LITERATURE REVIEW

1. 15 Crossings : crossing facilities for pedestrians (The design of the pedestrian network)
NZ transport agency
Pedestrians cross the road an average of two to three times on every walking trip and may also need to cross railways, waterways or other natural features. Their perceptions of the walking experience largely focus on difficulties crossing roads and any problems with this can cause delays and create a sense of insecurity. Therefore, correctly designing, building and signing appropriate crossing facilities should be a major consideration when developing pedestrian routes. This applies not only to facilities in the road reserve, but also to off-road environments shared with cars, such as car parks.

2. A methodology to assess pedestrian crossing safety
Basile, Olga; Persia, Luca; Usami, Davide Shingo
The safety level of a pedestrian crossing is affected by infrastructure characteristics and vehicular and pedestrian traffic level. This paper presents a methodology that allows assessing the safety level of a pedestrian crossing, regulated or not by traffic light, in an urban area according to the features of the crossing.

3. A within-subject design of comparison of waiting time of pedestrians before crossing three successive road crossings
Transportation Research Part F: Traffic Psychology and Behaviour
Volume 15, Issue 6, November 2012, Pages 625-634
Transportation Research Part F: Traffic Psychology and Behaviour
This study is a partial replication of the work of Hamed (2001) who found a negative correlation between waiting time of pedestrians before crossing the first and the second stage of a road divided by an island. The innovation of the current study is an addition of testing the waiting time before crossing a third successive crosswalk. The research is based on examining the correlation between the waiting times of pedestrians before each stage of crossing a triple-crossing. The research was conducted in two different types of three successive crossings: (1) with a narrow or (2)
with a wide refuge island dividing between the two parts of the main road. We hypothesized that in a narrow island condition the correlation between the waiting time of the first and the second crossings will be negative; a finding that would have replicated Hamed’s finding. However, in a wide island condition, so that the two-stage crossing will be perceived by the pedestrian as two separate units, the correlation between the waiting time in the first and the second crossings would be positive. More than 750 people (of which 54% were female) were observed crossing junctions with a triple-stage crossings in three different locations in the center of Israel (two with wide islands and one with a narrow island). The waiting time before crossing each part of the road was measured by two experienced observers. The mean waiting time beyond individual differences was 6.00, 5.76 and 0.79 s at the first, second and third crossings respectively. Our results are not in line with those of Hamed (2001). At the junction with the narrow island no correlation between the waiting time of the first and the second crossing was found. A positive correlation has been found between the waiting time of the first and the second crossing in the condition of the wide refuge island. In all locations a positive correlation has been found between the waiting times at the second and third crossings. These findings lead to an optional explanation that the width of the refuge island determines the way in which the pedestrian perceives the task of crossing two-stage crossings. These findings support a possible explanation by a newly suggested model – Renewed Patience Model. The implications of the research and other methodological issues are discussed. (Science direct) https://www.sciencedirect.com/science/article/pii/S1369847812000551

4. Advanced Yield Markings and Pedestrian Safety: Analyses of Use with Danish Offsets and Median Refuge Islands
Nambisan, Shashi S; Vasudevan, Vinod; Dangeti, Mukund; Virupaksha, Vinay
TRB 87th Annual Meeting, 2008
This paper summarizes an evaluation of the effectiveness of advanced yield markings in improving pedestrian safety when used with Danish offsets and median refuge islands. These countermeasures were deployed in combinations in two stages. The evaluations are based on field observations by trained observers at sites located in the Las Vegas metropolitan area, Nevada. Observational data were collected at one uncontrolled intersection, and one mid-block site. Motorist and pedestrian behaviors were observed, and various measures of effectiveness were used to evaluate the effectiveness the countermeasures. The results show that both sites experienced an increase in pedestrians’ observing behavior and an improvement in motorists’ yielding behavior. Also, a reduction in the number of pedestrians trapped in the roadway was observed at one of the study sites. The high visibility crosswalk and advance yield markings at the mid-block location showed positive safety benefits in motorists’ and pedestrians’ behaviors. The findings from this study could be used to enhance pedestrian safety on arterial roadway in other cities. (TRB) https://trid.trb.org/view/848875

5. Agent-based Modeling of Pedestrian Behavior at an Unmarked Midblock Crossing
Shaabana, Khaled; Abdel-Waritha, Karim
Procedia computer science, 2017, Vol. 109, pp. 26-33
Illegal pedestrian behavior is considered one of the main reasons for pedestrian-related crashes. This paper provides a detailed outlook of the gap acceptance behavior of pedestrians illegally crossing at an urban midblock section of a six-lane road. A simulation model was developed to capture the illegal crossing behavior for the pedestrians using agent-based modelling techniques and implemented in Anylogic. Once calibrated to study the crossing behavior, several distributions were fed into the model to determine the best distribution that mimics the pedestrians’ movements. It was found that the normal distribution is the closest fit. The results suggest that the pedestrians add a factor ranging from 1.25-1.5 to vehicle speeds before anticipating the gap, then determine whether to cross or not. The simulation tool was found useful for replicating the illegal crossing behavior. The results from this study can be helpful in assessing the pedestrian safety and providing better crossing facilities for pedestrians in urban areas. (Elsevier) https://reader.elsevier.com/reader/sd/A9352228623C3C660A07F7C1236BFA7CFED2F462534130E94CE6423EC6D715EF9EBF07224BDE9D5E1CA2CB3FFFE5CFE

6. Analyses of pedestrian behavior on mid-block unsignalized crosswalk comparing Chinese and German cases
Jiang, Xiaobei; Wang, Wuhong; Bengler, Klaus
Sagepublications, 2015, Volume: 7 issue: 11,
A large number of pedestrian fatalities are caused by the vehicle-pedestrian accidents. The application of new theory and technological approaches may hold great potential to reduce the accident frequency and severity for pedestrians.
Considered the different driving cultures between China and Germany, the adaptation of such application in new market triggers an “intercultural comparison” related to the road user behavior and traffic safety. Field traffic data have been collected by video recording and image processing at unsignalized mid-block crosswalks both in Beijing, China and Munich, Germany. Centered Vehicle-Pedestrian conflict situation, pedestrian speed performance in different pedestrian categories and walking phases, pedestrian waiting behavior related to waiting decision choice and waiting time, pedestrian gap acceptance were statistically analyzed for understanding the pedestrian behavior in the conflict process. Intercultural comparisons were made between China and Germany. The research results addressed how the conflict participants (pedestrians only) behave differently and would hopefully be the impetus for further intercultural analyses from urban traffic side. (Sage journals)

http://journals.sagepub.com/doi/full/10.1177/1687814015610468

7. Assessment of Pedestrian Refuge Islands on Vehicle Speed Changes and Pedestrian Safety: Case Study in Tehran
Sadraei, Arash; Safigarzadeh, M; Boroujerdian, Amin Mirza
International Journal of Civil Engineering, June 2017
Pedestrians are among one of the most vulnerable road users. Speed of vehicles is considered as one of the major causes of danger for pedestrians crossing the street (making cross movements). Therefore, it is of utmost importance to devise suitable solutions for reducing the speed of vehicles. One of these solutions is installation of pedestrian refuge islands (PRI) in very wide midblocks. With regard to fluctuations in pedestrian and vehicle traffic volume in traffic hours, there are different variations in collisions between vehicles and pedestrians. In this article, the effect of the constructed PRI in Tehran on speed of vehicles and consequently their effects on probability fluctuations of fatal accidents are determined. Speed of vehicles in two phases of before and after arriving to the PRI is assessed. Additionally, speed of vehicles in non-observed volumes of vehicles and pedestrians is calculated using Aimsun.v6 simulation software. Paired T test is applied to compare average speed of vehicles before and after the PRI. The results revealed that except for traffic volumes of 3000–4000 veh/h and 400–600 ped/h, in other volumes reduction of average speed of vehicles as a result of PRI is significant. In addition, the results show that in all volumes, these equipments reduce the probability of fatal accidents to under 10%. According to the results, it is recommended that PRI should be installed in midblocks where traffic volume of vehicles in each lane is less than 750 veh/h.
(Researchgate)
https://www.researchgate.net/publication/318238530_Assessment_of_Pedestrian_Refuge_Islands_on_Vehicle_Speed_Changes_and_Pedestrian_Safety_Case_Study_in_Tehran

