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Alternatives to enhance traffic conditions at U-turn sites

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A B S T R A C T

Traffic simulation models play a major role in allowing traffic engineers to assess complex traffic situations such as U-turn section. Such models help in proposing solutions and proposing alternative scenarios without committing too many expensive resources and this models are necessary to implement alternative strategies in the field. Simulation traffic models can significantly improve the quality of road network planning and design in urban areas. According to filed observation, the U-turn movement cause traffic congestion at both origin and distention (opposite) roads. This study introduced many alternatives to enhance the movement at U-turn section. These alternatives have been tested by using simulation models. The PTV VISSIM software was used to development the models. This development model has been calibrated and validated by using filed data collected from Al-Diwaniyah city, Iraq. The results show from the simulation results are in good agreement with the real data.

1. Introduction

The U-turn movement is defining as the turning movement that is implemented at u-shape and it aim to travel to the opposite side. This area represents unsafe and cases traffic congestion in both origin and destination (opposing) roads [1, 2].
There are many types of U-turn section. The median U-turn is the most common type that allow traffic to make the left turn through the median by using special path in the multilane roads. The other types including the U-turn at intersection, roundabout [3, 4].
The U-turn movement is more dangerous and having high accident since this movement is not control by traffic signals and it is dependent on the gap acceptance from drivers[5, 6] . If the gap is not enough to make the U-turn and turning to the opposite side, the accident accrues due to the conflict with the opposite traffic [4]. The turning vehicle should be reducing their speed near the U-turn section and stop at the U-turn section if the available gap is not enough to make the U-turn movement. When the gap is enough, the vehicle is executing the turning process to the opposite side.
The geometric layout of U-turn section may have the auxiliary lane (storage lane) used to story the traffic that waiting unite the enough gap is providing to turn to the opposite direction. The anther used of auxiliary lane as a deceleration lane to reduce speed of turning vehicles and not cause accidents. Figure 1 show the geometric layout of U-turn section with and without auxiliary lane.
During the past two decades, the U-turn movement used a treatment in intersections by replacing the direct left turn by right plus U-turn. The advantage of used this treatment including travel and delay could be less when the traffic volume in major street is high or Moderate, the capacity of

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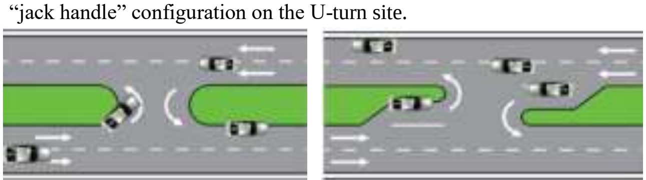
a U-turn movement at the median opening is much higher than the capacity of a direct left turn movement, and right turns plus U-turns have fewer conflicts than direct left turns [7].

Traffic simulation models play a major role in allowing traffic engineers to assess complex traffic situations. This models help in proposing solutions and proposing alternative scenarios without committing too many expensive resources that are necessary to implement alternative strategies in the field. Simulation traffic models can significantly improve the quality of road network planning and design in urban areas[8]

There are little studies of the alternative to enhance the movement at U-turn section. The speed humps are being used in many countries in the world as a technique to calm the traffic and make the turning process is easy and reduce the accident [9, 10]. Al-Obeadi (2019) studied the effect of speed hump on the (ATS) by the turning vehicles and the results show the used of speed hump can reduce the (ATS). AL-Jameel(2014) [11] suggested the new design for U-turn section and the result shown this design can increase the capacity of U-turn section. Rhaptyalyani H. Della and others (2015)[2], study the effect of used new design for U-turn section on the capacity, degree of saturation, and queue length and traffic delay. The new model including the use of roundabout and the second models used fly over U-turn. The results showed the used of second models give best perforce and reduced the delay and queue length, and increased the capacity.

The basic objective of the current research is to investigate the effect of using different scenarios to improve the movement at the median U-turn section by using PTV VISSIM 5.10 microsimulation software. The travel time is used to compares between the difference alternatives. These scenarios including studying the effect of using traffic control on the through, opposing, and merging traffic, the effect of using speed humps in the opposing direction, increasing number of lanes and finally applying "jack handle" configuration on the U-turn site.



