THE JOURNAL OF TRANSPORT AND LAND USE http://jtlu.org
VOL. 3 NO. 3 [Winter 2010] pp. 61–82 doi: 10.5198/jtlu.v3i3.110

JTLU

Compulsory Convenience?

How Large Arterials and Land Use Affect Midblock Crossing in Fushun, China

Wendy Tao [a]

Shomik Mehndiratta
World Bank, Beijing

Elizabeth Deakin
University of California, Berkeley

Abstract: This study focuses on how street design and land uses influence pedestrian behavior in a medium-sized Chinese city, Fushun. In cities throughout China, the change from workplace-managed and assigned housing to market housing has had profound effects on pedestrians. Coupled with motorization, pedestrian trips are increasingly external, pushed out of the protected space of the gated block and onto massive arterials that now carry automobiles, trucks, and buses in growing numbers. Long blocks, unenforced zebra crossings, and inadequate green time at traffic signals do not equitably accommodate those on foot; thus, pedestrians violate the system by crossing midblock. In Fushun, the long block lengths and large arterials, lack of enforcement, and unfavorable pedestrian policies creates an environment which incentivizes midblock crossing behavior.

Keywords: Transport, Land Use, China, Pedestrians

1 Introduction

The changing land use patterns in Chinese cities directly affect pedestrian behavior by fundamentally altering the system in which pedestrians operate. Land use is a critical component affecting pedestrian behavior; creating an environment where pedestrians are comfortable will maintain a higher pedestrian mode share. Currently, walking remains one of the dominant means of travel in most Chinese cities (National Bureau of Statistics of China 2006).

However, in China, the shift from managed and assigned housing to market housing has increased travel distances, and the large-block urban form which once created a pedestrian-oriented network has become less convenient for walking. The growth of the urban arterial in Chinese cities plays an important role in circulating vehicular traffic, but arterials' wide crossing distances can be problematic for pedestrians. Long pedestrian crossing distances increase exposure, potentially reducing pedestrian safety. Long crossings can also mean long waits for traffic during the pedestrian signal phase, with negative effects on traffic flow. Significant demand exists for crossing midblock because of the long distances between intersections, but drivers often fail to stop at unsignalized crosswalks. Investment in traffic signal infrastructure, including pedestrian signal lights, can help to manage flow, but such measures are expensive. Finally, overpasses and underpasses are costly and less convenient for pedestrians than surface crossings. Thus, a challenge for policymakers is to find a set of infrastructure investments, operations solutions and transportation and land use policies that balances all these elements.

[a] Corresponding author. wwrtao@gmail.com

This paper analyzes the typical tradeoffs involved in urban transportation planning as they are encountered in Fushun, a city of 1.4 million in China's northeast coastal region. It provides insight into the factors, including land use, that affect pedestrian crossing behavior.

2 Background

A vast body of research on how land use affects pedestrian activity has emerged in the United States over the last decade (Frank and Engelke 2001; Handy *et al.* 2002). Dense areas have been found to promote walking to destinations within the neighborhood, while large-block areas promote leisure walking outside of the neighborhood (Oakes *et al.* 2007); walking behavior within a neotraditional neighborhood has been found to be influenced by distance to destinations (Shay *et al.* 2006).

William Whyte 1971 used basic pedestrian tracking devices to observe how pedestrians moved in space and across intersections and developed a set of "rules of walking." At around the same time, research attempted to bridge the gap between the physical environment of a city and its more personal and social impact, coupling the experience of walking with people's experiences of cities (Appleyard 1981; de Certeau 1984; Lynch 1960). Similarly, other research verified the linkage between block lengths and walking mode share, and the influence of street design on walkability (Jacobs 1995).

Urban spatial structure in most of the United States is currently based on a suburban-style arrangement with wide arterials, sprawling destinations, and minimal land use mix. While the literature in the United States has begun to analyze the merits of the New Urbanist neighborhood, cities in China are only starting to grapple with the issue in reverse; the question is whether Chinese cities can preserve the traditional urban forms that support walking behavior rather than following the path of many cities in the United States.

Besides full-scale change to the built environment, other investments and policy interventions can influence pedestrian behavior. Sisiopiku and Akin (2003) reviewed behavior at urban crosswalks to measure pedestrian attitudes toward various facilities. They found that properly designed facilities can encourage users to cross, and that midblock crosswalks were one of the most influential designs in this respect. Pedestrians crossed depending on the distance of crosswalk to desired locations, traffic signal phasing, vegetation and concrete barriers, and the position of a crosswalk with respect to adjacent land uses that generate or attract pedestrian traffic. Other literature has used a before-and-after comparison of transportation investments to show that traffic calming techniques and policy measures prohibiting new roadway construction also contribute to walking behavior (Clarke and Dornfeld 1994; Pucher 1998). Whether specific facilities such as midblock crossings are effective depends not only on the facility but also on engineering, enforcement, and education enhancement (Zegeer *et al.* 2005).