8. Comparison of Analytical Methods on Staged Pedestrian Crossings at Crosswalks with a Rectangular Rapid Flashing Beacon
Avelar, Raul E; Fitzpatrick, Kay; Brewer, Marcus A
TRR, 2017, Vol. 2661, pp. 1–11
Previous studies of rectangular rapid-flashing beacons have found a wide range of driver yielding rates (19% to 98%). As part of the efforts to study yielding at different types of crosswalk locations better, this research compared alternative statistical methods to analyze staged crossing data. A database was compiled of 12,040 individual crossings at 73 sites representing 128 crossing periods, which included a set of 27 potentially influential variables. Analysis of this data set began with considering the hypothesis that negative binomial regression could be the most appropriate method of analysis, given the characteristics of the data collected at each staged crossing. However, alternative methods—in particular, logistic regression and analysis of variance—also appear appropriate. Even when these alternative methods may not explicitly account for some theoretical implications of staged-crossing data, the methods may prove to model yielding rates acceptably. A potential benefit of using the alternative methods is that the results may be easier to interpret in the context of decision making in regard to pedestrian crosswalk treatments. This research investigated the methodological aspect of analysis to advance the understanding of the explanatory factors, the results, and the phenomena under study. Results from various analyses indicated that logistic regression tended to yield results that were more accurate. Additionally, this research found that the statistical power of two of the techniques evaluated increased when explicitly accounting for the total number of cars observed at each crossing.
(TRB)

9. Complete Streets: what are complete streets?(Smart growth America) & We Can Get There from Here (Proquest)
Laplanche, John; Ptoe, PE; McCann, Barbara

Complete Streets are streets for everyone. They are designed and operated to enable safe access for all users, including pedestrians, bicyclists, motorists and transit riders of all ages and abilities. Complete Streets make it easy to cross the street, walk to shops, and bicycle to work. They allow buses to run on time and make it safe for people to walk to and from train stations. Creating Complete Streets means transportation agencies must change their approach to community roads. By adopting a Complete Streets policy, communities direct their transportation planners and engineers to routinely design and operate the entire right of way to enable safe access for all users, regardless of age, ability, or mode of transportation. This means that every transportation project will make the street network better and safer for drivers, transit users, pedestrians, and bicyclists—making your town a better place to live....

10. Contexually complete streets
Sousa, Lindsey R; Rosales, Jennifer
Green Streets and Highways Conference 2010, November 14-17, Denver, Colorado, US
Throughout the US and worldwide, great places can be defined as attractive, active, open, walkable, entertaining and full of people. Great places have great streets and great streets have a "place" function. Great streets are accessible, livable, safe, comfortable, and interactive. Over 130 municipalities across the US have complete streets policies. A Contextually Complete Street is a multi-modal complete street reflecting the principles of context sensitivity and sustainability. In a Contextually Complete Street, the stakeholders and context define what is meant by "complete." This paper describes Contextually Complete Street principles and provides examples of these complete street solutions. Common themes of Contextually Complete Streets are explored and tools that can be used in achieving a Contextually Complete Street are highlighted. These tools include road diets, traffic calming, intersection design, designing for pedestrians and bicyclists, transit design features, lane restrictions, and green street options. (ASCE) https://ascelibrary.org/doi/abs/10.1061/41148(389)9

11. Descriptive and parametric analysis of pedestrian gap acceptance in mixed traffic conditions
Chandra, Satish; Rastogi, Rajat; Das, Vivek R
Transportation
Crossing is an inevitable part of walking in which the desired path of pedestrians conflicts with vehicular traffic. These conflicts can result in either delay or risk to the pedestrians. Due to insufficient designated crossing points on a highway or improper design, most pedestrians are forced to cross at random unpredictable locations. As such, they create confusion and risks to themselves, as well as to the drivers. Road accident statistics reveal that pedestrian injury and deaths are very high in India and improper gap acceptance during crossing is a major contributing factor. Gap acceptance data collected at 17 locations in five cities of India are analysed in this study to understand the variation in the gap acceptance behavior through descriptive and parametric analysis. Descriptive analysis provided central tendency, dispersion and distribution of gap acceptance data, whereas, parametric analysis resulted in identification of relationships between factors affecting accepted gap. Accepted gap was found decreasing with conflicting traffic and crossing speed of the pedestrians. It also found varying with change in number of lanes on the road to be crossed. Critical gap was estimated from accepted gap and crossing time distribution functions for varied traffic and spatial conditions. (Springerlink) https://link.springer.com/article/10.1007/s12205-014-0363-z

12. Development of Canadian National Pedestrian Crossing Control Guide
Jeannette Montufar Related information1 Department of Civil Engineering, University of Manitoba, E1-328 EITC, 15 Gillson Street, Winnipeg, Manitoba R3T 5V6, Canada
Transportation Research Record: Journal of the Transportation Research Board, No. 2393, Transportation Research Board of the National Academies, Washington, D.C., 2013, pp. 50–58.
In 2010 the Transportation Association of Canada began the 2-year process of updating the 1998 pedestrian crossing control manual. The resulting document, the Pedestrian Crossing Control Guide, is expected to promote uniformity across the country with respect to the approach used in the provision of pedestrian crossing control. This standardization is done through the development of a decision support tool to assist in the decision-making process when the need for pedestrian crossing control is established and in identification of the type of crossing control to use for the location's characteristics. The development of the new Pedestrian Crossing Control Guide for Canada is
discussed, and findings of the research that led to its development are presented. The findings fall into two areas: existing Canadian and international pedestrian crossing control practices and safety performance of different pedestrian crossing control devices. Principal conclusions from this research are (a) international practice is changing toward providing guidance rather than formal, numerical warranting procedures in the decision-making process for the provision of pedestrian crossing control; (b) there are pedestrian crossing control treatments for which there is no available literature regarding safety performance, and the available literature for other treatments lacks rigorous safety evaluations; and (c) further research is needed regarding the safety performance of pedestrian crossing control devices, particularly in the areas of understanding pedestrian collisions and developing accident prediction models. (TRR)

13. Effect Of Pedestrians Un-Signalized Mid-Block Crossing On Vehicular Speed
Kadali, B Raghuram; Chiranjeevi, Tadi; Rajesh, Rankireddy
International journal for traffic and transport engineering, 2015, Vol. 5, No. 2, pp. 170-183
Pedestrian is one of the important component in urban transportation system and also vulnerable at un-protected mid-block locations under mixed traffic conditions. At unprotected mid-block locations, some of the vehicles may yield to pedestrians who are already at crosswalk location. However, some of the pedestrians are using forced gaps to cross the road. Hence, while pedestrians use the mid-block crosswalk with forced gaps, which decreases the vehicular flow characteristics. The pedestrian sidewalks do not show a direct effect on the vehicular flow characteristics when the pedestrian have pleasant walking facilities. The present study has analyzed the effect of pedestrian crossing on the characteristics of vehicular flow at mid-block location under mixed traffic conditions. The results indicate that the pedestrian forced gap condition has significant effect on vehicular characteristics. The study results may be useful for decreasing the travel time for vehicular drivers by controlling usage of pedestrian forced gaps.

