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Modeling factors affecting traffic management and reducing accidents on urban roads

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Abstract

Due to the limited internal space of urban tunnels and the inability to manoeuvre the vehicles in them, critical situations will be created for vehicle traffic in accidents. Under these situations, traffic management strategies should be utilized for improving traffic status. The common and applicable strategies in these situations include traffic flow direction, line management, and ramp control. Accordingly, this research is conducted to determine the impact of each of these strategies in the occurrence of the most critical accident in the Niayesh and Resalat tunnels of London. Therefore, the studied areas of tunnels are initially simulated by software and traffic data at the peak hours of the morning in 2013, and then the amounts of traffic flow parameters, the total travel time, delay time, stop time, flow density, and the average velocity of each strategy are studied by defining four different scenarios. The results of conducted survey and analyses indicate that adopting the target strategies of this paper improves the conditions of traffic functional parameters; and according to the comparisons, the traffic flow direction strategy has the highest efficiency in Niayesh tunnel and the ramp control strategy has the highest efficiency in Resalat tunnel.

Keywords: traffic flow direction strategy, line management strategy, ramp control strategy, tunnel, accident
2020 MSC: 49Q22

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1 Introduction

Building the urban tunnels is done with the aim of expanding the highway network as well as facilitating the citizens' movements. However, problems may be arisen in the traffic of vehicles due to its construction along with these positive effects. The traffic unfavourable condition due to the occurrence of accidents in these areas is one of the main problems in this regard. In this situation, traffic management strategies need to be utilized to reduce the negative effects of accidents. These strategies can be adopted in the form of demand and supply management, and the demand management techniques are only applicable due to the sudden occurrence of accidents. The new technologies of identification, intelligent control tools, and the strategies associated with demand management are dramatically adopted with regard to the development of transportation intelligent systems [3]. In this regard, this study utilizes the traffic flow direction strategy, line management and ramp control in the most critical accidents in urban tunnels and studies their effectiveness. Generally, the implementation of a traffic flow direction strategy is done in two ways. First, the situations under which the traffic inflow exceeds the capacity of the main route and it is less than the total capacity of routes; under this situation, the additional traffic flow is transferred to other routes and their traffic capacity is held at the capacity range. However, the second method refers to the situation under which the incoming traffic is more

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than the total capacity of all routes; therefore, the inflow is determined based on the capacity of routes, thus various ways of control should be utilized to maintain the traffic volume at capacity range [37].

The line management strategy is usually adopted for one of the following purposes: Making the traffic flow balanced, increasing capacity, reducing the number of accidents, or a combination of them. Sometimes, this strategy can be implemented by closing the lines or opening them. Under this strategy, the control place, control type and the number of controlled lines depend on the operational conditions of traffic and the possibility of its application in the network.

The ramp control has been developed in urban areas since 1964 with the aim of proper management of inflows from the ramp and improvement of traffic conditions [13]. The philosophy of this approach refers to the regular application of ramps with the aim of maintaining the performance of the highway in an optimal state and making the through traffic lower than the capacity. Therefore, various traffic control devices such as traffic lights, signs, etc regulate the number and time of vehicles incoming and exiting the highway. These tools perform their controls through traffic parameters including the traffic flow, velocity, occupancy, etc based on the tools for traffic management, identification and removal according to their values [21]. Accordingly, the traffic control devices perform with both fixed and variable scheduling approaches: The control is done with predetermined scheduling in fixed technique, but by information of traffic flow in variable technique [15].

2 Research literature

Traffic and transportation engineers became more involved in evacuation studies since Hurricane Floyd (1999) because of the heavy traffic jam that occurred during the evacuation [33, 11]. Traffic management strategies were expected to alleviate the situation but few states in the U.S. had a traffic management plan for hurricane evacuation at that time [33]. Since then, researchers have been striving to propose, evaluate, and improve evacuation traffic management plans by quantifying their effectiveness for different storm scenarios and/or implementation configurations [31, 21, 15, 29, 30]. However, there are limitations to the previous simulations. First, the routing algorithms embedded in the simulation tools are typically based on a form of optimality that assumes drivers are fully aware of the traffic conditions on all available paths [17, 23]. Traffic volume thus generally increases on routes with contraflow implementation [31]. Alternatively, evacuees have been assumed to follow prescribed evacuation routes. However, some drivers were found not to comply with evacuation route recommendations [19], while some others preferred taking an interstate route despite its congestion [11]. Fang and Edara illustrated the differences in evacuation performance estimates resulting from user equilibrium and system optimal route choice assumptions [12]. Some later simulation studies began to incorporate additional parameters, such as the percentage of drivers knowing the traffic condition and their compliance towards evacuation instructions [24]. Some behavioral studies investigated factors that could potentially affect route choice behavior. Lindell et al. found evacuees based their route choices on their familiarity and prior perceptions (about travel time, safety, and convenience) of routes [18]. Wu et al. suggested evacuees based their route choices on their past experiences, en-route traffic conditions, and route recommendations (from media and authorities) [35]. Assuming evacuees exclusively rely on any one of these factors will lead to inaccurate findings [35]. Based on this finding, traffic management strategies are highly likely to affect evacuees' route choices because the strategies would influence traffic conditions and route recommendations. With behavioral data, a step beyond setting up driver group percentages in traffic simulation is to have models predict route choice behavior at a disaggregate level. Chang et al. considered evacuation experience, expected travel time to the destination, and willingness to use the recommended route in modeling household interstate choice behavior [8]. The three factors all increased the likelihood for households to take interstates. While en route, length of delay and alternate route information (medium and content) in response to evacuation congestion could encourage route changes [26]. However, these considerations only account for the general travel time effects of congestion and do not explicitly account for the direct effects of traffic management strategies on route selection. Second, evacuation traffic simulation studies seldom considered whether and how the implemented traffic management strategies could influence other choices in household evacuation plans. For example, past evacuation traffic simulation studies implicitly assumed that implementing traffic management strategies would not affect the total evacuation demand. Thus, with capacity added from contraflow lanes, implementing contraflow on certain routes generally improves travel speed and shortens travel time [15]. Besides route choice [8, 1, 5, 28], household evacuation plans also involve the following choices. The evacuation/stay decision governs whether a household will leave the area [6, 4, 20, 34]. Accommodation choice indicates the type of facility where the evacuees will stay [10, 22], while destination indicates the location (e.g., city) of the accommodations [9, 25]. The travel to these destinations is based on travel mode [7, 27] and the number of vehicles for households who travel by personal vehicle [2, 36]. When these trips begin is based on households' choices of departure time [14, 16]. The most notable influence from authorities on household evacuation plans perhaps is whether a mandatory evacuation order is issued [32]. This factor was considered by most household evacuate/stay models. Households' responses to a given mandatory evacuation order are also consistent in both hypothetical and actual cases. Likewise, households may react to traffic management strategies implemented by authorities. Knowing that such strategies are being implemented could shape risk perceptions by providing cues that others are taking the hurricane threat seriously. Some households may update their evacuation plans accordingly [20]. Household evacuation plan updates in turn affect traffic loadings onto the road network and thus affect evacuation traffic simulation results. However, this topic has not been explored yet by evacuation traffic simulation studies.

