Impacts of Diagonal Crosswalk Misuse

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Impacts of Diagonal Crosswalk Misuse

A thesis submitted to fulfill the Undergraduate Thesis credit hours for a Bachelor of Science of Civil Engineering

By

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Project Summary

A diagonal crosswalk paired with an all-red phase traffic signal is an effective approach to manage intersections with high pedestrian volume. This allows pedestrians to cross both north-south and east-west bound roads at the same time. However, ineffective diagonal crosswalk marking, and lack of signs reduces the use of diagonal crosswalks which in turn results in jaywalking, often in unsafe capacities. The objective of this study is to determine the impacts of pedestrian-caused delay and safety impacts due to the misuse of a diagonal crosswalk. To better understand the impacts, a camera-based data collection was conducted during a four-hour period at a local intersection. The data was compiled and used in the analysis. Analysis includes estimation of pedestrian volume and delay.

The intersection located at Maple and Garland in Fayetteville, Arkansas was used for this study. The intersection is a four-approach signalized intersection with large pedestrian volumes. The traffic signals are timed for an all-red phase while the pedestrian walk sign is illuminated. The most common pedestrian path is to cross the intersection straight and then turn left across a bus route. The pedestrians often walk in front of passenger-carrying buses which results in a safety issue for pedestrians and a delay for buses and those on them.

The traffic signal is timed to allow for diagonal crossing but lack of pedestrian awareness prohibits them from utilizing it. This intersection is a key intersection for many campus movements. All buses pass through the intersection as it is the only way to the central bus station on campus. Additionally, it is the most efficient crossing for students living in on-campus accommodations to commute to central campus buildings on foot. The efficiency and safety of this area of campus could be greatly improved if pedestrians utilized the diagonal crossing.

Every day, hundreds of pedestrians use the study site intersection. They dangerously jaywalk in front of passenger-carrying buses which produces safety risks and delays. This problem could be alleviated by increasing striping and signage around the diagonal intersection. The proposed solutions are low cost but generate large benefits for all parties involved. Pedestrian safety would be increased as well as bus and passenger delays mitigated.
Chapter 1: Introduction and Background

The diagonal crosswalk principle has been effectively executed before. The most notable ones being in Shibuya, Tokyo, and Oxford, England. Both of these intersections were opened in order to safely accommodate the large flows of pedestrian traffic present at the intersection. The Shibuya and Oxford crossings are seen in Figures 1 and 2, respectively. The Shibuya crossing is often called the “world’s wildest intersection” (CNN). This is because of the large multi-directional flows present within the pedestrian crossing signal phase. Following this style, the Oxford Street crossing is often coined the “English Shibuya” (BBC). Both intersections are famous for their efficiency but also somewhat unique design. The diagonal crosswalk is not a common pedestrian traffic control design but is gaining popularity worldwide as the benefits are being recognized.
The concept is often termed a ‘Pedestrian Scramble’ as it allows for all directions of movement at once. Chunyan Mu, Liagshen Wang, Kening Liu, Jiuchun Gu, and Jing Sun, researchers at Ludong University, published a journal article about research they conducted pertaining to pedestrian safety around Ludong University’s campus in Yantai, China titled, *Study on Pedestrian Safety and Countermeasures in Crosswalks around Campus-Case Study at Ludong University in Yantai* (Gu, J., Mu, C., Wang, L., Liu, K., & Sun, J.). Their research was conducted on traditional crosswalks and university student’s misuse and illegal road crossing. Through this, they concluded that the best ways to mitigate the present misuse was to implement solutions grouped into demand management, supply management, education, and enforcement. This study provides context in the broadness of pedestrian crosswalk misuse. This problem is not specific to a region but applicable to a wider population.

In Jing Zhao and Yue Liu’s 2017 journal article, they discuss the improvements in pedestrian delay using diagonal crossings (Zhao, J., & Liu, Y). They discuss how the *Highway Capacity Manual 2010* does not contain accuracy in modeling pedestrian delay in diagonal crossings. Their research proposes a new model that considers diagonal crossings and moving paths. The model shows increasing accuracy in pedestrian control delay of diagonal crossings.

The topic of effects of diagonal crossings is fairly new to transportation research but is gaining popularity. The concepts most often presented are crossing efficiency and decreasing illegal crossings through implementation. The topic is being researched around the world and is seemingly more popular outside of the United States.

By increasing research on the topic, the safety impacts, crossing efficiency, and design can be studied. An increase of knowledge could work to better design and implement diagonal crosswalks that could change existing and future infrastructure.
Chapter 2: Site

This study uses the intersection of Maple and Garland in Fayetteville, Arkansas. This is located on the University of Arkansas Campus but is controlled by the Arkansas Department of Transportation (ARDOT). This can be seen in Figures 3 and 4. The intersection is a major pedestrian corridor from university housing to campus. It has peak flows before and after scheduled class times. Pedestrians often walk straight through the intersection during the pedestrian signal phase and then cross the street in a bus only area. This causes the buses to have to be conscious of pedestrians crossing the road as well as wait until it is safe to proceed. This results in safety issues for pedestrian bus collisions as well as delay for buses and passengers.