14. Effects of Refuge Island Settings on Pedestrian Safety Perception and Signal Violation at Signalized Intersections
Cao, Ying ying; Ni, Ying; Li, Keping
Pedestrians are the most vulnerable road users and great efforts have been made to find out countermeasures to improve pedestrian safety. One of the most widely accepted countermeasure is to install pedestrian refuge island, which has been proved to improve pedestrian safety at non-signalized crosswalks, especially at mid-block crossings, but some researchers also pointed out its adverse effects at signalized crosswalks. In order to explore the underlying mechanism how refuge islands impact pedestrians’ perception as well as their behaviors, the paper focuses on finding out important influencing factors related to refuge island settings and analyzing their effects explicitly. Intercept survey on pedestrians’ safety perception and video observation was carried out at four crosswalks in Shanghai, China. Random-effects ordered logistic model and binary logistic models are adopted to model pedestrians’ safety perception and signal violation, respectively. The model has revealed that installation of a refuge island can provide pedestrians with better safety perception, wider refuge island stimulates more pedestrians to cross on red from curbside, but meanwhile it can keep more pedestrians waiting at the median instead of violating signal for the second crossing part. Besides, it has been found that pedestrians are more likely to cross on red from curbside if signal indication for the second crossing part is green, especially if signal heads set at curbside and refuge island are non-staggered. The preliminary conclusions can provide evidences to improve planning, design and operation of refuge islands. For example, most of the existing guidelines only paid attention on the lower limit of refuge island width, but the fact is not the wider the better. It is necessary to optimize refuge island width with consideration of pedestrian volume, signal timing scheme etc., and try to make trade-off between good safety perception and low violation rate. (TRB)
https://pubsindex.trb.org/view/2017/C/1438608

15. Evaluating Driver and Pedestrian Behaviors at Enhanced, Multilane, Midblock Pedestrian Crossings: Case Study in Portland, Oregon
Foster, Nick; Monsere, Christopher M; Carlos, Katherine
Transportation Research Record, January 2014, Vol. 2464, No.1 pp. 59-66
This study examined driver and pedestrian behaviors at two enhanced midblock pedestrian crossings in Portland, Oregon. One crossing was at a five-lane arterial with a posted speed of 35 mph and featured eight rectangular rapid flash beacon (RRFB) assemblies and a narrow median refuge. The other crossing was at a suburban arterial with a posted speed of 40 mph, four travel lanes, and a two-way left-turn lane. The crossing was enhanced with four RRFB
2% of all crossings were investigated. Approximately 62 h of video was collected at the two locations. A total of 351 pedestrian crossings were analyzed for driver compliance (yielding) rates, pedestrian activation rates, pedestrian delay, and conflict avoidance maneuvers. The suburban arterial crossing was also evaluated to determine its effectiveness at diverting pedestrians to cross at the crossing instead of away from the crosswalk, as well as pedestrian compliance with the Z-crossing. The study found that average driver yield rates at both sites were slightly greater than 90% when the RRFB was activated, consistent with previous studies. RRFB actuation rates ranged from 83% to more than 90%. The results also showed that approximately 52% of all crossings at the marked crosswalk at the second location were made by diverted pedestrians and that the enhanced crossing captured about 82% of all crossings near the crosswalk. Finally, approximately 52% of the pedestrians who used the crosswalk followed the Z-crossing pattern through the median. (Ebsco)

16. **Evaluating Effectiveness of Infrastructure-Based Countermeasures for Pedestrian Safety**

Pulugurtha, Srinivas; Vasudevan, Vinod; Nambisan, Shashi; Dangeti, Mukund
This paper summarizes an evaluation of the effectiveness of selected infrastructure-based countermeasures to enhance pedestrian safety. The countermeasures evaluated in this paper were high-visibility crosswalk, median refuge, Danish offset, and pedestrian channelization. The selected countermeasures were deployed at eight locations in the Las Vegas, Nevada, metropolitan area. The evaluations were based on field observations of pedestrian and driver behaviors before and after the installation of the countermeasures. The selected countermeasures were evaluated with measures of effectiveness such as pedestrians who were trapped in the street, pedestrians who looked for vehicles before they began to cross, pedestrians who looked for vehicles before they crossed the second half of the street, pedestrians who were captured (those who modified their path to use the crosswalk but did not go out of their way to do so), pedestrians who were diverted (those who had to go out of their way to use the crosswalk or changed their course of action), drivers who yielded to pedestrians, the distance at which drivers yielded or stopped before the crosswalk, and drivers who blocked the crosswalk. Results showed that a high-visibility crosswalk and a median refuge helped to improve pedestrian as well as driver behavior, whereas a Danish offset increased the proportion of diverted pedestrians. At sites with those countermeasures, the distance at which drivers stopped or yielded for pedestrians before the crosswalk increased. Results based on analysis of data at the site with pedestrian channelization were inconclusive. (TRB) [https://trpjournalconline.trb.org/doi/abs/10.3141/2299-11](https://trpjournalconline.trb.org/doi/abs/10.3141/2299-11)

17. **Evaluation of Human Behaviour at Pedestrian Crossings**

Mako, Emese; Szakonyi, Petra
Transportation Research Procedia , 2016, Vol. 14, pp.2121-2128
[https://doi.org/10.1016/j.trpro.2016.05.227](https://doi.org/10.1016/j.trpro.2016.05.227)
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Road traffic crashes result from a combination of factors related to the road layout, the vehicles, the road users and the way they interact. First the main causes of pedestrian fatalities and the safety effects of road measures (traffic lights, roundabouts and refuge islands) at pedestrian crossings before and after implementation were investigated. The results indicate that there is a strong evidence for the positive effect of these measures especially on the number of the pedestrian related accidents. In the next phase a site survey was conducted in order to estimate the irregular crossing manoeuvres of car drivers and pedestrians at designated pedestrian crossings. Having analysed the irregular movements according to the type of crossing it was found, that car drivers behave the most irregularly at crossings without a refuge island. Crossings equipped with flashing yellow lights, refuge islands and traffic lights require a much more appropriate behaviour from car drivers. In the next phase of the research the waiting time of pedestrians and the delay of vehicle drivers again at pedestrian crossings were surveyed. Our results suggest that there is a need for a strong contribution of the human and the engineering fields to obtain an even more positive change in the safety of vulnerable road users. (Science direct) [https://www.sciencedirect.com/science/article/pii/S2352146516302307](https://www.sciencedirect.com/science/article/pii/S2352146516302307)

18. **Evaluation of pedestrian mid-block road crossing behaviour using artificial neural network**