The utilization of different strategies of traffic management is done with the aim of improving the traffic parameters and the necessary studies should be conducted for determining their effects. In this regard, two sites (one of them in Minneapolis and another in Toronto) are put under the ramp control strategy in conducted studies by Elefteriadou et al. The results of adopting this strategy indicate that its application reduces the risk of flow drop by 15% to 20% under the conditions for traffic flow drop. The through flow of the highway is increased by postponing or preventing the drop. Accordingly, the ramp control is a reliable method for postponing the flow drop, reducing the average travel time and reducing the time of queue creation, and it should be done in a way that the optimal balance is created between the flow drop and queue length in ramps. Another study in this regard investigates the traffic bottleneck due to rising demand for the use of highways: The sudden drop in traffic flow in a section of highway is considered as the reason for creating the traffic bottlenecks in this article, and thus the ramp control technique is utilized for enhancing the capacity and improving the traffic movement at these sections. The study on 27 sample sections in highways of 2 cities for 7 weeks through ramp control strategy and 7 weeks without using the ramp control strategy has investigated the way of optimizing the conditions and obtained the following results.

- This strategy delays the creation time or eliminates the activities of bottlenecks in some cases.
- In the case of using the ramp control strategy, the ability of higher through flow is created before queue creation.
- The application of ramp control technique after creation of flow drop increases the queue discharge flow rate.

According to the conducted studies by Zhangbing et al. [37], it is found that the traffic flow direction strategy to alternative routes should be developed based on the current traffic conditions and used for topical application (for limited numbers of roads) as well as the total road network. Therefore, this article proposes the following cases for above-mentioned strategy.

- Adoption of this strategy is based on the analytical solution and the route redirection is done based on the current traffic conditions in the main route.
- The way of traffic flow direction should be simple and accessible to vehicles, so that the users can easily select and use the alternative routes.
- To implement this strategy, the input data of traffic control centers should be easily calculated. The input data includes the traffic conditions, number of vehicles incoming and exiting the connection points, and the shape and arrangement of network. Various traffic control devices and tools should be applied for its calculation.

Other studies on the implementation of the line management strategy have investigated the adoption of this strategy for two highways in the east Paris with the length of 2.3 km during two periods of 1 (2010-2014) and 2 (2020). The through traffic from both these highways reach a connecting section, thus the traffic of vehicles at this section will be faced with problem at the peak hours; therefore, the line management strategy is adopted during 4 hours a day in order to improve these conditions (Adding the movement lines). Thus, this research investigates the impact of this strategy and the studies indicate the main effect of adopting this strategy in reducing the traffic congestion and the risks of accidents at peak hours [29].

In a recent research, Liao et al investigate the traffic management techniques in urban tunnels, and thus Hsuehshan Tunnel of Taiwan is selected as the case study. According to the enclosed space of inside tunnel and the spatial constraints for choosing the alternative routes, it is found that the expansion and determination of appropriate strategies are difficult for traffic management. On this basis, several possible methods including the ramp control, traffic control and direction of vehicles to alternative routes are selected in this regard. In this study, the severe accident is assumed in the tunnel and the traffic management strategies are adopted to prevent the queues of vehicles at the entrance of tunnel. The obtained results indicate that the application of traffic management strategies cannot prevent the formation of queue, but it only reduces the severe uncomfortable status of traffic in terms of queue formation and delay and produces better results than other methods in terms of ramp control method [5].

3 Research methodology

This research is conducted according to the traffic simulation by Aimsun software. First, the impact of case samples, Niayesh and Resalat tunnels of London, is determined considering the beginning and end of tunnel, the highways associated with the tunnel, and the main highways parallel to the tunnel, and then the modeling scenarios are defined, and finally the simulation is done through required data. In these scenario, the sites of accidents are simultaneously selected according to the conducted research by Albowarab [4] in areas with the highest probability of occurrence [4], namely the regions of 1 (50 meters outside the tunnel entrance) and 3 (100 meters after the tunnel entrance) of tunnel, and the West to East direction of tunnel is due to the highest statistics of traffic. The following figures show the exact site of accident and application of target strategies in Aimsun software.