A/ Median U-turn B/U-turn with auxiliary lane

Figure 1:The geometric layout of median U-turn section.

2. Methodology

The methodology of this research including the site selection, data collected and analyze, model building, calibration and validation for the model building and testing different scenarios to enhance the movement at the U-turn section.

The site for the U-turn section is selected from Al-Diwaniyah city, Iraq. The video recording is used to collect data and the through, opposite, merge1, merge2 volumes and average queue length is excavation for data collected.

Traffic simulation is applied using PTV VISSIM development the U-turn model. The model has been calibrated and validated based on real traffic data as published in the authors previous research work[12] .The developed model use to study the effect of applying the alternatives in order to enhance traffic conditions at U-turn sites.

3. Data collection

In order to achieve the objective of the research, the data should be collected. There are many methods of data collected. According to the information required in this study the video recording is the properly method to collected data.

As discussed above, the parameters extracted form the data collected including the through volumes "refers to the through traffic volumes in the direction of merge 1", the opposing volume" refers to the traffic volumes opposing to traffic volumes at merge 1" while merge 1 "refers to the U-turn direction with higher volumes than the another direction merge 2"and the average queue length that generate prior the U-turn section. The speed is collected by using the radar speed gun. The speed is measurement at the three location. The location NO.1 at (100 m before the U-turn section) to investigate the behaviour of drivers near the U-turn sections. Location NO.2 at the U-turn section and the location NO.3 at (100m before U-turn in the opposite direction) to investigate the behaviour of drivers near the U-turn sections. Table (1) illustration the range of traffic flow and average queue length for data collected and the mean for the measure speed.

Table 1 - The range of traffic flow and average queue length for data collected and the mean for the measure speed

Traffic volumes for each direction				Avg. queue length veh	Mean speed for each location		
Through veh/hr	Opposite veh/hr	Merg1 veh/hr	Merg2 veh/hr		NO.1 km/hr	NO.2 km/hr	NO.3 km/hr
780-1080	672-1392	372-648	96-216	2-5	51.31	27.96	47.53

4. Model development

This section describes the model development and the calibration and validation process for the development model. The VISSIM models were built by adding link (to draw the road) and connecter (to draw the u- turn), use "yield priority" to make the turning vehicle wait until enough gap is available. The hump speed is select by adding "reduce speed area". The traffic volume for each direction is entered to the networks by using the" vehicle input tool" The priorities of movements were applied by introducing "conflict area" which give the priority of opposing traffic. After the model building, the calibration and validation process are done to represent the real data. The results show the development models are representing the real.

5. Models applications

As described above, the calibrated and validated simulation models using PTV VISSIM was used in this research work. Many scenarios have been examined including the use of traffic signal, the use of speed humps, increase the number of lane and finally applying the "Jack handle" shape as shown in Figure 2 below. The travel time is used to examine the effect of applying these scenarios for the nearby sections. The travel times is defining as the difference in time between the vehicles arriving at the beginning of the section and the time the vehicles leaving the same section. Figure 2 illustration the location of travel time section.

According to traffic volumes in the real situation, the traffic volumes are used in these application are similar to the real (1000 veh/hr for the through direction), (500 veh/hr for merge1 direction), (1200 veh/hr for opposite direction) and (100 veh/hr for the merge2 direction).

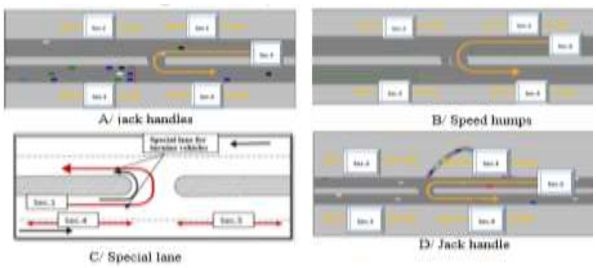
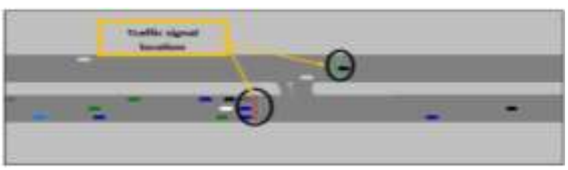


Figure 2: The location of travel time section

5.1 The effect of using traffic control

The traffic control was usually used in intersections if that was warranted and the use of such signals at other sites such as (U-turn sites) needs to be examined before been applied. Theoretically, the benefit of using traffic controls at U-turn section were to increase the safety by avoiding conflicting points. However, the effect of using traffic signals at such sites on capacity or travel time should also examined.