Kadali, B Raghuram; Rathi, Nivedan; Perumal, Vedagiri

Pedestrians usually cross the road at mid-block locations in India because of the ease and convenience to reach their destination as compared to intersection locations. It is important to evaluate the pedestrian gap acceptance behavior at mid-block locations because of inadequate vehicular gaps under mixed traffic condition, which translates into the
pedestrian road crossing behavior. The present study examines the pedestrian gap acceptance behaviour by employing an artificial neural network (ANN) model for understanding the decision making process of pedestrians, i.e., acceptance or rejection of vehicular gaps at a mid-block location. From the results it has been found that the pedestrian rolling gap, frequency of attempt, vehicular gap size, pedestrian speed change condition and vehicle speed have major role in pedestrian gap acceptance. These results can lead to a better design of pedestrian crossing facilities where adequate gaps are not available in vehicular flow at mid-block crosswalk locations. (Science direct) https://www.sciencedirect.com/science/article/pii/S2095756415300957

Mead, Jill; Zegeer, Charlie; Bushell, Max
This document represents an effort to compile all known research on the effect of the pedestrian safety countermeasures discussed in PEDSAFE: Pedestrian Safety Guide and Countermeasure Selection System. It is intended to serve as a companion document for the guide, providing a complementary overview of the researchers, research methods, and evaluation results that have guided the development and design of pedestrian safety countermeasures. (TRID)

20. Exploration of Pedestrian Refuge Effect on Safety Crossing at Signalized Intersection
Lingjie Li Related information1 Transportation Research Center, Beijing University of Technology, 100 Ping Le Yuan, Chaoyang District, Beijing 100124, China
, Xiaokuan Yang Related information1 Transportation Research Center, Beijing University of Technology, 100 Ping Le Yuan, Chaoyang District, Beijing 100124, China
, Li Yin Related information2 Beijing Municipal Institute of City Planning and Design, No. 60 South Lishi Road, Beijing 100045, China
Pedestrian safety has become a major issue in the traffic management systems of major cities in China. This is particularly true where a signalized intersection is relatively large and a significant number of pedestrians must wait to cross. This study investigated the safety issues of pedestrian crossings at signalized intersections in Beijing. Field observations were conducted and evaluated, and a questionnaire survey was administered to both pedestrians and motorists at 45 signalized intersections in Beijing. Safety implications of pedestrian crossings at wider signalized intersections and traffic conflict analyses are elaborated on with respect to the survey. It can be concluded from this study that it is vital to install a pedestrian refuge island at the medians of roadways to provide pedestrians with a risk-free waiting area to complete two-step crossings. This measure is particularly necessary at signalized intersections where green time designated for pedestrian crossing is scarce. This study shows that a refuge island has proved acceptable to both pedestrians and drivers. (Ebsco)

21. Factors Affecting Driver Yielding Compliance at Uncontrolled Midblock Crosswalks on Low-Speed Roadways
Stapleton, Steven; Kirsch, Trevor; Gates, Timothy J; Savolainen, Peter T
TRR, 2017, Vol.2661, pp. 95-102
Field studies were performed to compare the effectiveness of traffic control countermeasures commonly used at uncontrolled midblock crosswalks. Various crosswalk treatments were evaluated at 31 low-speed midblock crosswalks located near three public universities. The study locations included unmarked crosswalks, in addition to standard and continental crosswalk markings, some including an additional enhancement device such as the pedestrian hybrid beacon (PHB), rectangular rapid flashing beacon (RRFB), or an in-street R1–6 sign. Driver yielding compliance during staged pedestrian crossing events was used as the measure of effectiveness. To isolate the crosswalk treatment effects, several roadway and traffic characteristics were included in the analysis, including the crossing distance, median presence, vehicular and pedestrian volumes, travel lane of the subject vehicle, and the subject vehicle’s position in a queue. A mixed effects logistic regression model was used to account for correlation in yielding rates within the same sites as well as for unobserved heterogeneity across locations. The results indicate that the type of crosswalk treatment has a strong influence on driver yielding compliance. While yielding compliance improved substantially when crosswalk markings were used, the highest compliance rates were achieved when an additional enhancement device (i.e., RRFB, PHB, or R1–6 sign) was also provided. Yielding compliance showed little sensitivity to the particular travel lane of the subject vehicle at locations where a crosswalk enhancement device was used, further validating the effectiveness of these treatments. Finally, yielding compliance rates were generally higher across each of the crosswalk enhancement devices compared with prior studies performed in the same areas, suggesting compliance improves as drivers become more familiar with these devices. (TRB)
22. **Human factors of pedestrian walking and crossing behaviour**  
Papadimitriou, Eleonora; Lassarre, Sylvain; Yannis, George  
Human factors related to pedestrians have received somewhat less attention in the literature compared to other road users, although it is often underlined that road and traffic factors appear to explain only a small part of pedestrian walking and crossing behaviour in urban areas. The understanding of pedestrian behaviour in urban areas may assist in the improved design and planning of the road and traffic environment, and consequently to the improvement of pedestrian comfort and safety. The objective of this research is the exploration of human factors of pedestrian walking and crossing behaviour in urban areas. More specifically, this research aims to capture and analyse key components affecting pedestrian walking and crossing behaviour, namely the pedestrians’ attitudes, perceptions, motivations, behaviour and habits. (Ebsco)  

23. **Improvement of Pedestrian Crossing Safety on Urban Roads**  
Qiu, Dongdong; Xu, Qing; Zhang, Jielin  
IEEE May 2010 International Conference on Intelligent Computation Technology and Automation (ICICTA), Changsha, China  
There is a big number of pedestrians on Chinese urban roads. A specific study on pedestrian crossing is therefore significant in ensuring pedestrian safety and convenience. This article analyzed that the increase in pedestrian traffic accidents resulted from the pedestrian violation of traffic rules and the poor crossing facilities. Based on the improvement of pedestrian crossing facilities, the article gave some important proposals, such as building marked crosswalks, median barriers, pedestrian refuge islands, pedestrian traffic signals, overpasses and underpasses, to improve pedestrian safety. The three forms of pedestrian refuge islands were emphasized and illustrated further. At last, some suggestions to the related work which was likely to be done in China were given.  

24. **Improving Crosswalk Safety: Rectangular Rapid-Flashing Beacon (RRFB) Trial in Calgary**  
Domarad, J; Grisak, P; Bolger, J  
Monograph Title: Calgary 2013 - The Many Faces of Transportation - Technical Compendium (TRID)  
In 2011, 323 injury and fatality collisions involving pedestrians occurred within the city of Calgary. Even though pedestrian vehicle interaction will always pose a level of risk, pedestrian safety is improved with the use of active crossing devices which include signs, pavement markings, and push-button activated overhead flashers. The rectangular rapid-flashing beacon (RRFB) is an innovative alternative to the traditional pedestrian-activated overhead flasher assembly. Installed below the sidemounted pedestrian crosswalk signs, RRFBs use dual rectangular LED lights to display intermittent rapid flashes. The RRFBs achieve significant cost savings as they are solar powered and use a wireless connection for communication between the terminals. RRFBs have been evaluated in the United States with positive results; however, no installations or evaluations have taken place in Canada. This paper describes the RRFB Pilot Project undertaken by the City of Calgary to assess motorist yielding behaviour and the performance of the solar power systems. The before-and-after studies using staged crossings revealed that the RRFBs increased yielding compliance at all six crosswalks reaching nearly 100 percent compliance in majority of cases. Motorist yielding increased between 5 and 26 percent, depending on site, with an average of 15 percent. The findings were statistically significant at the 95 percent confidence interval at five of six locations. The performance of the solar power system during winter conditions was found to be satisfactory. (TRID)  
https://trid.trb.org/view/1263306