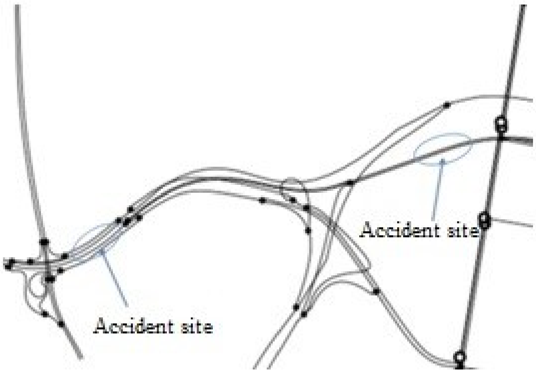

Figure 1: The accident site for Niayesh tunnel

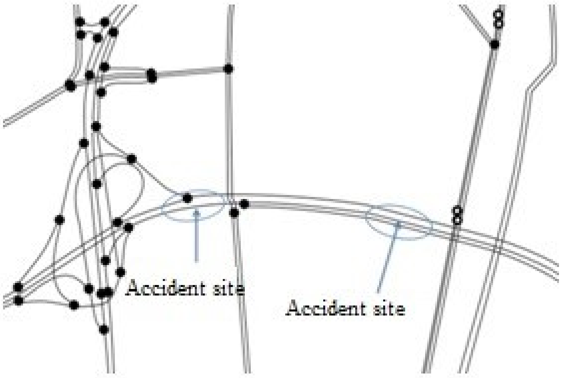

Figure 2: The accident site for Tunnel

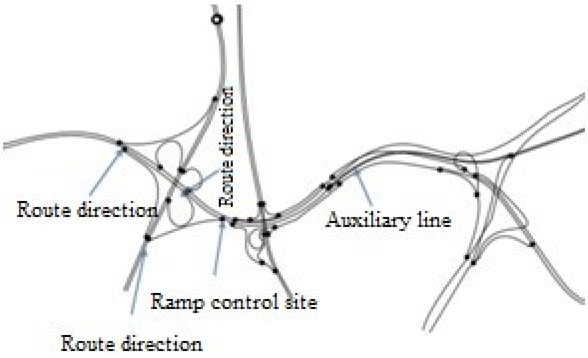

Figure 3: Site of adopting the strategies for Niayesh tunnel

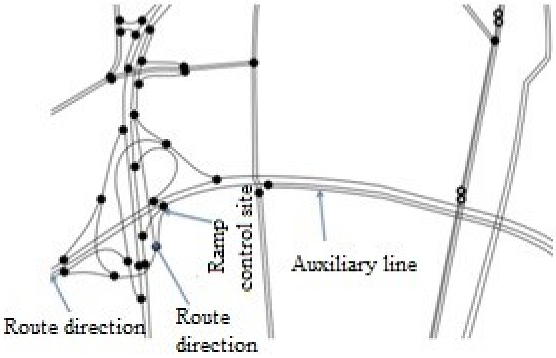

Figure 4: Site of adopting the strategies for Resalat tunnel

The accidents are started 10 minutes after implementation of modeling and lasted for 20 minutes and have impaired a section with the length of 15 meters. The adoption of strategies is started 5 minutes after the occurrence of accident and lasted for 20 minutes. Thus, the modeling scenarios are defined as follows.

- First scenario: Implementation of model for an hour at the morning peak traffic in occurrence of accident and determination of functional specifications of traffic consisting of traffic flow, the entire travel time, delay time, stop time, flow density, and average velocity for study site.
- Second scenario: Implementation of model for an hour at the morning peak traffic in occurrence of accident and determination of functional specifications of traffic consisting of traffic flow, the entire travel time, delay time, stop time, flow density, and average velocity for study site under the adoption of traffic flow direction strategy.
- Third scenario: Implementation of model for an hour at the morning peak traffic in occurrence of accident and determination of functional specifications of traffic consisting of traffic flow, the entire travel time, delay time, stop time, flow density, and average velocity for study site under the adoption of tunnel motion line adding strategy.
- Fourth scenario: Implementation of model for an hour at the morning peak traffic in occurrence of accident and determination of functional specifications of traffic consisting of traffic flow, the entire travel time, delay time, stop time, flow density, and average velocity for study site under the adoption of ramp control strategy.

4 Research findings

Based on the defined scenarios, the simulated output data are summarized for Niayesh and Resalat tunnels of London respectively in Table 1. The presented diagrams also compare the scenarios in addition to the display of changes in traffic parameters at 10-minute intervals.

A) Traffic flow

According to the diagram in Figure 5 for Niayesh tunnel, the first scenario has the minimum value during the entire time of implementation. The performance of second, third, and fourth scenarios are similar until 7:20 am, and the second scenario has the maximum value and the third scenario has the minimum value from until 7:20 am until the end of model implementation. For Resalat Tunnel based on the diagram in Figure 6, the performance of scenarios are similar from the beginning of model implementation until 7:20 am. The second scenario has the maximum value from 7:20 am until the end of model implementation, and the first, third, and fourth scenarios have the similar values, but the third and fourth scenarios have higher values than the first scenario.

B) Total travel time

According to the diagram in Figure 7 for Niayesh tunnel, the scenarios have similar performance until 7:20 am. From 7:20 am onwards, the scenarios have fluctuations, but generally the third scenario has the minimum value and

Table 1: Results of traffic modeling of case sample

Niayesh tunnel area						
Scenario	Index					
	Traffic flow (veh/hr)	Total travel time (hr)	Delay time (sec/km)	Stop time (sec/km)	Flow density (veh/km)	Average velocity (km/hr)
First scenario (Accident occurrence)	18201	3999.85	92.23	76.86	38.00	24.89
Second scenario (Flow direction strategy)	21873	3910.61	89.10	72.76	34.96	25.61
Third scenario (Line management strategy)	21293	3893.13	89.11	74.62	35.05	26.43
Fourth scenario (Ramp control strategy)	21655	3911.96	89.85	72.35	36.97	25.80
Resalat tunnel area						
Scenario	Index					
	Traffic flow (veh/hr)	Total travel time (hr)	Delay time (sec/km)	Stop time (sec/km)	Flow density (veh/km)	Average velocity (km/hr)
First scenario (Accident occurrence)	45976	4299.58	73.81	49.83	45.89	27.83
Second scenario (Flow direction strategy)	46276	4269.58	70.81	47.88	42.89	28.63
Third scenario (Line management strategy)	46388	4278.43	71.23	47.73	42.53	28.42
Fourth scenario (Ramp control strategy)	46205	4231.48	70.84	47.90	42.73	28.70