In this work, two signals were examined using traffic simulations, one for merging traffic and the second is for opposing traffic as shown in **Figure**

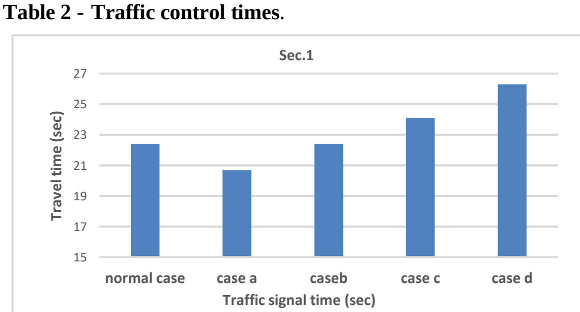


3. Figure 3: The traffic signal location.

Different green times with 60 second cycle length have been examined as shown in Table 2 below. Figure (4) show the travel time for sec.1, sec.2, sec.3, sec.4, and sec.5 for all case of traffic signal. For sec.1 (before traffic signal in through direction) when the green time is high, the travel time is reducing. The travel time begin increase when the green time is decrease. For sec.3 (before traffic signal in opposite direction), the travel time for all cases (a, b, c, d) is higher than the normal case since the red time is higher than the green time. For sec.5, the travel time for all cases (a, b, c, d) is lower than the normal cases. For sec.2 and sec.4, the travel time is no effect when using the traffic signal.

Case	Cycle length (s)	**Traffic control data** For through traffic		For opposite traffic	
		Green time(s)	Red time (s)	Green time (s)	Red time (s)
Case a	60	50	10	10	50
Case b	60	45	15	15	45
Case c	60	40	20	20	40
Case d	60	35	25	25	35

Table 2 - Traffic control times.



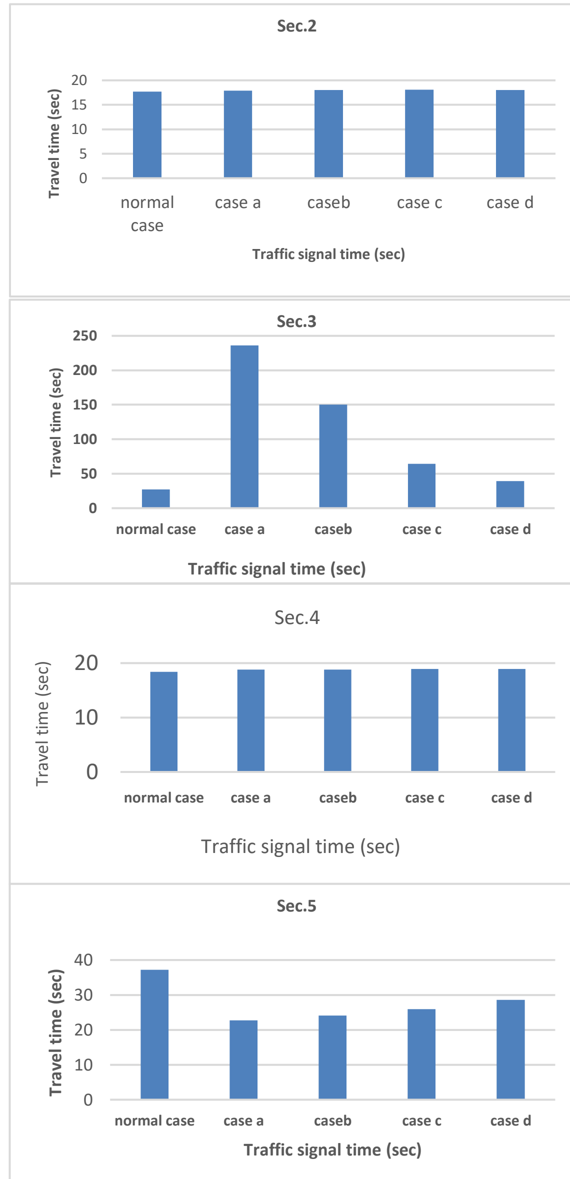


Figure 4: The travel times with used of traffic control.