25. **Integrated optimization of location and signal timings for midblock pedestrian crosswalk**  
Yu, Chunhui; Ma, Wanjing; Yang, Xiaoguang  
Journal of advanced transportation, 2016, Vol. 50, pp. 552-569  
Finding the optimal location and signal timing plan is one of the most critical operational issues for a signalized midblock crosswalk on an arterial section, which is increasingly being installed in highly populated areas in developing countries such as China. This paper presents a multiobjective optimization model and an efficient solution
algorithm for a one- or two-stage midblock crosswalk on an arterial section. The proposed model aims to produce the optimal location and corresponding signal settings to balance the trade-off between pedestrian delays and vehicular bandwidth when the signals of the crosswalk and adjacent intersections are coordinated. The proposed model has three distinguishing features: (i) the costs for both pedestrians and vehicles are considered in a unified framework; (ii) the location and signal settings of the midblock crosswalk are simultaneously optimized; and (iii) a multiobjective optimization approach is developed to study the effectiveness of the midblock crosswalk under conditions in which the priorities between pedestrian and vehicle flows differ. A nondominated sorting genetic algorithm II (NSGA II)-based algorithm is developed to solve the model efficiently. The results of the case study showed that the proposed model would help traffic practitioners, researchers, and authorities properly locate and signalize a one- or two-stage midblock pedestrian crosswalk on an arterial section.


26. Investigation of Crosswalk Design and Driver Behaviors at Roundabouts

Findley, Daniel J; Searcy, Sarah E; Schroeder, Bastian J
Conference: Transportation Research Board 96th Annual Meeting, 2017,
This research explored the relationship between the location and configuration of pedestrian crosswalks and driver yielding behavior at roundabouts using data from staged pedestrian crossings (consistent crossing events by a research team member) at entry and exit crosswalks at 14 roundabouts. Driver yielding rates were found to be higher at crosswalks at roundabout entries than at crosswalks at roundabouts exits. Driver yielding rates were also higher for pedestrians waiting at the splitter island than those waiting at the curb. A model of yielding behavior found crosswalk distance from circulatory roadway affected yielding percentage, but the effect was too small to be practically significant. (TRID)
https://trid.trb.org/view/1437107

27. Investigation of Pedestrian Accidents Analysis at signalised pedestrian crossings in Edinburgh

Alnaqbi, Khalfan
4th IRTAD Conference 16-17 September 2009, Seoul, Korea
Data from STATS 19 show that pedestrian accident rates are higher over the pedestrian crossing points than these away from it, or within 50 meters of pedestrian crossing facilities. This is contrary to the expectations that accidents should be least over these crossing facilities. This study investigates in more details the factors that affect accidents occurrence at pelican crossing and signalised pedestrian area in Scotland. Accidents data of 14 years (from 1993 until 2006) in selected site, that is 441 pedestrian accidents occurred in or within 50m on signalised pedestrian crossing area (238 on pedestrian phase at traffic junction and 203 on pelican, puffin and toucan). Grid references of accident locations as well as locations of pedestrian crossings were obtained from STATS 19 database and the local city councils. The data was used to identify the locations of accidents relative to the location of pedestrian crossing facilities. The results show an increase in accidents rates decrease as distance increase from the pedestrian crossing facilities. The most risky locations are these at the pedestrian crossings or within 10m and the distance from 10 to 30 before the pedestrian crossing facilities. Analysis of pedestrian accidents rates for each of pelican and signalised crossings were discussed. Modelling accidents rates and severities at these pedestrian crossings is also presented in the paper. Linear regression and logit modelling are both used to analyse the results. The paper is divided into four sections. Firstly, the literature review and background of the work is presented is Section 1. Section 2, discusses the data and the case studies. The results of the work and analysis of the results are presented in Section 3. Finally, Section 4 summarises the results and concludes the work. (OECD)
https://www.itf-oecd.org/sites/default/files/docs/p01_alnaqbi.pdf

28. Median and pedestrian crossing islands in urban and suburban areas

FHWA-SA-17-064
https://safety.fhwa.dot.gov/provencountermeasures/ped_medians/

29. Modeling of pedestrian dynamics on central refuge island of signalized two-stage midblock pedestrian crossing

Ma, Wanjing; Lu, Yan
2011, 16-18, Dec. International Conference on Transportation, Mechanical, and Electrical Engineering (TMEE)
With the goal of improving pedestrians' convenience and safety, signalized two-stage midblock crossings are increasingly installed in highly populated areas in developing countries such as China. Accurately design of crosswalk, especially the area of central refuge island is one of the most critical issues should be properly decided. In this paper, three signalization types for two-stage midblock pedestrian crossings are proposed. Pedestrian dynamics
on central refuge island is formulated. Number of pedestrian waiting on central refuge island at any time of a cycle can be calculated by the model. Then, the maximum number of pedestrian waiting on central refuge island and the minimum needed area of central refuge island under a signal plan can be calculated. A case study is used to evaluate the proposed model. Sensitivity analysis has also been done to better assist traffic engineer in designing of two-stage midblock pedestrian crossing.


30. **Multiobjective Optimization of Signal Timings for Two-Stage, Midblock Pedestrian Crosswalk**

Ma, Wanjing; Liu, Yue; Xie, Hanzhou; Yang, Xiaoguang

To improve convenience and safety for pedestrians, signalized two-stage, midblock pedestrian crosswalks are increasingly being installed in highly populated areas in developing countries such as China. This paper presents a multiobjective optimization model and its solution algorithm for optimal control of a two-stage, midblock crosswalk on a street with both vehicular and pedestrian traffic. The proposed model aims to produce the optimal signal timings at the crosswalk to accommodate both traffic modes and to adjust the offsets of the pedestrian signals for the two stages concurrently to minimize pedestrian delays and relieve congestion at a central refuge island, the safe area for pedestrians to stop. The proposed model and algorithm have three distinguishing features: (a) they explicitly model pedestrian delays at the two-stage controlled crosswalk, including delays at both the curbside and the central refuge island; (b) they model the number of pedestrians waiting on the central refuge island according to the change in signal timing; and (c) they have application in a multiobjective optimization approach to study the effectiveness of midblock crosswalk control under conditions in which the priorities between vehicular and pedestrian traffic differ. A heuristic based on nondominated sorting genetic algorithm II was designed to solve the model and generate the Pareto solution set for signal timings. The results of the case study showed that the proposed model would help traffic practitioners, researchers, and authorities properly design signal timing plans and central refuge islands for two-stage midblock pedestrian crosswalks.


31. **Pedestrian behavior and safety on a two-stage crossing with a center refuge island and the effect of winter weather on pedestrian compliance rate**

Li, Yue; Fernie, Geoff
Accident Analysis & Prevention, 2010, Vol. 42, No. 4, pp.1156-1163

Despite a burgeoning research effort directed at understanding the effects of age, gender, disability, group size, traffic control condition and street width on pedestrian safety and compliance rate as they cross a signalized intersection, remarkably little is known about the compliance rate at a signal controlled two-stage crossing and how pedestrians react to different weather conditions. The purpose of this study was to determine whether pedestrian behavior becomes more risky in inclement weather through the investigation of street crossing behavior and compliance under different weather and road surface conditions at a busy two-stage crossing. Road crossing behavior was filmed at one eight-lane divided road strip at a downtown site in Toronto metropolitan area. The intersection was filmed unobtrusively from a rooftop by one camera set to record both oncoming near-side traffic and pedestrian movements. Pedestrian behavior and compliance rate were scored for a number of determinants of safe road crossing actions. Overall, the results show that road crossing behavior in inclement weather conditions was less safe than in fine weather. The designs of signal timing and configuration of the center refuge island also adversely influenced pedestrian behavior at this crossing, and adverse weather conditions further exacerbated the noncompliance rate. This paper presents new information on compliance rate at a two-stage crossing that emphasizes the need to consider the influence of traffic signal design and weather conditions on pedestrians’ behavior. More studies are needed to develop traffic control techniques to allow pedestrians to cross wide two-stage crossings in safety.