Extensive case study information and published literature on walking behavior to date are based on data from the United States or other developed countries where walking has a very low mode share, and most examples are based on suburban locations (Cao *et al.* 2006; Chu 2004; Greenwald and Boarnet 2001).

The situation in China differs greatly. Because China is still developing, it can take steps to affect pedestrian behavior that go beyond traffic calming measures, treatments to individual trouble spots, and adjustment of signal phasing at certain intersections; China can consider how the preservation or alteration of land use patterns and landforms influence the development of the transportation system. Should a city such as Fushun seek to maintain a dense urban area with multimodal shared streets, or to achieve a more automobile-oriented development pattern? This provides a remarkable opportunity to incorporate pedestrian needs at the early stages of a long-term development plan.

Providing for pedestrians in Chinese cities has been an evolving process. The latest trend is to integrate pedestrian signals, safety islands, and junction channelization in urban traffic projects, and to make greater efforts at the policy level and through national standards to ensure non-conflicting pedestrian phases are standard practice (Frame 2004). Table 1 displays the historical trends of pedestrian provisions in Chinese cities as surveyed by Frame.

Over the last several years, Chinese research on pedestrian level of service, pedestrian infrastructure, behavior, and safety has steadily entered the international discourse. Even though traffic engineering in China continues to focus on highway geometry, intelligent transportation technologies, and road construction, two schools—the Beijing University of Technology and Nanjing's Southeast University—have produced significant research focused on pedestrians in the urban realm (Gong *et al.* 2007; Shi *et al.* 2007; Yang *et al.* 2006; Zhao and Wu 2003).

The earliest studies in China focused on pedestrians as "disturbances" to traffic flow, and suggested engineering solutions for them at intersections (Wei *et al.* 2003). More recent studies have attempted to analyze behavior and to question whether crossings are adequate to accommodate pedestrians (Shi *et al.* 2007). Both of these studies take a micro-level approach, examining the current road situation to determine whether additional infrastructure should be built to separate the modes even further. Another study, by Tanaboriboon and Jing (1994), reported the attitudes of pedestrians in Beijing, finding that they preferred signalized intersections to above- or below-grade crossings. Most of the present-day research is focused on Beijing, a city that has constructed a massive concrete network of pedestrian flyovers and underpasses, and therefore may not be directly applicable to small and medium-sized cities in other regions.

In China, as in the United States, pedestrian planning has been considered a sub-discipline of traffic engineering rather than of urban design (Wang 2003). Thus the indicator of success has been an optimization of traffic flow and overall safety, resulting in solutions which involve grade separation (Transportation Research Board 2000). Sidewalks and pedestrian facilities have been integrated at the level of infrastructure planning. This viewpoint, however, neglects the intricacies of pedestrian behavior and the environmental and social benefits of maintaining this important mode share in the transportation mix.

3 Methodology

This research evaluates current pedestrian facilities and examines the links between land use, street design, and pedestrian behavior using both traditional techniques (traffic counts) and more unconventional methods (pedestrian tracking). Observed behavior at intersection approaches on wide roadways is a function of infrastructure design, traffic operations, enforcement methods, and user characteristics. The study hypothesizes that changes in pedestrian infrastructure or traffic operations, when coupled with enforcement mechanisms, have the potential to alter pedestrian behavior.

Table 1: Historical trends in provisions for pedestrian travel in Chinese cities.

Decade	Pedestrian Provision	Comments
1950s–60s	Not in urban vision	• no perceived need for special pedestrian provision as road construction is given priority • construction of wide new roads includes wide footways but no crossing facilities for pedestrians • pedestrians seem "lost" in the grand scale of city construction; cities begin to lose "human scale" • the form of urban plans (large blocks with few secondary and access roads) sets the scene for future pedestrian access problems • residential areas and work unit compounds are essentially pedestrian predominant areas because there are few motor vehicles
1970s–80s	Disregarded	• pedestrians disregarded because focus in on motor vehicles • pedestrians uncontrolled, with few safe crossing facilities • poor footway provision, construction, and maintenance • traffic signals have parallel pedestrian phases ("walk with traffic" phases), which conflict with vehicle turning movements
1990s	Segregated and marginalized	• segregation by barriers and grade-separated crossing facilities as the pace of motorization and road construction quickens • street markets increasingly removed indoors and "street life" is diminished
2000s	Commerce-driven	• implementation of pedestrianized shopping streets driven by economic and commercial motives • multi-phase signals enable non-conflicting parallel pedestrian phases • implementation of midblock signalized crossings • central safety island designs improve and provision is more widespread

3.1 Conceptual Model

This study was designed to examine a variety of factors that could contribute to midblock crossing behavior, including: individual socio-demographic factors such as gender and age; environmental factors such as land use, street design, and facilities such as pedestrian overpasses and underpasses; traffic conditions such as heavy, high-speed traffic; enforcement factors; and factors related to education and policy. Figure 1 provides a conceptual model of the study design. The study aimed to show a strong correlation between the combination of factors, including land use factors, and midblock crossing behavior.