5.2 The effect of using speed humps

Speed humps is one of the most traffic calming that produce significant reduction for speeds of traffic. In this study, the speed hump is placed in opposite direction to reduce the speed of vehicles that conflict with the turning vehicles to ease the turning process. Such speed humps are usually located upstream of the U-turn sites as show in Figure (5).

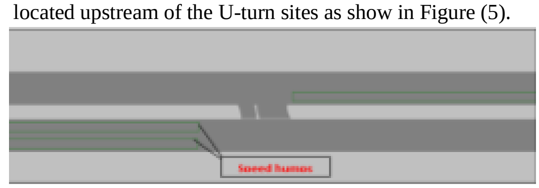


Figure 5: The speed humps location.

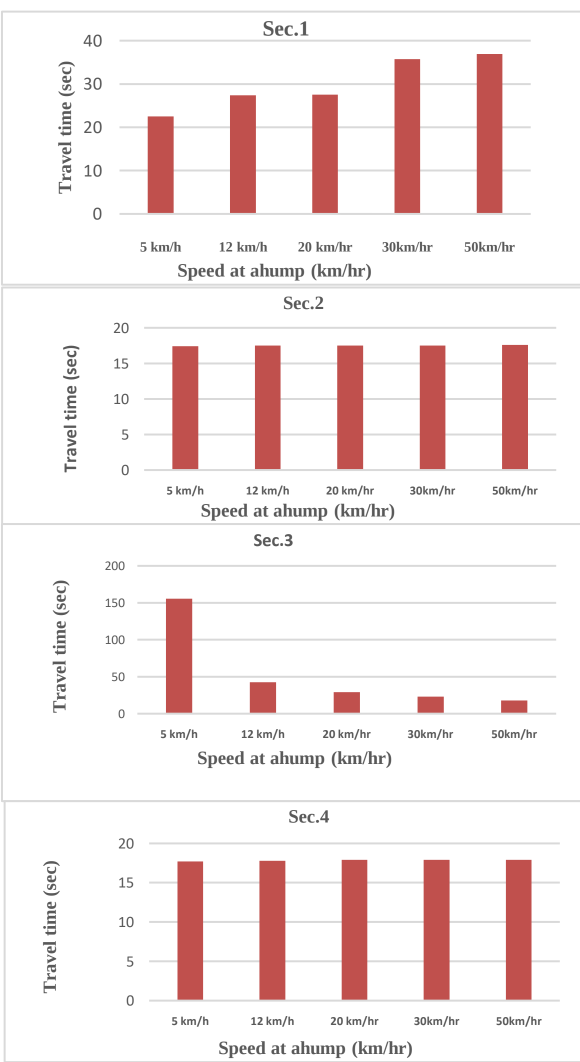
Different speeds for opposing traffic have been tested to simulate the effect of humps on opposing traffic speeds and to examine the effect of that on merging traffic. Table (4) shows the speed of vehicles at hump. Figure (6) shows the travel time results for sec.1, sec.2, sec.3, sec.4, and sec.5 for all case of speed hump.

The used of the speed humps can significantly effect to reduce the travel time for the turning vehicles and make the U-turn process is easy. For sec.1, the use of speed hump decreases the travel time and when the speed of vehicles at the hump increase the travel time also increase. For sec.3, the used of speed hump at the opposite direction increase the travel time since the speed in the section is lower due to the use of hump and when the speed of vehicles at hump increase the travel time is decrease.

For sec.5, when the speed of vehicles in humps increase the travel time also increase since the speed in main street (opposing direction) is increase and the turning vehicles should be waiting unite the enough gap is providing. For sec.2 and sec.4, the travel time is not effect when using the speed hump.