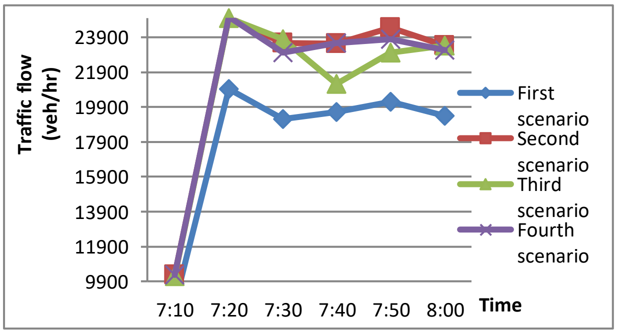

Figure 5: Changes in traffic flow in Niayesh tunnel area

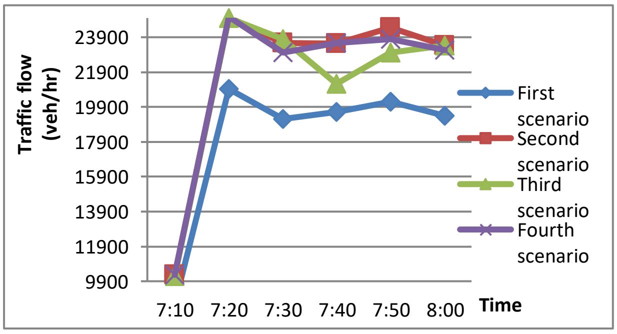

Figure 6: Changes in traffic flow in Resalat tunnel area

the second scenario has the maximum value. For Resalat Tunnel based on the diagram in Figure 8, the performance of scenarios is similar from the beginning of model implementation until 7:20 am. The third scenario has the maximum value and the second scenario has the minimum value from 7:20 to 7:30 am. From 7:30 to 7:50 am, the fourth scenario has the maximum value and the third scenario has the minimum. At the last ten minutes of model implementation, the third scenario has the maximum value and the fourth scenario has the minimum.

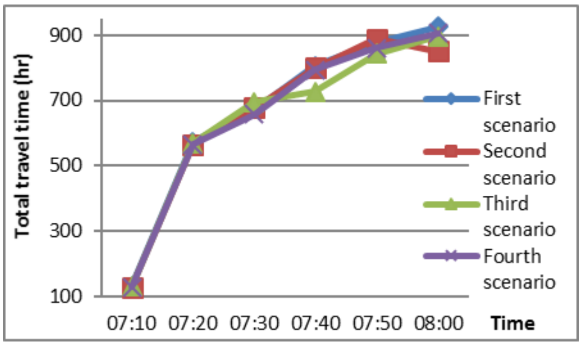

Figure 7: Changes in Total travel time in Niayesh tunnel area

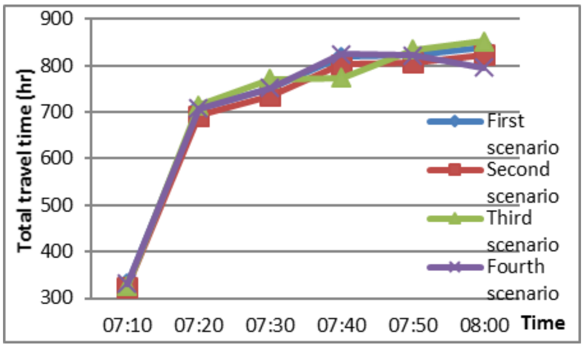

Figure 8: Changes in Total travel time in Resalat tunnel area

C) Delay time

According to the Figure 9 for Niayesh tunnel, the scenarios have similar performance until 7:40 am. From 7:40 to the end of implementation, the fourth scenario has the minimum value and the first one has the maximum. For Resalat Tunnel based on the diagram in Figure 10, the performance of scenarios is similar until 7:20 am. The third scenario has the maximum value and the second scenario has the minimum value from 7:20 to the end of model implementation.

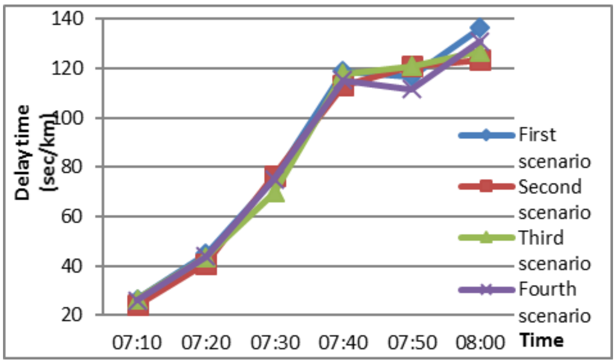

Figure 9: Changes in Delay time in Niayesh tunnel area

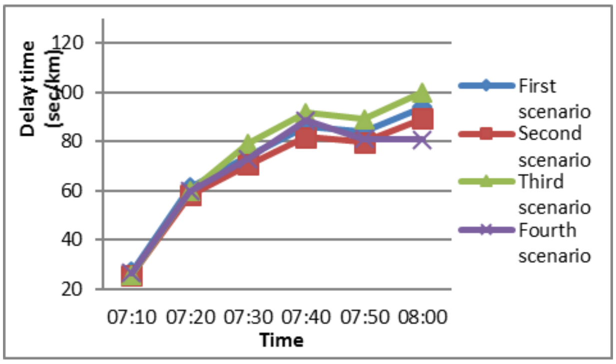

Figure 10: Changes in Delay time in Resalat tunnel area

D) Stop time

According to the Figure 11 for Niayesh tunnel, the scenarios have similar performance until 7:40 am. From 7:40 to the end of implementation, the third scenario has the maximum value and the fourth one has the minimum. For Resalat Tunnel based on the diagram in Figure 12, the performance of scenarios is similar until 7:20 am and they have fluctuations in performance from 7:20 onwards, so that from 7:20 to 7:30 am, the third scenario has the maximum value and the second scenario has the minimum. Furthermore, from 7:30 to 7:50 am, the third scenario has the minimum value, but the fourth scenario has the maximum value; from 7:30 to the end of model implementation, the first scenario has the maximum value and the fourth one has the minimum value.