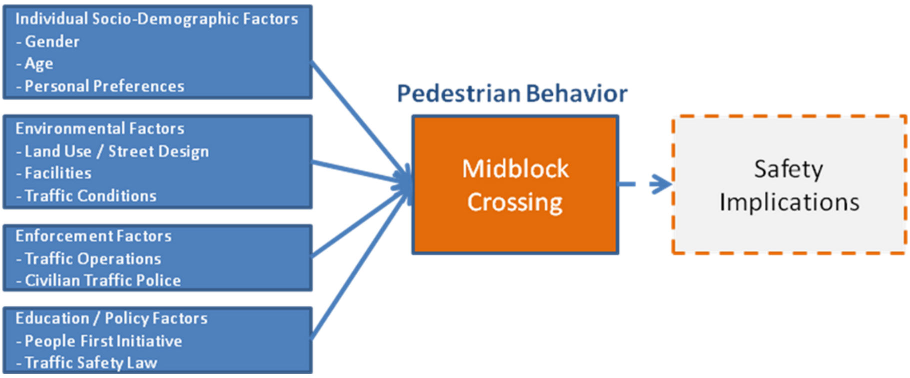

Figure 1: Conceptual model of the factors affecting pedestrian behavior.

3.2 Data Collection and Analysis: A Site-Specific Approach

Several different techniques were employed to understand pedestrian crossing behavior around intersections in Fushun. First, observations were made at several major intersections, and casual interviews were conducted to inquire about residents' level of understanding about crossing behavior. Traffic and pedestrian counts were made around several key intersection approaches to evaluate how many and what type of people cross at the midblock versus at the intersection, and how many people cross on a red pedestrian light versus on a green light.

To uncover the reasons for the observed behavior, a qualitative attitudinal survey was conducted for pedestrians crossing at intersections, on pedestrian overpasses, on striped crosswalks, and midblock. Surveys were collected of pedestrians crossing on designated facilities and midblock to assess the characteristics of midblock crossers and to determine what might convince them to change behavior. These surveys ($N = 469$) were intended to provide insights into pedestrian characteristics and major issues people face when they travel by foot. However, acknowledging that pedestrians may claim to be more rule-abiding than they actually are, the qualitative instruments may give a biased perspective on actual pedestrian behavior. Essentially, these are stated preferences rather than revealed preferences. Lastly, two focus groups were conducted to find out what attitudes and values pedestrians had that contributed to the observed behavior.

Supplementary block length studies, analyses of signal timing along a main corridor, and spatial tracking surveys were designed to give a broader picture of the context and environment of pedestrian behavior. A full account of the survey content, sampling protocol, focus group design, and detailed methodology is available in Tao (2007).

This set of qualitative and quantitative survey instruments looks at micro-scale issues such as midblock crossings, medium-scale issues such as building layout infrastructures such as pedestrian overpasses and underpasses, and large-scale issues such as overall city structure, block length, and increasing motorization and its effect on walkability.

3.3 Study Site

Fushun is situated in Liaoning Province within China's northeastern region (Figure 2) and is a medium-sized city with an urban population of 1 428 000 (Liaoning Statistical Bureau 2005).

Figure 2: Location of Fushun, in Liaoning Province, northeastern China.

Walking currently accounts for 41 percent of travel in Fushun, and travel by bus accounts for 28 percent of daily trips (Figure 3). Continued widespread reliance on walking and buses reinforces the need to ensure that pedestrian needs are accounted for throughout the city. Mode split projections indicate that the number of trips by bus will increase, and since bus trips most often start and end with a walking segment, the focus on the pedestrian is crucial for Fushun's current and future transportation plans.

Compared with other Chinese cities, Fushun still has a very high proportion of walking trips, and the city's dense bus network also attracts a high percentage of trips by public transportation (Figure 4).

As for crossings, several pedestrian flyovers and one underground tunnel exist in Fushun. Zebra crossings are the most common form of at-grade crossing infrastructure, periodically laid out across the landscape. These are common in Fushun, where they are found in two forms: white striping is used for typical crossings, usually placed in busy areas, near the entrances to shopping malls and major destinations; yellow striping is used near schools and hospitals to emphasize a warning. In some areas of the city, the paint has nearly worn away, and without sufficient funding and dedicated project planning, there is no guarantee that striping will be maintained.

