Muh., Y., Sulistio, H. & Abusini, S. (2014). Kajian Audit Keselamatan Jalan raya Kapongan Kabupaten Situbondo, Jurnal Rekayasa Sipil Universitas Brawijaya, 8(3) ISSN 1978-5658.

[15] Naveen, N., Rajesh, M., Srinivas, M., & Fasioddin, M. (2017). Road Safety Audit of a Rural Road. International Journal of Civil Engineering and Technology, 8(4), 752–761.

[16] Gichaga, F. J. (2017). The Impact of Road Improvements on Road Safety and Related Characteristics. IATSS Research, 40(2), 72–75.

[17] Galanis, A., Botzoris, G., & Eliou, N. (2017). Pedestrian Road Safety in Relation to Urban Road Type and Traffic Flow. Transportation Research Procedia, 24, 220–227.

[18] Intini, P., Berloco, N., Colonna, P., Ranieri, V., & Ryeng, E. (2018). Exploring the Relationships between Drivers' Familiarity and Two-Lane Rural Road Accidents. A Multi- Level Study. Accident Analysis and Prevention, 111, 280–296.

[19] Treat, J. R., Tumbas, N.S., McDonald, S.T., Shinar, D., Hume, R.D., Mayer, R.E., Stansifer, R.L. &

Castellan, N.J. (1977). Tri-level Study of the Causes of Traffic Accidents. Institute for Research in Public Safety, Indiana University.

[20] Karim, H., Magnusson, R., & Wiklund, M. (2012). Assessment of Injury Rates Associated with Road Barrier Collision. Procedia - Social and Behavioral Sciences, 48, 52–63.

[21] Modul 6-Bahaya Sisi Jalan (2016). Kementerian Pekerjaan Umum dan Perumahan Rakyat.

[22] Bagi, A. S. & Kumar D.N (2012). Road Safety Audit. IOSR Journal of Mechanical and Civil Engineering, 1(6), 01–08.

[23] Mulyono, A. T., Antameng, M, Budiarto Ahmad, A.T. (2010), Audit Defisiensi Keselamatan Infrastruktur Jalan Nasional KM 29-KM 30 Jalur Pantura Jawa, Kabupaten Semarang, Jurnal Teknik Sipil, Jurusan Teknik Sipil dan Lingkungan, Fakultas Teknik Universitas Gadjah Mada.

[24] Indriastuti, A. K., Fauziah, Y., & Priyanto, E. (2011). Karakteristik Kecelakaan dan Audit Keselamatan Jalan pada Ruas Ahmad Yani Surabaya. Jurnal Rekayasa Sipil, 5(1), 40–44.

[25] Rakhmat, L. A., Kusumawati, A., Frazila, R. B., & Hendarto, S. (2012). Pengembangan Model Prediksi Kecelakaan Lalu Lintas pada Jalan Tol Purbaleunyi. Jurnal Teknik Sipil, 19(3), 277.

[26] Putra, Y. P., (2016), Analisis Keselamatan Jalan Tol Dalam Kota Jakarta Ruas Cawang – Tanjung Priok, Magister Thesis. ITB.

[27] Sugiyanto, G. (2010). Biaya Kecelakaan Lalulintas Jalan di Indonesia dan Vietnam. Jurnal Transportasi, 10(2), 135–148.

[28] University of New Brunswick Transportation Group (1999). Road Safety Audit Guidelines. New Brunswick, Canad.

[29] Karsaman, R. H. (2016). Audit Keselamatan Jalan Tol di Indonesia (Studi Kasus Jalan Tol Cikampek-Padalarang/Cipularang). Jurnal Teknik Sipil, 14(3), 135.

[30] Huvarinen, Y., Svatkova, E., Oleshchenko, E., & Pushchina, S. (2017). Road Safety Audit. Transportation Research Procedia, 20, 236–241.

[31] Liu, X., Zhang, J., Zhong, X. & Jia, J. (2012). Research om Highway Route Alternative Based on RoadSafety Audit. CICTP 2012, 239-250.

[32] Bačkalić, T., Jovanović, D., & Bačkalić, S. (2016). Effort Allocation in Rural Road Safety Analysis under Data-Limited Conditions. Journal of Transportation Engineering, 142(2), 1–9.

[33] Guido, G., Saccomanno, F., Vitale, A., Astarita, V., & Festa, D. (2011). Comparing safety performance measures obtained from video capture data. Journal of Transportation Engineering, 137(7), 481–491.

[34] Audit Keselamatan Jalan, Pedoman Konstruksi dan Bangunan Pd T-17-2005-B. Kementerian

Pekerjaan Umum dan Perumahan Rakyat.

[35] Modul 3-Data Kecelakaan Lalu-Lintas (2016). Kementerian Pekerjaan Umum dan Perumahan Rakyat.

[36] Modul 4-Investigasi Lokasi Rawan Kecelakaan dan Program Penangulangannya (2016). Kementerian Pekerjaan Umum dan Perumahan Rakyat.

[37] Vardaki S., Evangelos B., & George K., (2018), Addressing Education and Training Needs of Road Safety Auditors. Cogent Engineering 5(1), 1-19.