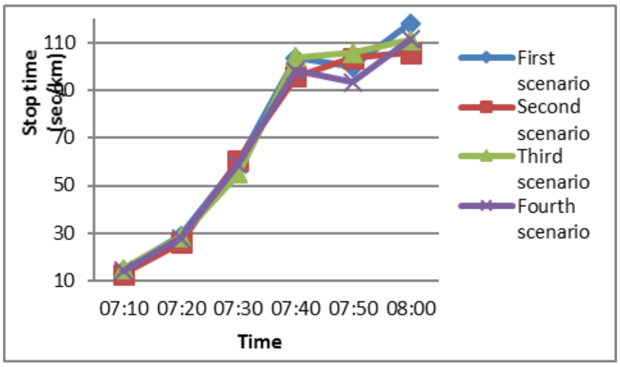

Figure 11: Changes in Stop time in Niayesh tunnel area

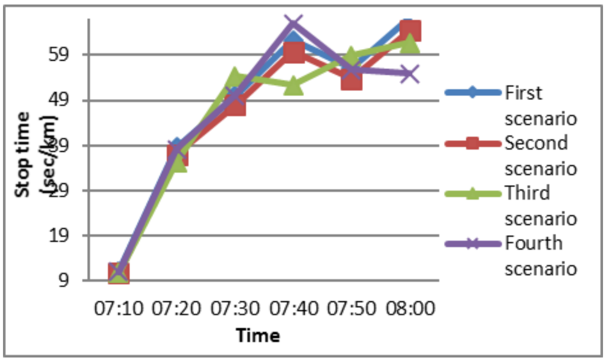

Figure 12: Changes in Stop time in Resalat tunnel area

E) Flow density

According to the diagram of Figure 13 for Niayesh tunnel, the first scenario has the maximum value from the beginning to the end of model implementation, and the third scenario has the minimum value from the beginning to 7:50 am, and the second scenario has the minimum value from 7:50 am to the end of implementation time. For Resalat Tunnel based on the diagram in Figure 14, the first scenario has the maximum value at the whole time of implementation. For this area, the second, third, and fourth scenarios have similar performance and the close values.

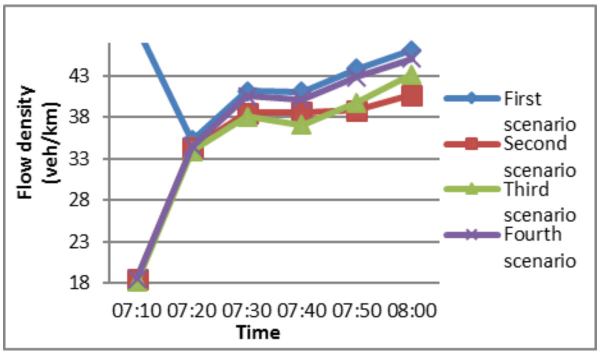

Figure 13: Changes in Flow density in Niayesh tunnel area

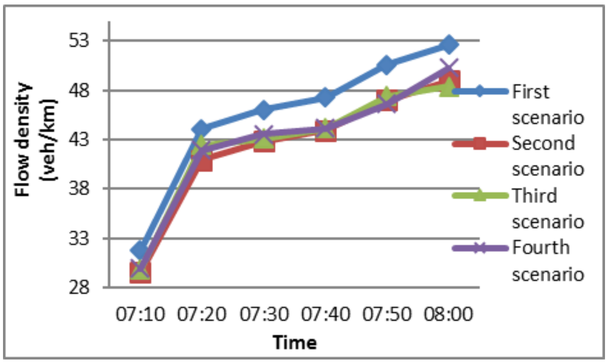

Figure 14: Changes in Flow density in Resalat tunnel area

F) Average velocity

According to the diagram of Figure 15 for Niayesh tunnel, the first scenario has the minimum value at the whole implementation time. The second, third, and fourth scenarios have similar values from until 7:20 am, and the third scenario has the maximum value from 7:20 to 7:50 am beginning, and the second scenario has the maximum value at the last ten minutes of model implementation. For Resalat Tunnel based on the diagram in Figure 16, all scenarios have similar values until 7:20 am, and the first scenario has the minimum value from 7:20 am to the end of model implementation. From 7:20 to 7:30 am, the fourth scenario has the maximum value and the third scenario has the maximum value from 7:30 to 7:50 am. Again, the fourth scenario has the maximum value at the last ten minutes of model implementation.

Statistical tests

The statistical test at the significance level of 0.05 is done on the results of simulations in order to determine the impact of each strategy on the traffic performance parameters. The tables 2 and 3 summarize the data and results of tests for Niayesh and Resalat tunnels, respectively. According to the proposed table, the adequacy or inadequacy of changes can be examined in the case of adopting each strategy.

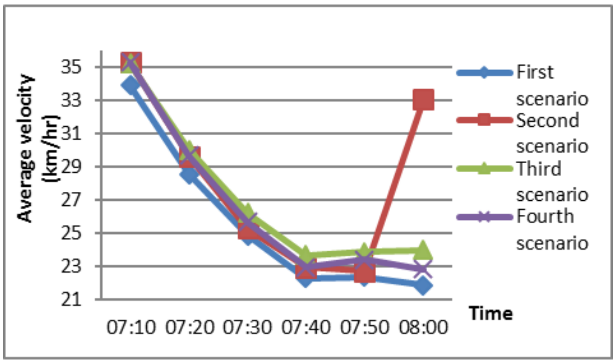

Figure 15: Changes in Average velocity in Niayesh tunnel area

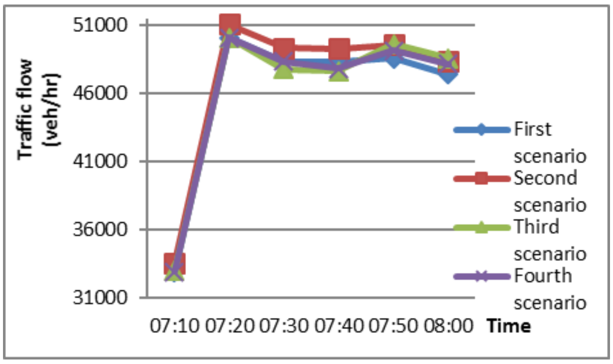

Figure 16: Changes in Average velocity in Resalat tunnel area

5 Discussion and conclusion

According to the research findings, it can be concluded that generally the adoption of target strategies improves the conditions of traffic parameters. Among the adoptable strategies, the traffic flow direction strategy has the maximum efficiency in Niayesh Tunnel and the ramp control strategy has the maximum efficiency in Resalat Tunnel.