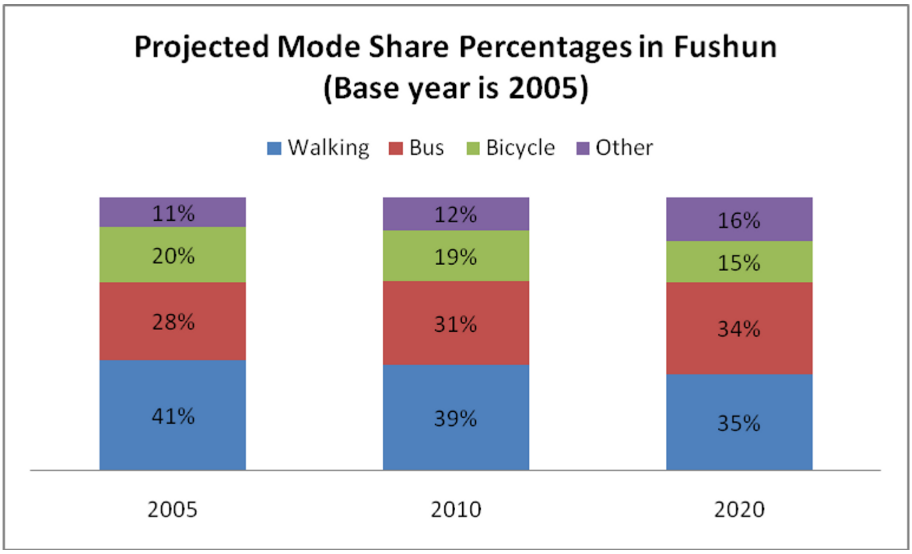

Figure 3: Projected mode share percentages in Fushun.

Base year 2005. "Other" includes private motor vehicles, taxis, and company-owned cars. (World Bank 2006).

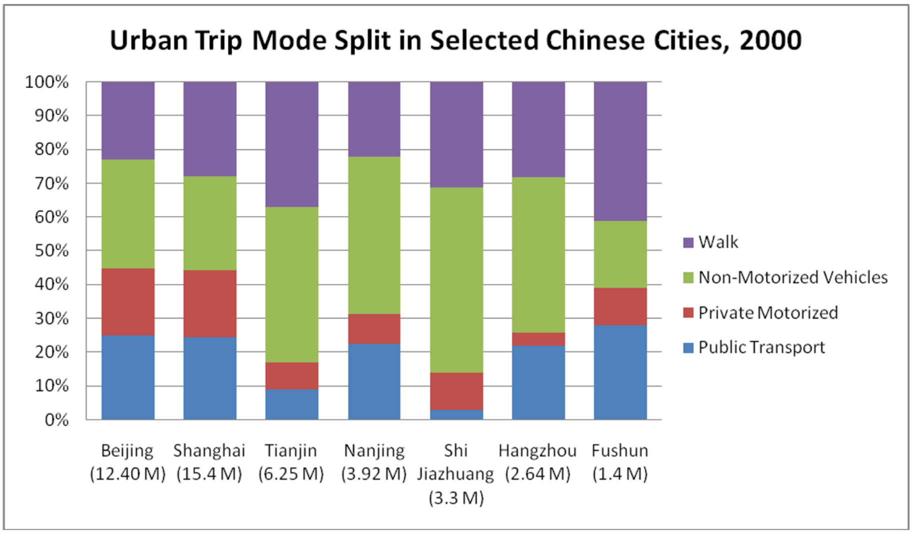

Figure 4: Urban trip mode split in selected Chinese cities, 2000.

"Private motorized" includes company-owned cars and taxis. (Pucher *et al.* 2007; World Bank 2006).

4 Research Findings

This study found evidence that even when faced by moderate-to-heavy traffic on an arterial of six to eight lanes, pedestrians in Fushun are willing to cross midblock. In fact, pedestrians in Fushun often cross at unmarked locations on an intersection approach within 150 to 200 m of a signalized intersection with pedestrian lights. Several factors were found to affect this behavior, ranging from traffic operations issues to the fundamental design of city structure. When pedestrians encounter a transportation environment that marginalizes the walking population, they react by not following the rules and crossing midblock. This section documents the finding that midblock crossing is prevalent and problematic in Fushun, and infer why midblock crossing occurs.

4.1 Midblock Crossing is Prevalent and Problematic

Midblock crossing was found to be a frequent phenomenon in every part of the city and on all types of roadways (Figure 5). Pedestrians tended to cross at midblock even when another type of infrastructure (e.g. designated zebra crossings or pedestrian overpasses) existed.

Figure 5: Midblock crossings are common on many types of urban arterials.

A survey of eleven intersection areas in the central city showed that midblock crossing activity constituted between 20 percent and 66 percent of all crossings. Table 2 details the pedestrian counts on blocks with varying road widths, block lengths, and speed limits. A simple regression model using width of street, block length, and speed limit was used to predict midblock crossing behavior. However, due to the small size of the intersection sample and the large variability in confounding factors such as land use type (i.e. school, hospital, retail, residential) and presence of bus stops, results were inconclusive. The survey did, however, observe that midblock crossing behavior was prevalent along a wide range of arterials in Fushun.

Two sites were then chosen for more detailed analysis—one in the city center and one in the area of newer development. The goal was to obtain a qualitative understanding of midblock crossing behavior, and to conduct individual-level surveys that would elucidate the reasons for this behavior. Both sites were along major arterials, but one had a designated crosswalk and the other a pedestrian overpass overhead. Table 3 compares the characteristics of these sites.