Figure 3. Location of the Study Intersection in Fayetteville in the State of Arkansas (GISGeography)
As seen in Figure 5, the red line is the most common pedestrian route. The intention is to be on the law center side of the intersection and the route taken is straight through the cross walk and then diagonally through the street. The yellow line shows the route taken by Razorback Transit buses. They enter the route from all three legs of the intersection as well as depart along the same route. They proceed straight to Union Station. This causes an overlap of the yellow and red lines meaning there is a point of intersection between buses and pedestrians. The blue line demonstrates the ideal route if the diagonal crosswalk was utilized by pedestrians. They would optimize the intersection by using the diagonal crossing and then proceed straight on a sidewalk to continue the route to their destination.
The intersection is already designed and timed for a diagonal crossing. There are small triangles painted at each leg of crosswalk, but pedestrians are not commonly aware of the meaning. As a result, many are uninformed that crossing diagonally is an option and would enhance safety and decrease delays.
Chapter 3: Data Analysis

Data was collected at the intersection including video recordings of pedestrian crossings. Four camcorders were set up, three at corners of the intersection and one at the pedestrian and bus crossing point. In Figure 6, the site and orientation of each is shown. Each camcorder collected the same 3 hours and 45 minutes of footage. They recorded activity from 8:15am until 12pm. This occurred on a standard university school day to allow for the most representative data.

![Figure 6. Camcorder Location (blue marker) and Orientation (yellow arrow)](image)

The camcorders were used to record pedestrian volumes by crossing direction and paths of pedestrians. The number of pedestrians using the regular crosswalk and the diagonal crosswalk were counted, as well as the number of pedestrians crossing in the bus lane and the delay for the bus in seconds.

Pedestrians appeared to be approaching from the north leg of the intersection and intending on path towards the southeast. This is coming from university housing towards the student union and academic campus buildings. As this route is often used to commute between housing and class those walking it seem to do so regularly, often on their phones, wearing headphones, or having conversation. This creates a monotony for the route meaning they will walk the same path every day and will not mentally acknowledge it after the first week. The pedestrians using the straight crosswalk and then in front of the buses appeared to be traditional
aged students between eighteen and twenty-two. Those using the diagonal appeared to be older students, faculty, or staff. The pedestrians using the straight crosswalk did not appear to notice those crossing diagonally no matter the direction. Despite the use, while infrequent, the regular crosswalk users appear unaware of the diagonal crosswalk’s existence.

Figure 7 shows the number of pedestrians crossing in front of buses as well as the number of buses traveling on the street to and from the bus station. The data was collected at the minute of appearance for the pedestrians and buses. This is reflected in the x-axis in the exact values. The peak pedestrian flow is at 10:33am with a pedestrian count of 187. The peak bus flow is at 9:16am with four buses, two arriving and two departing. The intersection of the peak bus flow has a pedestrian count of 165. The penultimate pedestrian peak aligns with the maximum bus count. The top busiest times for each population correspond and occur together. This increases the overlap and probability of a collision.

![Figure 7. Number of Pedestrians and Buses Crossing the Intersection](image)

The data seen in Figure 8 is a comparison between pedestrians using the regular crosswalk versus pedestrians using the diagonal crosswalk during the four-hour collection period. The peak 15-minute flows were at 8:15am, 9:15am, and 11:30am with total volumes of 370 pedestrians, 447 pedestrians, and 457 pedestrians, respectively. The rate of diagonal crossings relative to the total crossings ranged from 3% to 14% with the peak observed at 8:15AM with a rate of 14%. The highest pedestrian volume was observed as 457 for the regular crossing and 60 for the diagonal crossing.
The difference between the regular crosswalk use and the diagonal crosswalk use are plotted in Figure 9. These values were obtained by subtracting the number of people using the diagonal crosswalk from the number of those using the regular crosswalk. It can be seen that the relationship is linear meaning it is directly proportional. As the number of people crossing the intersection increases, the number of people crossing both straight and diagonally both increase. As the population crossing in front of the bus increases, the chance of a pedestrian involved bus accident increases.
Figure 9. Regular Crosswalk Count vs. Difference
The delay for Razorback Transit buses is seen in Figure 10. This data was determined by when the bus reduced speed to allow a pedestrian to cross. The time was counted, in seconds, until the bus was able to resume travel towards its destination. The delay was counted at the study site where pedestrians are jaywalking in front of the buses. Bus delay was not considered at the diagonal crossing as it is a signalized intersection. The data included in the table is the cumulative number of seconds the bus was paused for pedestrians to cross. A total of 176 buses crossed the study site during data collection with 70 of them having a pedestrian caused delay. The figure was created by removing the zero values (no delay) and plotting the remaining data. Analyzing the data this way initially, allows for understanding of the affected buses. The mean wait time for the affected buses is 19 seconds per bus. This is when the bus is completely stationary while allowing pedestrians to cross in front of the vehicle. The mean wait time for all buses, including those that did not have to stop, was 7 seconds. The maximum wait time for affected buses was 163 seconds (approximately 2.5 minutes). The Razorback Transit bus schedule is to the minute. By creating a delay, this creates large ripple effects of scheduling and timing of the bus system. 44 buses pass through the study site per hour during data collection. While 19 seconds may not seem like a lot, on a route that is supposed to have no delay and at default is often running behind, if every bus must pause for 19 seconds for pedestrians, the delay will become cumulative. This will result in consequential delay times.