Based on the performed statistical test, the adoption of line management strategy in Niayesh Tunnel does not adequately change any parameter, but the adoption of ramp control and traffic flow direction strategies adequately change the traffic flow and stop time parameters. However, the adoption of all three parameters in Resalat tunnel will improve the delay time, stop time, and average velocity. The line management and ramp control strategies adequately change the flow density parameter.

Finally, a practical plan for traffic management is presented based on the research findings The traffic management plan checklist indicates traffic, parking, and pedestrian management techniques to mitigate any and all anticipated problems on the day-of-event. The challenge to stakeholders involves not only developing operations strategies and resource applications to mitigate a potential congestion or safety "hot spot", but also ensuring each operations tactic does not defeat the objectives of another. A successful traffic management plan: (1) satisfies the customer requirements of all transportation system users and (2) meets the allotted budget for personnel and equipment resources assigned to the day-of-event operation. The figure below summarizes the types of assessments made for each of the six steps in the traffic management plan checklist:

Table 2: Results of statistical test for adoption of strategies in Niayesh tunnel

$\boldsymbol{H}_0 : \mu < \mu_0,\ H_1 : \mu \geq \mu_0,\ \mu_0 = 18201,\ \alpha = 5\%,\ \boldsymbol{Z}_{0.95} = 1.70,\ \delta = 776.72$				
Strategy	**Parameter**	$\boldsymbol{\mu}$	$\boldsymbol{Z}$	$\boldsymbol{Z} > \boldsymbol{Z}_{0.95}$
Flow direction	Traffic flow	21873	1.93	O.K
Line Management	Traffic flow	21293	1.62	N.G
Ramp Control	Traffic flow	21655	1.82	O.K
$\boldsymbol{H}_0 : \mu > \mu_0,\ H_1 : \mu < \mu_0,\ \mu_0 = 3999.85,\ \alpha = 5\%,\ \boldsymbol{Z}_{0.95} = 1.70, \delta = 61.74$				
Strategy	**Parameter**	$\boldsymbol{\mu}$	$\boldsymbol{Z}$	$\boldsymbol{Z} > \boldsymbol{Z}_{0.95}$
Flow direction	Total travel time	3910.61	0.59	N.G
Line Management	Total travel time	3893.13	0.71	N.G
Ramp Control	Total travel time	3911.96	0.58	N.G
$\boldsymbol{H}_0 : \mu > \mu_0,\ H_1 : \mu < \mu_0,\ \mu_0 = 92.23,\ \alpha = 5\%,\ \boldsymbol{Z}_{0.95} = 1.70, \delta = 0.819$				
Strategy	**Parameter**	$\boldsymbol{\mu}$	$\boldsymbol{Z}$	$\boldsymbol{Z} > \boldsymbol{Z}_{0.95}$
Flow direction	Delay time	89.10	1.56	N.G
Line Management	Delay time	89.11	1.55	N.G
Ramp Control	Delay time	89.85	1.18	N.G
$\boldsymbol{H}_0 : \mu > \mu_0,\ H_1 : \mu < \mu_0,\ \mu_0 = 76.86,\ \alpha = 5\%,\ \boldsymbol{Z}_{0.95} = 1.70, \delta = 0.74$				
Strategy	**Parameter**	$\boldsymbol{\mu}$	$\boldsymbol{Z}$	$\boldsymbol{Z} > \boldsymbol{Z}_{0.95}$
Flow direction	Stop time	72.76	2.25	O.K
Line Management	Stop time	74.62	1.23	N.G
Ramp Control	Stop time	72.35	2.48	O.K
$\boldsymbol{H}_0 : \mu > \mu_0,\ H_1 : \mu < \mu_0,\ \mu_0 = 38.00,\ \alpha = 5\%,\ \boldsymbol{Z}_{0.95} = 1.70, \delta = 0.82$				
Strategy	**Parameter**	$\boldsymbol{\mu}$	$\boldsymbol{Z}$	$\boldsymbol{Z} > \boldsymbol{Z}_{0.95}$
Flow direction	Flow density	34.96	1.51	N.G
Line Management	Flow density	35.05	1.47	N.G
Ramp Control	Flow density	36.97	0.51	N.G
$\boldsymbol{H}_0 : \mu < \mu_0,\ H_1 : \mu \geq \mu_0,\ \mu_0 = 24.89,\ \alpha = 5\%,\ \boldsymbol{Z}_{0.95} = 1.70, \delta = 0.40$				
Strategy	**Parameter**	$\boldsymbol{\mu}$	$\boldsymbol{Z}$	$\boldsymbol{Z} > \boldsymbol{Z}_{0.95}$
Flow direction	Average velocity	25.61	0.72	N.G
Line Management	Average velocity	26.43	1.54	N.G
Ramp Control	Average velocity	25.80	0.91	N.G

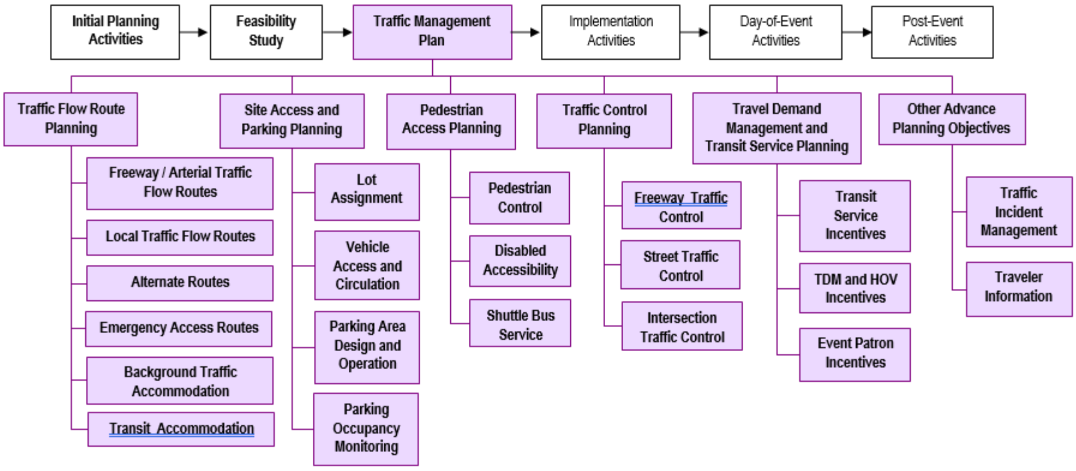

Table 3: Results of statistical test for adoption of strategies in Resalat tunnel