(Science direct)

32. **Pedestrian Crossing Behavior at Unsignalized Mid-block Crosswalks Around the Primary School**

Li, Pengfei; Bian, Yang; Rong, Jian; Shu, Shinan
Proceedia - Social and Behavioral Sciences, 2013, Vol. 96, pp. 442-450

To obtain the laws of pedestrians’ crossing behaviors, especially children, this paper analyzes the characteristics of four crossing behaviors (crossing speed, waiting time before crossing, running across the street, not looking before crossing) of three groups of pedestrians (adults, adult-child pairs, and children alone) at unsignalized mid-block...
crosswalks. 579 pedestrians are recorded. The data are analyzed by mean, analysis of variance (ANOVA), and Chi-Square test. The results show that: 1) pedestrians’ crossing speed on the second half of the crosswalk is systematically faster than the first half; 2) children's behaviors are influenced by adults and children rely on their parents; 3) children often feel overwhelmed because of the difficulty judging when and how to cross the street. Children's crossing behavior should be considered when people plan and design the crossing facilities where children may use. And it is necessary to improve children's skills of crossing street. (Researchgate) https://www.researchgate.net/publication/274028327_Pedestrian_Crossing_Behavior_at_Unsignalized_Mid-block_Crosswalks_Around_the_Primary_School

33. Pedestrian crossing behavior, an observational study in the city of Ushuaia, Argentina
Poó, Fernando Martín; Ledesma, Ruben Daniel; Trujillo, Roberto
Pedestrian crashes are a critical problem in Latin American countries. However, little research has been published about pedestrians and even less about their behaviors in a naturalistic context. The objective of the present research was to explore risky pedestrian crossing behaviors in traffic intersections in an argentine city (Ushuaia). It is focused in different stages of the crossing process, traffic code violations, and other potentially risky behaviors such as distractions. A high frequency of risky behaviors among pedestrians was expected. Moreover, according to previous findings, it was hypothesized that men and younger pedestrians would show riskier behaviors.Methods: Participants were 802 pedestrians (53.9% females) observed at several intersections (with and without traffic lights) in the city of Ushuaia. Behaviors were codified following a standardized observation protocol. Observers documented information on behavior previous to, during, and after crossing. Gender and age were also registered. Data were gathered through video recording. Frequency analyses of observed behaviors were conducted for the total sample, as well as by gender and by age group. A general crossing risk index was calculated to facilitate comparisons between the genders and age groups. We conducted an analysis of variance to evaluate gender and age differences for this index.Results: A high proportion of risky behaviors were observed among pedestrians. The majority of pedestrian waited in the street (as opposed to on the sidewalk) before crossing, did not comply with traffic lights, or crossed outside the crosswalk. A large number of pedestrians were distracted while crossing. Men presented higher scores on risky behaviors than women. No differences were observed by age group.Conclusions: The high level of risk behaviors during the different stages of street crossing is worrisome and reinforces the idea that pedestrians are responsible for many of the conflicts with motorists. Many of the risky behaviors seem to be associated with gender, which is in line with the previous literature showing more risk behaviors among men than among women. No differences were found for age group. Findings are interpreted considering some features of the Argentine road culture. (Ebsco)

34. Pedestrian Delay at Signalized Intersections with a Two-Stage Crossing Design
Wang, Xuan; Tian, Zong
Transportation Research Record; December 2010, Vol. 2173, No. 1. pp. 133-138
An improved pedestrian delay model was developed for signalized intersections with a two-stage crossing design. This model provides a timely enhancement tool for the Highway Capacity Manual for conducting multimodal-oriented level of service assessments at signalized intersections with unconventional pedestrian crossings. The proposed model is presented in a general form that provides estimation of three portions of pedestrian delay involved in a two-stage crossing: the first-stage delay; the second-stage delay for pedestrians who crossed during the Walk phase of the first stage; and the second-stage delay for pedestrians who crossed during the flashing Don’t Walk and Stop phases of the first stage. The model was validated through microscopic simulation under a wide range of traffic scenarios. Statistical analysis suggests that the proposed model is able to give satisfying results (R<sup>2</sup> = 99.9%, p-value = .000). The model can be applied in various cases knowing some basic input parameters and variables. (Ebsco)

35. Pedestrian safety action plan 2014-2016
TfNSW

36. Pedestrian Safety in Road Traffic in Poland (design)
Budzynski, Marcin; Jamroz, Kazimierz; Mackun, Tomasz
Every third road accident in Poland involves a pedestrian as a participant or, most of the time, a casualty. Pedestrian
accidents are usually the result of complex situations and the outcome of a number of factors related to driver and pedestrian behaviour and road infrastructure. Safety depends largely on how well the traffic condition is perceived and on visibility in traffic. The paper presents the results of analyses of methodologies for systematic studies of pedestrian behaviour and pedestrian-driver relations. The effects of the location of the site, type of crosssection and other selected parameters on pedestrian and driver behaviour are demonstrated. The analyses showed that pedestrians are most often put at risk by too long pedestrian crossings, vehicles going too fast around pedestrian crossings, lack of proper sight distance and poorly lit or unlit pedestrian crossings. The reason for such defective infrastructure is that planners, designers, contractors and maintenance services are not receiving any support from design, marking and maintenance regulations for pedestrian traffic. In addition, the Road Traffic Law is not restrictive enough when it comes to drivers’ obligations towards pedestrian safety. Polish design regulations allow long pedestrian crossings up to four lanes in one direction or three lanes in two directions irrespective of traffic control and speed limits. Pedestrian crossings should be kept at a maximum of three lanes. There is nothing in the design regulations about the required driver-pedestrian sight distance. Neither does the Road Traffic Law help engineers with that. It is legal to park vehicles within 10 m of a pedestrian crossing which does not guarantee the necessary sight distance. Drivers must be able to see a pedestrian waiting or stepping onto the crossing from a distance that will help them come to a stop safely. It is safer to follow the principle of providing adequate pedestrian sight distance. Recommendations for pedestrian crossing design are also provided.