Table 3 - The speed of traffic at humps

Case NO.	The speed of vehicles at hump
Normal case	50 (km/hr)
Case a	5 (km/hr)
Case b	12 (km/hr)
Case c	20 (km/hr)
Case d	30 (km/hr)



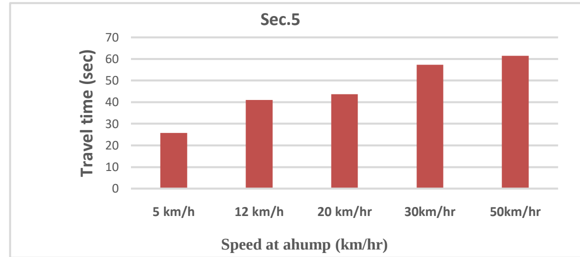
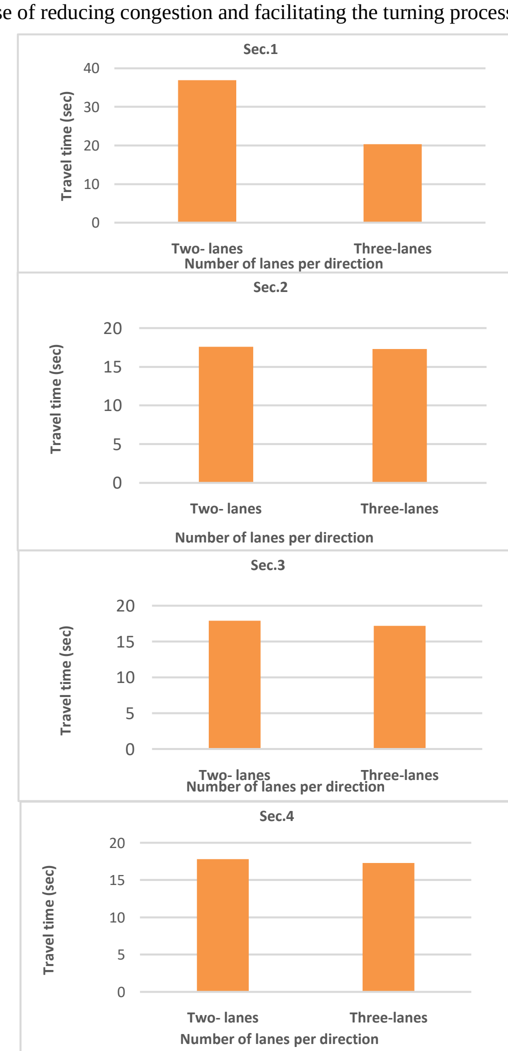


Figure 6: The effect of speed hump on the travel time.

5.3 The effect of increasing number of lanes

In Al-Diwaniyah, most of multilane roads having three lanes for each direction but however, one of these lanes is usually utilized as on line parking. This section examines the effect of increasing the no. of lanes of the travel time of the through, opposing, merging directions by preventing such on line parking. Figure (7) shown the travel time for sec.1, sec.2, sec.3, sec.4, and sec.5 for using two lanes and three lanes. The results show that the increase the number of lanes have significantly reduced the travel time in (sec.1, 5) because the capacity of two lanes is lower than the capacity of the three lanes and (sec.2,3,4) are not effect. From that, it should be recommended to prevent vehicles to stop near the U-turn section for the purpose of reducing congestion and facilitating the turning process.