At the Xiyi Lu/Xisan Jie section, there were more intersection crossings during peak periods than during non-peak periods (48 percent during A.M. peak, 58 percent during P.M. peak, and 38 percent during the midday count). The largest number of intersection crossings occurred during the P.M. peak, when pedestrian volume was the highest. Observation suggests that two major variables could account for this. First, there were civilian traffic control (enforcement) which guide pedestrians to walk on designated intersection crosswalk rather than in the middle of the road. Second, the volume of motor vehicle traffic was higher during peak periods, and people were therefore less willing to cross midblock. Tables 4 and 5 show how the distribution of user types also influenced crossing behavior during the midday and P.M. peak periods.

Table 2: Percentage of midblock crossings on typical arterials in Fushun.

ID	Road	Time	Dir.	Count		% Midblock
				Intersection	Midblock	
1	Xincheng Lu/ Hunhe Jie	0845–0900	N S	234 292	454 388	66 57
2	Changchun Jie/ Xincheng Lu (Bei)	1030–1045	E W	41 37	49 54	54 59
3	Changchun Jie/ Fushuncheng Lu	1115–1130	E W	30 20	15 7	33 26
4	Zhandong Jie/ Fushuncheng Lu	1345–1400	E W	93 55	44 48	32 47
5	Zhandong Jie (Zhong)	1430–1445	E W	64 72	77 78	55 52
6	Zhandong Jie/ Xingchen Lu	1515–1530	E W	74 38	52 36	41 49
7	Liquan Lu/ Ankang Jie (Dong)	0930–0945	N S	101 125	57 32	36 20
8	Liquang Lu/ Ankang Jie (Bei)	1015–1030	E W	39 43	20 15	34 26
9	Liquan Lu/ Ankang Jie (Nan)	1115–1130	W	94	22	19
10	Xiyi Lu/ Xisan Jie (Nan)	1345–1400	E W	86 59	75 23	47 28
11	Xiqi Lu/Xisan Jie	1600–1615	E	366	238	39
Total				1963	1784	48

Locations 1–6 observed on 27 July 2006; locations 7–16 observed on 28 July 2006.
Lu = Road; *Jie* = Street; *Bei* = North; *Zhong* = Middle; *Dong* = East; *Nan* = South.

Although these results show that gender had little to do with midblock crossing at the Xiyi Lu site, other user traits were important. Children (young students) tended to use the pedestrian overpass disproportionately more than other users. Although they comprised 6.1 percent of the total crossings in the mid-day and peak-hour crossings counted, they were 15.3 percent of the overpass users during the same time period. The elderly tended to use intersections rather than crossing midblock or using the overpass. Although they comprised 6.1 percent of the total counted population in the midday and P.M peak, they were 8.6 percent of the ones crossing at the intersection. Although there were only 22 disabled people in the total sample (A.M period not shown, midday period shown in Table 4 and P.M period shown in Table 5), every one of them used the intersection to cross the road, rather than crossing midblock or at the intersection.

Table 3: Comparison of the crossing count sites.

	Xiyi Lu	Xincheng Lu
Road Classification	Trunk (主)	Trunk (主)
Roadway Width	28 m	35.4 m
Barrier	1 m metal; frequent openings	None
Bus Lanes	12	6–12
Bus Stop Location	Midblock	Nearside intersection
Ped. Signal Timing	26 sec green, 44 sec red	22 sec green, 93 sec red
Ped. Crossing at Intersection	Faded crosswalk markings	Crosswalk with painted safety island
Accident data (2005)*	5 accidents; 3 injuries	3 accidents; 1 injury
Vehicle Volume (PM peak)	4087 veh/hr	3573 veh/hr
Avg. Vehicle Speed	27.9 km/h	33 km/h
Distance to Next Intersection	500 m	420 m
Land Uses	Commercial & retail; government offices	Neighborhood commercial retail

*Injuries and accidents are reported separately.

Table 4: Crossings at Xiyi Lu/Xisan Jie, midday.

	Intersection		Midblock		Ped. Overpass		Total	
	No.	%	No.	%	No.	%	No.	%
Single	435	*38*	574	*50*	132	*12*	1141	*100*
Elderly	91	*67*	37	*27*	7	*5*	135	*100*
With Child	21	*58*	11	*31*	4	*11*	36	*100*
Carrying Load	18	*78*	4	*17*	1	*4*	23	*100*
Child	42	*37*	31	*27*	40	*35*	113	*100*
Disabled	4	*100*	0	*0*	0	*0*	4	*100*
Total	611		657		184		1452	

At the Xincheng Lu site, the 35 m roadway width (compared to 100 m from the bus stop to the nearest designated crossing) might induce alighting bus riders to cross midblock rather than trekking the extra distance to the intersection. Observed crossings suggest that pedestrians alighting from buses crossed midblock during times of lower motor vehicle volumes. Tables 6 and 7 show how the distribution of user types influences crossing behavior during the midday and P.M. peak periods at the Xincheng Lu survey site.

The pedestrian counts conducted at Xincheng Lu suggest that distance and traffic volume were the most important factors influencing the decision to cross outside of designated cross-

Table 5: Crossings at Xiyi Lu/Xisan Jie, P.M. peak.