37. Pedestrian safety index for evaluating street facilities in urban areas
Asadi-Shekari, Zohreh; Moeinaddini, Mehdi; Shah, Muhammad Zaly
Safety Science, 2015, Vol. 74, April, pp. 1-14

We proposed a new practical pedestrian safety index (PSI) for urban areas. This PSI can evaluate pedestrian safety on various urban streets. A complete pedestrian safety guideline for different urban streets is presented. One street in Singapore is examined with this PSI model. This PSI method presents improvements toward safe streets for pedestrians. The majority of current evaluation methods for assessing pedestrian safety conditions on streets only consider limited facilities that cannot cover all of the safety needs of pedestrians with different ages and abilities. These models are not developed based on sufficient facilities at the micro-level. Several of these studies are limited to evaluating safety at intersections. However, pedestrians also require safety along street segments and in intersections. Accordingly, the objectives of this study are to conceptualize the pedestrian safety index (PSI), which evaluates facilities along the streets for pedestrians. To estimate this PSI, a point system method is proposed that compares existing conditions to a standard. This method can be used to identify existing problems and to propose improvements. In addition, the pedestrian safety enhancements described using this method can enhance the safety of older and disabled pedestrians that suffer the most from a lack of facilities. Although this practical model uses international standards to become universally applicable, one collector street in Singapore is chosen to test the model. Because this study tries to cover various street facilities, the designers can use these results to implement safe routes for pedestrians. (Science direct)

38. Pedestrian safety: a road safety manual for decision makers and practitioners

Pedestrian safety: a road safety manual for decision-makers and practitioners describes: the magnitude of pedestrian deaths and injuries; key risk factors; ways of assessing the pedestrian safety situation in a given setting and prepare an action plan; and how to select, design, implement and evaluate effective interventions. The manual stresses the importance of a comprehensive, holistic approach that includes engineering, legislation and enforcement as well as behavioural measures. It also draws attention to the benefits of walking, which should be promoted as an important mode of transport given its potential to improve health and preserve the environment. (Google scholar)
http://apps.who.int/iris/bitstream/handle/10665/79753/9789241505352_eng.pdf?jsessionid=75A936258B6BB6A16468B8DD92DEA0FE?sequence=1

39. Pedestrians’ Safety Perception at Signalized Intersections in Shanghai
Ni, Ying; Cao, Yingying; Li, Keping

Pedestrians are the most vulnerable users at signalized intersections, and their incorrect behaviors such as signal violation, and not crossing at crosswalks etc., which is greatly determined by their safety perceptions, makes the situation even worse. To understand pedestrians’ perception can help traffic engineers to improve facility planning,
design and operation so as to provide better experiences of pedestrians crossing at signalized intersections. The study conducted intercept survey at 32 crosswalks in Shanghai. 1286 pedestrians were asked to rate their safety perception from 1 to 5. Pedestrian behavior types have been categorized into three types according to the signal indications when they enter crosswalk, namely Green walkers (GW) who enters in green, Late walkers (LW) who enters in flashing green, and Red walkers (RW) who enters in red. A random-effects ordered logit model has been developed and estimated, the results showed that the refuge island settings and being involved in conflicts had significantly impact on pedestrian perceptions. All types of pedestrians are in favour of the presence of refuge island, however, LW feel safer if they can stop at refuge island, while the RW perceive less safe. Some recommendation on crosswalk design and operation are proposed based on the conclusions. (Science direct) https://www.science direct.com/science/article/pii/S2352146517305239

40. Quantitative analysis of pedestrian safety at uncontrolled multi-lane mid-block crosswalks in China
Zhang, C; Zhou, B; Chen, G; Chen, F
A lot of pedestrian-vehicle crashes at mid-block crosswalks severely threaten pedestrian’s safety around the world. The situations are even worse in China due to low yielding rate of vehicles at crosswalks. In order to quantitatively analyze pedestrian’s safety at multi-lane mid-block crosswalks, the number of pedestrian-vehicle conflicts was utilized to evaluate pedestrian's accident risk. Five mid-block crosswalks (Wuhan, China) were videoed to collect data of traffic situation and pedestrian-vehicle conflicts, and the quantity and spatial distribution of pedestrian-vehicle conflicts at multi-lane mid-block crosswalk were analyzed according to lane-based post-encroachment time(LPET). Statistical results indicate that conflicts are mainly concentrated in lane3 and lane6. Percentage of conflict of each lane numbered from 1 to 6 respectively are 4.1%, 13.1%, 19.8%, 8.4%, 19.0%, 28.1%. Conflict rate under different crossing strategies are also counted. Moreover, an order probit (OP) model of pedestrian-vehicle conflict analysis (PVCA) was built to find out the contributions corresponding to those factors (such as traffic volume, vehicle speed, pedestrian crossing behavior, pedestrian refuge, etc.) to pedestrian-vehicle conflicts. The results show that: pedestrian refuge have positive effects on pedestrian safety; on the other hand, high vehicle speed, high traffic volume, rolling gap crossing pattern, and larger pedestrian platoon have negative effects on pedestrian safety. Based on our field observation and PVCA model, the number of conflicts will rise by 2% while the traffic volume increases 200 pcu/h; similarly, if the vehicle speed increases 5km/h, the number of conflicts will rise by 12% accordingly. The research results could be used to evaluate pedestrian safety at multi-lane mid-block crosswalks, and useful to improve pedestrian safety by means of pedestrian safety education, pedestrian refuge setting, vehicle speed limiting, and so on. (Pub med) https://www.ncbi.nlm.nih.gov/pubmed/28841407

41. Road, Traffic, and Human Factors of Pedestrian Crossing Behavior
Papadimitriou, Eleonora; Lassarre, Sylvain; Yannis, George; Tselentis, Dimitrios I
Transportation Research Record; October 2016, Vol. 2586, No. 1, pp.28-38
This study analyzed road, traffic, and human factors of pedestrian crossing behavior through the development of integrated choice and latent variables models. The analysis used recent research as a starting point, in which a two-stage approach was successfully tested, including a separate estimation of human factors and choice models. Data from a dedicated field survey were used: pedestrian field observations of road crossing behavior in different road and traffic scenarios were combined with a questionnaire on pedestrian attitudes, perceptions, motivations, and declared behaviors. The integrated choice and latent variables models were developed for four road types: major urban arterials, main roads, secondary roads, and residential roads. Results suggest that the effect of traffic conditions on pedestrian crossing choices was more important on main and secondary urban roads, whereas on major urban arterials and on residential roads it was nonsignificant. In regard to the effects of human factors, a risk latent variable was found to enhance the explanatory power of most of the models. This variable was estimated on the basis of different indicators in each case, reflecting a clear risk-taking tendency on major and main roads and an optimization tendency on minor roads. Overall, it is indicated that the integration of human factors in pedestrian crossing models provides meaningful and insightful results, and they may be advantageous compared with the two-stage approach. (Ebsco)

42. Roads safety toolkit
IRAP (international Road Assessment Programme, 2018
Most pedestrian crashes happen while the pedestrian is attempting to cross the road. Crossing a busy road with fast flowing traffic can be very difficult. Pedestrian refuge islands can help pedestrians to cross such roads safely. They
can be used where there is a demand for pedestrians to cross the road, but where the numbers of pedestrians are not high enough to warrant a signalised pedestrian crossing. Pedestrian refuge islands are raised median islands that provide a location for pedestrians to safely wait for a gap in the traffic so they can finish crossing the road. This makes crossing the road easier for pedestrians by allowing them to cross in two stages and deal with one direction of traffic flow at a time. Pedestrian refuge islands should ideally be at least 1.8 metres wide (narrow refuge islands put pedestrians at risk of being hit by truck side mirrors) and can be part of an unsignalised pedestrian crossing. Refuge islands are usually used on wide, multi-lane roads. They can be helpful where pedestrian crossings would result in traffic congestion. Traffic islands at intersections can also act as refuge islands (especially to assist in movement across the minor road), and provide additional safety benefit at these locations. 