![Figure 10. Bus Delay (n =70)](image)

During the highest 15 minutes, there were 399 pedestrians that crossed in front of a bus. This was 399 chances for a pedestrian to be struck by a large moving vehicle. The bus driver must remain more alert while driving through this area. While there have not been any reported pedestrian-bus incidents at this location, Razorback Transit has been involved in numerous collisions around other parts of Fayetteville as reported by the University of Arkansas Police Department.
Figure 11, as provided by the Transit and Parking Annual Report of the 2022 Fiscal Year, provides the ridership totals. With the exception of COVID in 2020 and 2021 the anticipated annual ridership is between 1 million and 1.4 million persons. With each bus having a closed loop originating and terminating at Union Station, over 1 million passengers ride through this unofficial pedestrian crossing.

![Total Razorback Transit Passengers - All Routes](image)

*Figure 11. Razorback Transit Ridership (University of Arkansas)*
Chapter 4: Practice and Policy Implications of Findings

The diagonal crosswalk already exists at the study intersection through striping and signal timing. Therefore, creation of the crosswalk in terms of markings and signal timings (all red phase provision) is not the proposition. However, by increasing the prevalence of striping and by adding signage, pedestrians may be more aware of the presence of the diagonal and thus more inclined to use it. 10.5% of individuals are already using the diagonal so by shifting the larger group, the number of those crossing in front of buses would be significantly decreased. The existing striping can be seen in Figure 12 from an aerial view and Figure 13 from a street view. This striping is likely perceived as confusing and not effective by the lack of pedestrians utilizing the diagonal. Future work will implement an intercept survey to ask pedestrians about their awareness of the diagonal crossing system.

Figure 12. Existing Striping at the Study Intersection (Aerial View)
There are many options for striping a diagonal crossing intersection that can be seen around the US and abroad. A standard zebra crossing as seen in Figure 14 could be utilized to better demark crossing options. Figure 14 depicts the Chicago Scramble intersection. It is the first of its kind within Chicago. They constructed it with the goal of, “reducing conflicts between pedestrians and turning vehicles” (Tribune, 2013). This striping method is an overt and clear way to indicate to pedestrians that a diagonal crosswalk is present and is to be utilized.
Another striping method would be an outline as seen in Figure 15. This image is of one in Los Angeles. This fits with the diagonal triangle already present at the crosswalk. This outline is a more subtle way to indicate the ability to cross diagonally without creating an overstimulating environment.

Figure 15. Los Angeles Diagonal Crosswalk Striping Example (Broverman)
Chapter 5: Conclusions and Recommendations

In this study, we observed the diagonal crosswalk behavior at the intersection of Maple and Garland in Fayetteville, Arkansas. This intersection sees approximately 900 pedestrians per hour with peak 15-minute volumes of 457 for a typical weekday. The average rate of diagonal crosswalk use was found to be 10.5%, i.e., the ratio of the diagonal crossings to the total number of crossings. Additionally, we observed the delay caused by pedestrian interactions with bus operations. On average, each bus experienced 9 seconds of delay due to pedestrians crossing in front of the bus. Ideally, pedestrians can avoid crossing in front of the bus by using the diagonal crosswalk properly.

With hundreds of pedestrians crossing in front of moving buses, bus passengers are delayed hundreds of seconds every day at the intersection of Maple and Garland. By increasing awareness of the existing diagonal crossing, pedestrian safety would be improved as well as the delay times of buses decreased. The pedestrian activity would be shifted to a more conducive path that better fits their needs. They need to be on the diagonal side of the road instead of walking at ninety-degree angles, the forty-five-degree angle created by the diagonal crosswalk would not only make their path more efficient, it would also decrease the potential for a pedestrian involved collision at the bus intersection.

The existing intersection has the capabilities of optimizing the pedestrian crossing since the signal is already timed for an all-red phase to allow the diagonal crossing to be used. Thus, the infrastructure would not have to be modified and the signals would not have to be retimed. The main recommendation is to repaint the striping to better demark the diagonal crossing. This is a low-cost solution that can have large benefits in reducing delay and improving safety. By painting the crossing in a more intentional and clear manner, pedestrian safety would increase, and the bus delay would be mitigated at a minimum or eliminated altogether.

Future work will include a survey of the population using the crosswalk. This would include questions about pedestrian awareness, intent, and safety as well as bus passenger and driver awareness and implications. Actions could also include an awareness campaign in conjunction with an existing crosswalk safety program run by the University. Other studies that could be conducted on the area include bus entrance timing in respect to pedestrian crossing signal phase.
References