$\boldsymbol{H}_0 : \mu < \mu_0,\ H_1 : \mu \geq \mu_0,\ \mu_0 = 45976,\ \alpha = 5\%,\ \boldsymbol{Z}_{0.95} = 1.70, \delta = 108.38$				
Strategy	**Parameter**	$\boldsymbol{\mu}$	$\boldsymbol{Z}$	$\boldsymbol{Z} > \boldsymbol{Z}_{0.95}$
Flow direction	Traffic flow	46276	1.13	N.G
Line Management	Traffic flow	46388	1.56	N.G
Ramp Control	Traffic flow	46205	0.86	N.G
$\boldsymbol{H}_0 : \mu > \mu_0,\ H_1 : \mu < \mu_0,\ \mu_0 = 4299.58,\ \alpha = 5\%,\ \boldsymbol{Z}_{0.95} = 1.70, \delta = 26.05$				
Strategy	**Parameter**	$\boldsymbol{\mu}$	$\boldsymbol{Z}$	$\boldsymbol{Z} > \boldsymbol{Z}_{0.95}$
Flow direction	Total travel time	4269.58	0.47	N.G
Line Management	Total travel time	4278.43	0.33	N.G
Ramp Control	Total travel time	4231.48	1.08	N.G
$\boldsymbol{H}_0 : \mu > \mu_0,\ H_1 : \mu < \mu_0,\ \mu_0 = 73.81,\ \alpha = 5\%,\ \boldsymbol{Z}_{0.95} = 1.70, \delta = 0.34$				
Strategy	**Parameter**	$\boldsymbol{\mu}$	$\boldsymbol{Z}$	$\boldsymbol{Z} > \boldsymbol{Z}_{0.95}$
Flow direction	Delay time	70.81	3.57	O.K
Line Management	Delay time	71.23	3.07	O.K
Ramp Control	Delay time	70.84	3.53	O.K
$\boldsymbol{H}_0 : \mu > \mu_0,\ H_1 : \mu < \mu_0,\ \mu_0 = 49.83,\ \alpha = 5\%,\ \boldsymbol{Z}_{0.95} = 1.70, \delta = 0.43$				
Strategy	**Parameter**	$\boldsymbol{\mu}$	$\boldsymbol{Z}$	$\boldsymbol{Z} > \boldsymbol{Z}_{0.95}$
Flow direction	Stop time	47.88	1.85	O.K
Line Management	Stop time	47.73	2.00	O.K
Ramp Control	Stop time	47.90	1.83	O.K
$\boldsymbol{H}_0 : \mu > \mu_0,\ H_1 : \mu < \mu_0,\ \mu_0 = 45.89,\ \alpha = 5\%,\ \boldsymbol{Z}_{0.95} = 1.70, \delta = 0.73$				
Strategy	**Parameter**	$\boldsymbol{\mu}$	$\boldsymbol{Z}$	$\boldsymbol{Z} > \boldsymbol{Z}_{0.95}$
Flow direction	Flow density	42.89	1.67	N.G
Line Management	Flow density	42.53	1.87	O.K
Ramp Control	Flow density	42.73	1.75	O.K
$\boldsymbol{H}_0 : \mu < \mu_0,\ H_1 : \mu \geq \mu_0,\ \mu_0 = 27.83,\ \alpha = 5\%,\ \boldsymbol{Z}_{0.95} = 1.70, \delta = 0.1170$				
Strategy	**Parameter**	$\boldsymbol{\mu}$	$\boldsymbol{Z}$	$\boldsymbol{Z} > \boldsymbol{Z}_{0.95}$
Flow direction	Average velocity	28.63	2.79	O.K
Line Management	Average velocity	28.42	2.06	O.K
Ramp Control	Average velocity	28.70	3.04	O.K

References

[1] M. Akbarzadeh, *Dynamic Route Choice in Hurricane Evacuation*, Louisiana State University, 2012.

[2] R.J. Alawadi, *Modeling of household evacuation decision, departure timing, and number of evacuating vehicles from hurricane Matthew*, PhD Thesis, Clemson University, Clemson, 2019.

[3] A. Al-Bakry, S. Almamory, M. Sahib, H. Haitham G. Oreku, Th. Nayl and J. Al-Dhaibani, *New Trends in Information and Communications Technology Applications*, Proc. 4th Int. Conf., Baghdad, Iraq, June 15, 2020.

[4] M. Albowarab, N. Zakaria, Z. Abidin and Zaheera, *Load balancing algorithms in software defined network*, Int. J. Recent Technol. Eng. **7** (2018), 686–693.

[5] R. Alsabah, M. Aljshamee, A. Abduljabbar and A. Alsabbagh, *An insight into internet sector in Iraq*, Int. J. Electr. Comput. Eng. **11** (2021), no. 6.

[6] E.J. Baker, *Hurricane evacuation behavior*, Int. J. Mass. Emerg. Disasters **9** (1991), no. 2, 287–310.

[7] R. Bian, C.G. Wilmot, R. Gudishala and E.J. Baker, *Modeling household-level hurricane evacuation mode and destination type joint choice using data from multiple poststorm behavioral surveys*, Transp. Res. Part C: Emerg. Technol. **99** (2019), 130–143.

[8] D. Chang, P. Edara, P. Murray-Tuite, J. Trainor and K. Triantis, *Taking the freeway: inferring evacuee route selection from survey data*, Transp. Res. Interdiscip. Perspect. **11** (2021), 100421.