http://toolkit.irap.org/default.asp?page=treatment&id=21

43. Safety evaluation of pedestrian behaviour and violations at signalised pedestrian crossings
Fernie, G; Koh, PP; Wong, YD; Chandrasekar, P
Pedestrians could start crossing very late during Green Man (10s before next Red Man onset). About 1%, 45% and 100% of them who started crossing during SGM, FGM and LFGM could not complete crossing. 15th percentile crossing speed of a pedestrian is 1.12m/s. Pre-GM violators dominates over Post-GM violators. Pedestrians being the most vulnerable road users, take up about one in every four road deaths in Singapore. Of all pedestrian fatal accidents, 22% occurred at signalised pedestrian crossings though they are time-separated designated facility for pedestrians to cross the road. As such, it is important to examine crossing behaviour of pedestrians at these locations to further enhance their safety. Violators, in particular, have higher risks of encountering traffic conflicts or accidents. Violating behaviour of pedestrians is studied and a relationship is established with dependent variables such as waiting time, the number of conflicting traffic lanes, conflicting vehicular traffic volume and personal characteristics of the pedestrian. The outputs obtained from the study can be used for predicting violations, identifying countermeasures and establishing realistic micro-simulation modelling to further enhance safety at these crossings. Recommendations on enhancing design for pedestrian crossings shall be made where possible. (Ebsco)

44. Signal Timing Optimization Models for Two-Stage Midblock Pedestrian Crossing
Ma, Wanjing; Yang, Xiaoguang; Pu, Wenjing; Liu, Yue
Transportation Research Record, January 2010, Vol. 2198, No.1, pp.133-144
Finding an optimal signal timing plan is one of the most critical operational issues for signalized two-stage midblock crossings, which are increasingly being installed in highly populated areas in developing countries, such as China. In this paper, three signalization control types (simultaneous, progressive, and separate signalization) for two-stage midblock pedestrian crossings are proposed. Both vehicular traffic and pedestrian movements are considered in a unified framework by solving two problems: the optimization of cycle length and the optimization of offsets. The cycle length optimization problem is formulated as a mixed-integer linear programming problem to minimize the cycle length with constraints of the maximum acceptable degree of saturation of vehicle movements, the minimum clearance time, the pedestrian green time, and the maximum number of pedestrians waiting on a central refuge island. The optimization problem of the offset of the two-stage pedestrian signal is also formulated as a mixed-integer linear programming problem to provide the maximum green bandwidth for two successive pedestrian crossings. A VISSIM simulation and a case study in Shanghai, China, were carried out to validate the proposed models. The proposed models are promising in determining the signalization control type and optimizing the signal timings of two-stage midblock pedestrian crossings. Analysis of the sensitivity of the performance of the system was also conducted to assist traffic engineers with selecting appropriate signalization control types and acceptable degrees of saturation. The results from this study offer a basis for traffic practitioners, researchers, and authorities to design and assess signal plans for two-stage midblock pedestrian crossings. (Ebsco)

45. Staged Pedestrian Crossings
Fowler, Megan; Wilke, Axel
The safety of pedestrians crossing multi-lane road intersections is often threatened by filtering turning vehicles. The introduction of staged pedestrian crossings, where the crossing of departure and approach lanes are treated as two separate tasks, can provide more protection to pedestrians by allowing greater control of the traffic. Related changes to the phasing arrangement such as direction-depandent pedestrian crossing timings can also result in the staged pedestrian crossing increasing the intersection efficiency. This technical note discusses the design and modelling of
46. **State best practice policy for medians**  
FHWA-SA-11-019  
Safety is the number one priority for the U.S. Department of Transportation (USDOT) and it's the agency's policy to provide safe and effective pedestrian accommodation wherever possible. The Federal Highway Administration (FHWA) encourages the use of specific proven pedestrian safety countermeasures that can help achieve local, State and National safety goals. One of those countermeasures is the inclusion of raised medians. FHWA's Safety Office has promoted the evidence-based safety benefits of raised medians (or refuge areas). This flyer highlights three agencies that have implemented policies and plans that promote the inclusion of raised medians: the New York State Department of Transportation (NYSDOT), the Oregon Department of Transportation (ODOT), and the Florida Department of Transportation (FDOT).

https://safety.fhwa.dot.gov/ped_bike/tools_solve/fhwasa11019/

47. **Streetscape Guidance – Part D. Physical design and materials - Section 12. Crossings**  
Streetscape Guidance provides a standard for London's streets and spaces for those who will be working on or affecting London's streets. Whether a one-off major project or a smaller local adjustment, it defines our aspirations and outlines the criteria for good design, material selection, installation and maintenance.


48. **Stutter-Flash Light-Emitting-Diode Beacons to Increase Yielding to Pedestrians at Crosswalks**  
Houten, Ron Van; Ellis, Ralph; Marmolejo, Erick  
TRR, 2008, No. 2073, pp.69-78  
Motorists often fail to yield to pedestrians in marked multilane crosswalks at uncontrolled locations. Several studies have demonstrated that the use of advance yield markings along with a “Yield Here to Pedestrians” sign can reduce the incidence of multiple-threat crashes but have only a small effect on overall driver yielding behavior. A low-cost alternative to increase driver yielding is the use of amber light-emitting-diode (LED) flashers with an irregular flash pattern. As part of an FHWA cooperative agreement to evaluate intelligent transportation system treatments, amber LED flashers with an irregular flash pattern were installed at two multilane crosswalks in Miami-Dade County, Florida, in an experiment to increase yielding behavior. A reversal design was employed in this experiment to demonstrate experimental control at each site. This design involves alternating sessions with and without the devices activated. The results showed that the LED flashers installed on the pedestrian sign produced a marked increase in yielding behavior at both crosswalks and that similar data were collected from staged pedestrians and local residents using these crosswalks. Data also indicated that the use of the device produced a reduction in evasive conflicts between drivers and pedestrians at both sites and a reduction in the percentage of pedestrians trapped in the crosswalk at the center of a road without a median island. A second experiment evaluated the effects of illuminating the departure area with LED lighting when the system was activated at night. This treatment did not produce a further increase in yielding. The LED stutter-flash beacons likely overshadowed the effect of the pad lighting. (TRB)

https://trrjournalonline.trb.org/doi/abs/10.3141/2073-08

November 2017  
The Department of Transport and Main Roads has agreed to adopt the standards published in the Austroads Guide to Traffic Management. Supplements have been developed to reflect Queensland practice variations and take precedence over the Austroads guide.


50. **The severity of pedestrian crashes: an analysis using Google Street View imagery**  
Hanson, Christopher S; Noland, Robert B; Brown, Charles  
Google Street View is used to obtain pedestrian and road infrastructure features. Logit models of the severity of
pedestrian casualties are estimated with this data. The probability of pedestrian crashes cannot be analyzed with this data. Sidewalks and buffers reduce severity, high speed roads increase severity. Crashes during darkness increase the severity of pedestrian casualties. Data derived from visual inspection of Google Street View imagery associated with a variety of pedestrian and road infrastructure features are analyzed with a database of pedestrian casualties. These features include the presence of sidewalks, buffers between the road and the sidewalk, street lighting, number of travel lanes and the presence of medians, traffic controls at intersections, and posted speed limits. The analysis focuses on how these features affect the severity of a pedestrian casualty once it has occurred. Other controls used in the analysis include the age of the victim, ambient lighting conditions, and whether the vehicle driver was intoxicated. Results suggest that severity of pedestrian casualties is associated with the lack of sidewalks and buffers, high-speed roads, roads with six or more lanes and a median, and lack of traffic lighting when it is dark. Speed is a critical factor in determining the severity of crash outcomes, and most road characteristics affect crash outcomes to the extent that they moderate or facilitate high speeds. Casualties are more severe when it is dark than when it is daylight. Older pedestrians tend to have more severe casualties. A key contribution of this work is the use of Google Street View imagery; however, a limitation is that the analysis cannot examine the probability of a pedestrian casualty. Implications for road safety are consistent with national efforts to make streets safer via Complete Streets policies. (Science direct)