	Intersection		Midblock		Ped. Overpass		Total	
	No.	%	No.	%	No.	%	No.	%
Single	971	*58*	570	*34*	141	*8*	1682	*100*
Elderly	55	*80*	13	*19*	1	*1*	69	*100*
With Child	6	*18*	20	*61*	7	*21*	33	*100*
Carrying Load	13	*81*	3	*19*	0	*0*	16	*100*
Child	41	*45*	37	*41*	13	*14*	91	*100*
Disabled	9	*100*	0	*0*	0	*0*	9	*100*
Total	1095		643		162		1900	

Table 6: Crossings at Xincheng Lu (midday).

	Zebra		Midblock		Intersection		Total	
	No.	%	No.	%	No.	%	No.	%
Single	69	*19*	144	*39*	155	*42*	368	*100*
Elderly	10	*29*	10	*29*	15	*43*	35	*100*
With Child	5	*29*	6	*35*	6	*35*	17	*100*
Carrying Load	0	*0*	0	*0*	3	*100*	3	*100*
Child	9	*38*	11	*46*	4	*17*	24	*100*
Disabled	0	*0*	0	*0*	0	*0*	0	*100*
Total	93		171		183		447	

ings. In cases like this, more frequent zebra crossings or median safety islands would be more important to pedestrians than improvements at the intersection or the construction of additional facilities (such as pedestrian overpasses).

Table 7: Crossings at Xincheng Lu, P.M. peak.

	Zebra		Midblock		Intersection		Total	
	No.	%	No.	%	No.	%	No.	%
Single	95	*22*	173	*40*	162	*38*	430	*100*
Elderly	12	*63*	1	*5*	6	*32*	19	*100*
With Child	4	*25*	3	*19*	9	*56*	16	*100*
Carrying Load	0	*0*	0	*0*	0	*0*	0	*100*
Child	21	*64*	6	*18*	6	*18*	33	*100*
Disabled	0	*0*	0	*0*	0	*0*	0	*100*
Total	132		183		183		498	

4.2 Reasons for Midblock Crossing

In Fushun, midblock crossings are a function of a bundle of factors including traffic operations, road structure, enforcement of pedestrian regulations, and type of available pedestrian facilities.

Signals are Not Timed for Pedestrian Walking Speeds

The timing of traffic signals at several intersections in Fushun did not take typical walking speeds into account. It was posited that the green light for pedestrian crossing was too short, encouraging midblock crossing behavior.

During the morning peak period on August 9, 2006, an evaluation of four intersections on Xincheng Lu was conducted to compare the existing pedestrian signal timings with generally accepted standards.

According to the Manual on Uniform Traffic Control Devices (MUTCD), the length of the pedestrian clearance phase (including the flashing "Don't Walk" segment) should be based on the "normal" pedestrian walking speed of 1.22 m (4.0 feet) per second (United States Department of Transportation 2003). At Xincheng Lu, walking speeds required to safely cross the intersection ranged from 0.46 m/s (1.5 ft/s) on a minor cross-street to 2.96 m/s (9.7 ft/s) on the Xincheng Lu/Jingyu Lu intersection. Table 8 shows that none of the crossings on Xincheng Lu would meet the 1.22 m/s (4.0 ft/s) requirement set forth by the MUTCD standard.

Table 8: Evaluation of pedestrian walk times at four intersections along Xincheng Lu.

	Street Name	Cross Street	Width (m)	Green Time (s)	Walking Speed (m/s)
1	Xincheng Lu	Jiangjun	35.4	28	1.26
	Jiangjun	Xincheng Lu	24	40	0.6
2	Xincheng Lu	Jingyu	35.4	12	2.95
	Jingyu	Xincheng Lu	14	28	0.5
3	Xincheng Lu	Qianan	35.4	18	1.97
	Qianan	Xincheng Lu	9	37	0.24
4	Xincheng Lu	Zhandong	35.4	24	1.48
	Zhandong	Xincheng Lu	14.8	32	0.46

Xincheng Lu, an eight-lane major arterial 35 m wide, has been built on and expanded during the last ten years. One of the longest arterials in Fushun, it stretches through a large portion of the newer Shuncheng District, with a total length of nearly seven kilometers (Fushun Municipal Government Facilities Management Bureau 2004). Snaking through major commercial sections of the newer district, it is both a commercial and employment attractor, but also reaches more sparsely developed territory on the eastern side of the city.

A series of pedestrian tracking surveys was conducted at the same four major intersections along Xincheng Lu in order to determine if any correlation existed between short green times and midblock crossing. Pedestrian tracking revealed that when pedestrian green times were short (for example, 12 seconds to cross 35 m), people had a tendency to cross immediately outside the intersection rather than at the intersection itself. Figure 6 shows the pedestrian tracking diagram conducted for the intersection of Xincheng Lu and Jingyu Street.