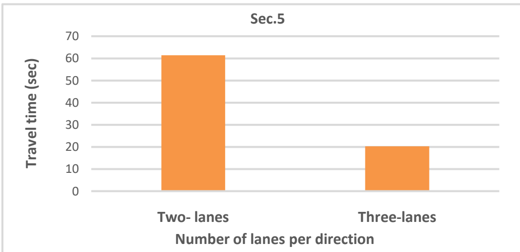
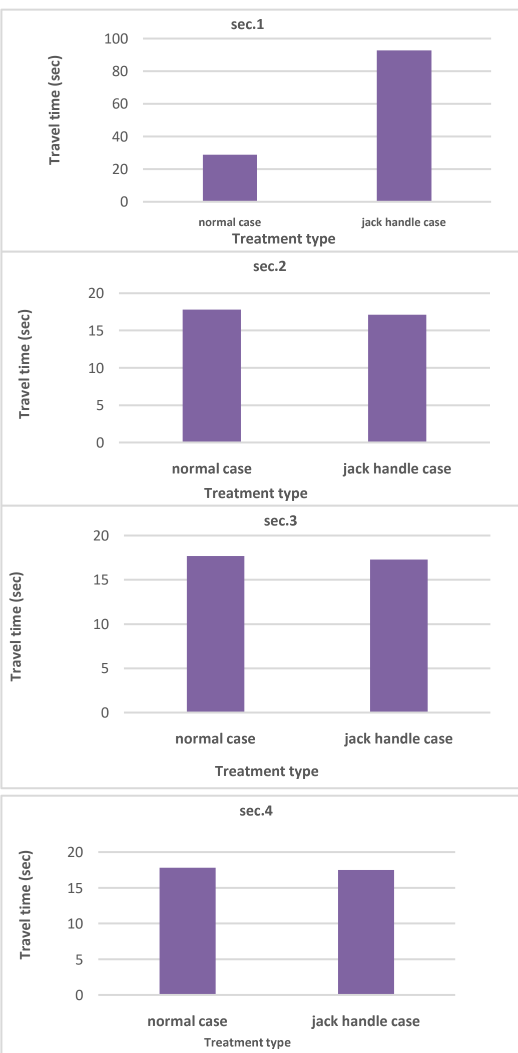


Figure 7: The effect of increase NO. of lanes of the travel time.

5.4 The effect of using jack handles

The geometric design of jack handle is required a spacious place on the side of the road near the U-Turn section. No lane uses nearby the site selection. The jack handle treatment cannot use in crowded cities with urban buildings on the sides of road. It might be effective on external roads that contain empty spaces on the sides of the road. Figure (2) shows the U-turn model with jack handle. Figure (8) shown the result of using jack handle.



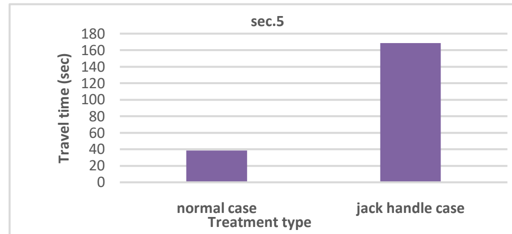


Figure 8: The effect of using jack handle on the travel time.

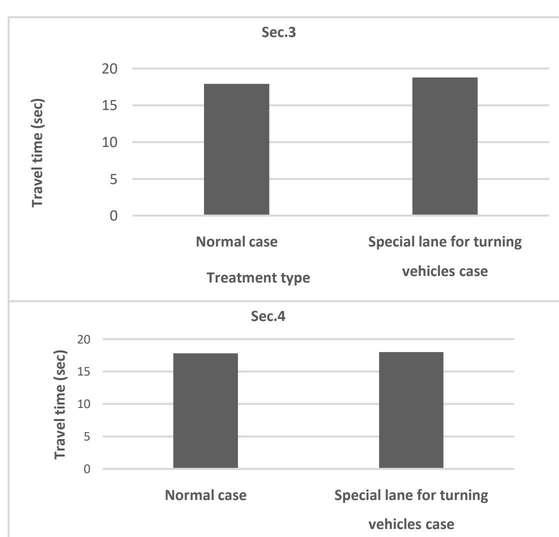
In this study, the gap is take (2.5 sec.).This gap take from the calibration and validation processes .

For sec.1 (before jack handle in through direction), the used of jack handle increase the travel time for this section as compared to the normal section. For sec.5 (turning direction), the travel time for normal section is lower than the travel time when using jack handle because the turning vehicles in jack handle should wait unit the enough gap is providing in the through and opposite direction. On the other hand, the turning vehicles in normal case wait unite the enough gap is providing in opposite direction only. For sec.2, sec.3, and sec.4, the travel time is not effect when using the jack handle treatment. Finally, the used of jack handle is not effective to enhance the movement at the U-turn section.

5.5 The effect of using special lanes for turning vehicles

The used of special lane (see Figure 2) for the turning vehicles is an effective way to increase the capacity of U-turn section as well as making the U-turn movement safer as a result of eliminating conflict points during the turning process. This section examines the effect of allocating of a special U-turn path through both directions. Figure (9) shows the results of the effect of using special lane for turning vehicles on the travel time.