[9] G. Cheng, C.G. Wilmot and E.J. Baker, *Development of a time-dependent disaggregate hurricane evacuation destination choice model*, Nat. Hazards Rev. **14** (2013), no. 3, 163–174.

[10] D. Deka and J.A. Carnegie, *Forecasting shelter accessibility and vehicle availability for hurricane evacuation in Northern New Jersey using sample enumeration*, Int. J. Mass. Emerg. Disasters **30** (2012), no. 3, 275–300.

[11] K. Dow and SL. Cutter, *Emerging hurricane evacuation issues: hurricane Floyd and South Carolina*, Nat. Hazards Rev. **3** (2002), no. 1, 12–18.

[12] L. Fang and P. Edara, *Sensitivity of evacuation performance estimates to evacuee route choice behavior*, Transport. Res. Record **2376** (2013), 20–26.

[13] P.B. Gallagher, *Redesigning audiences in technical communication*, Proc. 37th ACM Int. Conf. Design Commun., 2019, pp. 1–10.

[14] R. Gudishala and C.G. Wilmot, *Comparison of time-dependent sequential logit and nested logit for modeling hurricane evacuation demand*, Transp. Res. Rec. **2312** (2012), 134–140.

[15] A. Hussein, K. Hussein, H. Saleh and I. Farhan, *Survey, towards a sustainable information and communication technologies (ICT) in Iraq*, J. Phys. Conf. **1530** (2020), 012089.

[16] J. Li, K. Ozbay, B. Bartin, S. Iyer and J.A. Carnegie, *Empirical evacuation response curve during hurricane Irene in Cape May County, New Jersey*, Transp. Res. Rec. **2376** (2013), no. 1, 1–10.

[17] M.K. Lindell and C.S. Prater, *Critical behavioral assumptions in evacuation time estimate analysis for private vehicles: examples from hurricane research and planning*, J. Urban Plan Dev. **133** (2007), no. 1, 18–29.

[18] M.K. Lindell, J-C. Lu and C.S. Prater, *Household decision making and evacuation in response to hurricane Lili*, Nat Hazards Rev **6** (2005), no. 4, 171-179.

[19] M.K. Lindell, C.S. Prater and A. Mohite *Texas Gulf Coast Residents' Expectations and Intentions Regarding Hurricane*, College Station, Texas, 2001.

[20] D. Lipika, *Efficient Round Robin scheduling algorithm with dynamic time slice*, Int. J. Educ. Manag. Engin. **5** (2015), 10–19.

[21] M.K. Mahmood, F.M.M. Al-Naima, and Z. Zaidan, *Reliability assessment of the Iraqi national communication network*, Indones. J. Electric. Engin. Inf. **6** (2018), no. 4, 448–457.

[22] R. Mesa-Arango, S. Hasan and S.V. Ukkusuri, *Murray-Tuite P. Household-level model for hurricane evacuation destination type choice using hurricane Ivan data*, Nat. Hazards Rev. **14** (2013), no. 1, 11–20.

[23] A.J. Pel, M.C.J. Bliemer and S.P. Hoogendoorn, *A review on travel behaviour modelling in dynamic traffic simulation models for evacuations*, Transportation **39** (2012), no. 1, 97–123.

[24] A.J. Pel, S.P. Hoogendoorn and M.C.J. Bliemer, *Evacuation modeling including traveler information and compliance behavior*, (2010), no. 3. 101-11.

[25] E. Radwan, M. Mollaghasemi, S. Mitchell, G. Yildirim and C. Bd, *P. D. Candidate. Framework for modeling emergency evacuation*, Orlando, 2005.

[26] R.M. Robinson and A. Khattak, *Route change decision making by hurricane evacuees facing congestion*, Transport. Res. Record **2196** (2010), 168–175.

[27] A.M. Sadri, *Ukkusuri SV, Murray-Tuite P, Gladwin H. Analysis of hurricane evacuee mode choice behavior*, Transp. Res. Part C: Emerg. Technol. **48** (2014), no. 11, 37–46.

[28] A.M. Sadri, S.V. Ukkusuri, P. Murray-Tuite and H. Gladwin, *Hurricane evacuation route choice of major bridges in Miami Beach, Florida*, Transp. Res. Rec. **2532** (2015), 164–173.

[29] E. Sahin, *Relationship between politic risk and firm value: an application on the transportation, communication and warehousing sector in ise*, Int. J. Manag. Econ. Bus. **16** (2017), no. Special Issue, 531–536.

[30] L. Stephen, *Evaluation of Different Contra-Flow Strategies for Hurricane Evacuation in Charleston*, Clemson University, South Carolina, 2007.

[31] G. Theodoulou and B. Wolshon, *Alternative methods to increase the effectiveness of freeway contraflow evacuation*, Transport. Res. Record **1865** (2004), 48–56.

[32] R.R. Thompson, D.R. Garfin and R.C. Silver, *Evacuation from natural disasters: A systematic review of the literature*, Risk Anal. **37** (2017), no. 4, 812–839.

[33] B. Wolshon, *One-way-out: Contraflow freeway operation for hurricane evacuation*, Nat. Hazards Rev. **2** (2001), no. 3, 105–112.

[34] S.D. Wong, A.J. Pel, S.A. Shaheen and C.G. Chorus, *Fleeing from hurricane Irma: empirical analysis of evacuation behavior using discrete choice theory*, Transp. Res. Part D: Transp. Envir. **79** (2020), 102227.

[35] H-C. Wu, M.K. Lindell and C.S. Prater, *Logistics of hurricane evacuation in hurricanes Katrina and Rita*, Transp. Res. Part F: Traffic Psychol. Behav. **15** (2012), no. 4, 445–461.

[36] W. Yin, P. Murray-Tuite and H. Gladwin, *Statistical analysis of the number of household vehicles used for hurricane Ivan evacuation*, J. Transp. Eng. **140** (2014), no. 12, 04014060.

[37] He. Zhangbing, G. Wei and Ma. Shoufeng, *A Traffic-Condition-based route guidance strategy for a single destination road network*, J. Transport. Res. Part C **32** (2013), 89-102.