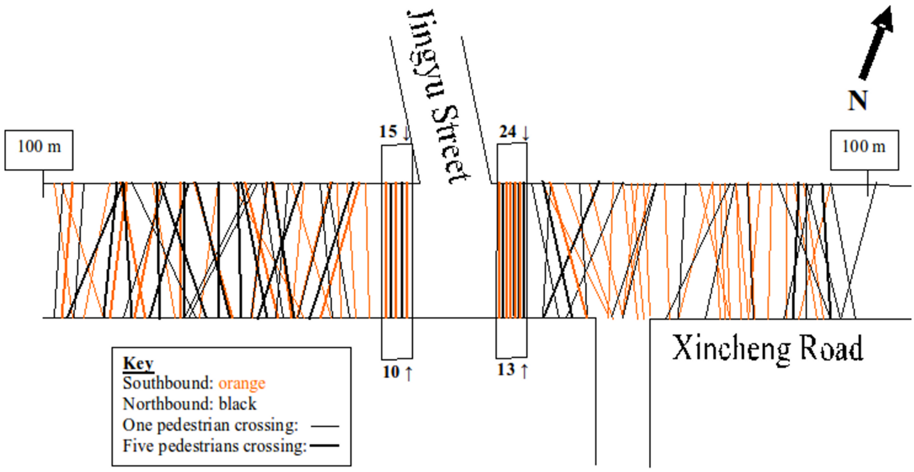

Figure 6: Pedestrian tracking diagram for Xincheng Lu in Fushun.

Although the results of this study represent a simple qualitative correlation between pedestrian-signal timing and crossing behavior, there is nevertheless an indication that the signals on Xincheng Lu could be adjusted to adhere to standard walking speeds. Additional studies could be conducted to examine whether longer pedestrian crossing times would encourage pedestrians to use the intersection crosswalk.

Superblocks Can Encourage Midblock Crossing

Due to their length, city blocks in Fushun can be characterized as "superblocks." Their average length of 200 to 300 m is typical of many Chinese cities, but much larger than typically found in the United States and other western countries. Table 9 displays the average city block size in various cities around the world. Only the newer style cities, like Irvine, California, have block sizes larger than typical Chinese superblocks. This superblock structure is a remnant of the *danwei* work-live unit structure of Chinese cities.

Pedestrian infrastructure on these large arterials in Fushun currently takes the form of the addition of pedestrian signals at intersections, the building of some pedestrian overpasses and underpasses, and the establishment of midblock zebra crossings.

Transport planning standards in China, which lack specific guidelines for the design of pedestrian infrastructure, do not adequately address the crossing realities of pedestrians. The Standards for Transport Planning on Urban Roads (城市道路交通规划设计规范) includes general guiding principles for the selection of crosswalk locations on trunk roads. On most trunk roads, the distance between crosswalks (either midblock zebra markings or at intersections) must be 250 to 300 m or less. In commercial areas, the standards flexibly note that crossings should be closer to each other, but specific details are left to the engineers who evaluate

Table 9: Average block sizes in various cities around the world.

City (area)	Mean	Median
Rome	58	51
Bologna (center)	68	91
Paris (Louvre)	75	61
Pompeii	68	91
New York (lower Manhattan)	84	79
New York (Midtown)	129	79
San Francisco (center)	108	107
San Francisco (mid-city)	125	99
San Francisco (Sunset)	141	91
Los Angeles (center)	119	110
Irvine, CA	393	396

Source: Adapted from Jacobs (1995).

crossing locations based on the volume of pedestrians crossing, especially when there is not enough capacity for a pedestrian overpass or underpass.[1]

In the older areas of Fushun, a tight grid pattern provides vehicle access throughout the area, but the poor quality of secondary streets tends to focus traffic on better-quality arterials. Unfortunately, this also means that for pedestrians, instead of crossing two-lane linked streets in a densely gridded network, they must cross six- to eight-lane arterials with controlled intersections separated by up to 500 m. Figure 7 shows the long blocks of over 400 m in Fushun's center city area.

The placement of several large arterials through the core of Fushun has many implications for traffic flow, pedestrian movement, and increased midblock crossings. Traditional Chinese urban forms involved larger complexes such as the *danwei* (单位) where people worked, lived, and performed civic functions within the space of several blocks. Land market changes have caused people to live further from their workplaces, and transportation networks such as roads and rails sustain inner-city travel and circulation.

In Fushun, buses have been a popular mode of travel during the last decade. The dense network of bus lines provides mobility to the citizens at low cost, but has also encouraged the dispersion of destinations so that walking is not as local as it once was. With an inherited structure of state-owned work-live complexes, Fushun has a grid pattern that is overlaid with a larger network of superblock streets. As of March 2006, although 83 percent of trunk road arterials were classified in acceptable condition,[2] only 37 percent of the secondary and branch roads were in acceptable condition (World Bank 2006). Several studies indicated that secondary routes were critical links in the system (Chen and Mehndiratta 2007; Reguero and Finn 2005). Accordingly, Fushun is filling in some of the grid by creating more links in the network, including the addition of cross-streets that break up superblocks.

[1] To justify the construction of a pedestrian overpass or underpass, the intersection crossing volume should be greater than 5000 pedestrians per hour and vehicle traffic greater than 1200 vehicles per hour.

[2] Acceptable conditions are determined by the Municipal Maintenance Departments. Roads in unacceptable condition are no longer possible to drive safely and comfortably during specified weather conditions.