The use of special lane for the turning vehicles has a significant effect to reduce the travel time for the turning vehicles. For sec.3,4, the travel time is not effect. For sec.5, the travel time is reducing when using the special lane for turning vehicles since the turning vehicles are not effect by the opposite volume and turn directly without waited to provide the enough gap. As well as, the (500 veh/hr) is the input turning volumes and the output volumes after the run is (400 veh/hr) in normal case and (528 veh /hr) in used of special lane for turning veh case. This result lead to the capacity of U-turn also increase.



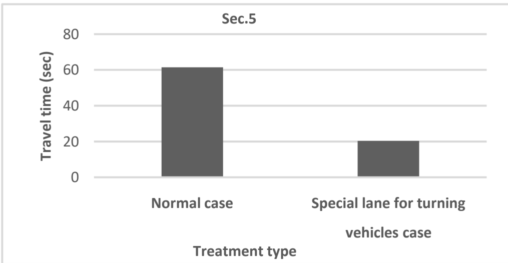


Figure 9: The effect of using special lane for turning vehicle on the travel time.

6. Conclusions

This paper used VISSIM microsimulation software to development model for the U-turn section and test different scenarios to enhance the movement at U-turn section. The video recording was used to collect data for Al-Diwaniyah city, Iraq. The calibration and validation process were done for model development to represent the real data. After this stage, the models used to test different alternatives and the result shown the ability of use VISSIM software to model the complicated section such as U-turn section. The following conclusions could be highlighted.

- The use of traffic signal at U-turn section may enhance traffic conditions at U-turn sites if appropriate signal timings is used.
- The use of speed hump in the opposite direction causes the reduction of travel time for the turning vehicles since the driver at the speed hump should reduce their speed. In addition, when the speed of the vehicles at a hump is increased, the average travel time for turning is increase but the average travel time for opposing traffic also decrease.
- The increase the number of lanes have significantly reduced the travel time in turning vehicles. Therefore, it should be recommended to prevent vehicles to stop near the U-turn section for the purpose of reducing congestion and facilitating the turning process.
- The use of Jack handle layout has increased the travel time for sections and therefore, such layout has not recommended based on this study results.
- The used of special lane for the turning vehicles has significantly reduced the travel time for the turning vehicles.

REFERENCES

1. Combinido, J.S.L. and Lim, *Modeling U-turn traffic flow.* 2010. **389**(17): p. 3640-3647.
2. Della, R.H., J. Arliansyah, and Riga, *Traffic performance analysis of u-turn and fly over u-turn scenario; a case study at Soekarno Hatta Road, Palembang, Indonesia.* 2015. **125**: p. 461-466.
3. Al-Obaedi, *Investigation the effect of speed humps on merging time of u-turn traffic.* 2019. **10**(1): p. 1-4.
4. Al-Obaedi, *Simulating the effect of speed humps on the U-turn traffic.* 2019. **32**(12): p. 1773-1780.
5. Meel, I.J.A.T.J., *The optimal design of u-turns on thai highways.* 2014. **7**(1): p. 21-32.
6. Meel, I.P., et al., *Safety impact of application of auxiliary lanes at downstream locations of Thai U-turns.* 2017. **41**(1): p. 1-11.
7. Yang, X., et al. *The gap acceptance study of U-turn at median openings*. in *ITE 2001 Annual Meeting and ExhibitInstitute of Transportation Engineers (ITE)*. 2001.
8. Detemple, J., et al., *Simulation methods for optimal portfolios.* 2007. **15**: p. 867-923.
9. binti Bachok, R. and K. Sarah. *Residents' Perceptions on the Effectiveness of Road Humps in Improving Malaysian Residential Environments*. in *Proceedings of the 2nd World Congress on Civil, Structural, and Environmental Engineering*. 2017. Citeseer.
10. Organization, W.H., *Global status report on road safety 2015*. 2015: World Health Organization.
11. Al-Jameel, *Contribution to the U-turn Design at Median Openings in Iraq: Al-Najaf City as a Case Study*. 2014. **6**(1).
12. Al-Kareawi, Z.A. and J.T. Al-Obaedi. *Simulation of U-turn traffic based on VISSIM and PARAMICS micro simulation*. in *Journal of Physics: Conference Series*. 2021. IOP Publishing.