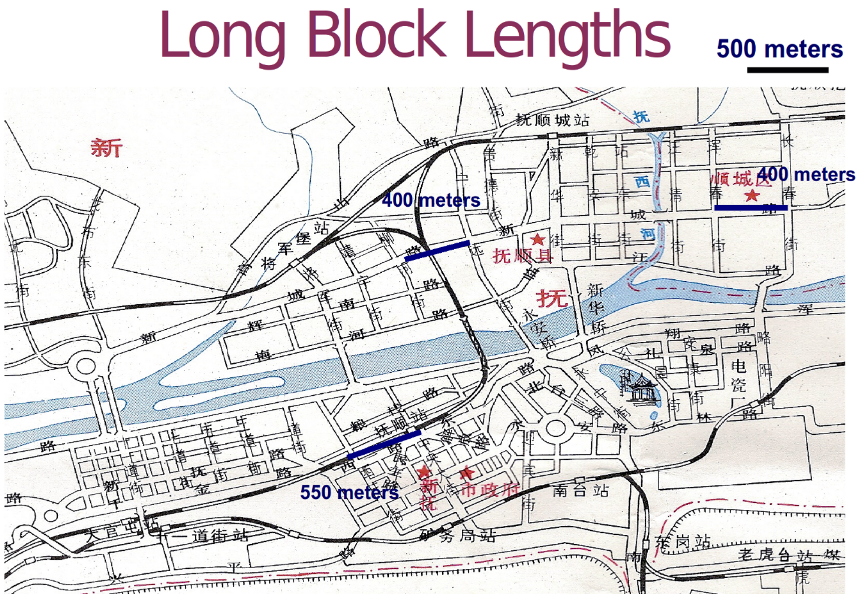

Figure 7: Block lengths of more than 400 mare common in Fushun.

Source: Fushun Maps Office (2000).

The literature identifies several characteristics of livable streets and urban form. The consensus is to provide convenient access for local residents, but discourage through traffic. Gridded neighborhood street patterns with limited hierarchy have the most connectivity, but also tend to disperse traffic evenly throughout a neighborhood (Southworth and Ben-Joseph 1997).

This study found that pedestrians are motivated to cross midblock on large arterials by personal convenience, and that the long distances between designated crossings discourages pedestrians from walking to them. Additionally, focus groups confirmed that pedestrians felt safer crossing at midblock rather than controlled intersections.

In urban areas of other countries, distances of 250 to 300 m are considered too long for pedestrians to walk in order to reach a crosswalk. Field observations confirm that pedestrians in Fushun are also unwilling to walk 250 to 300 m. Preliminary investigations in Fushun indicate that midblock crossing is ubiquitous on major arterials, but that adding zebra crossings has a noticeable effect on pedestrian behavior: zebra crossings in close proximity encourage pedestrians to cross on the marked crosswalk rather than outside pedestrian facilities.

These findings imply that long, uninterrupted blocks encourage haphazard pedestrian crossings along multi-lane arterials. Although Xincheng Lu does have some painted "safety islands," they do not provide any physical barrier to protect crossing pedestrians. The building of major arterials can increase vehicle throughput, but unless these arterials are designed with pedestrian crossings in mind, they are dangerous and inconvenient for the walking population.

Weak Enforcement of Regulations for Drivers and Pedestrians

Traffic regulations in Fushun are enforced by the Municipal Traffic Bureau. In Fushun there are two types of enforcement personnel. The first type is the traffic police, who have the ability to deal with all aspects of traffic management, including vehicles, signal systems, and non-motorized modes. The second type are civilian traffic coordinators; approximately 200 coordinators are positioned at certain hotspots around the street network to guide pedestrians to obey the pedestrian signals and to monitor bicycle traffic at intersections (Figure 8). Traffic coordinators are usually deployed during peak periods and at busy signalized intersections, rather than on the street.

Figure 8: Civilian traffic enforcement personnel monitor non-motorized transportation.

In taxi driver interviews, focus groups, and discussions with traffic police about the midblock crossing behavior, a major theme emerged: enforcement was weak and people's attitudes and norms (素质) towards midblock crossing needed to be changed. Each stakeholder group considered another to be accountable for their actions; for instance, drivers mentioned that pedestrians had to be more aware and cross at intersections, while pedestrians asserted that drivers should yield to those crossing at midblock.

Figure 9: Enforcement in Fushun by traffic police and through barrier construction.

To change pedestrian attitudes and norms that favor illegal midblock crossings, Chinese cities have implemented stronger enforcement mechanisms and installed taller, impenetrable barriers (Figure 9). Cities such as Nanjing, Guangzhou, Shanghai, and Shenyang have fined pedestrians for illegal midblock crossings and for crossing against the red light at an intersection. According to a survey of 469 pedestrians in Fushun, enforcement and fines seem more effective than barriers, although stated preferences may differ significantly from revealed preferences.

Focus group discussions also made it clear that there is a strong social element to both pedestrian and driver behavior. Taxi drivers, in interviews, expressed the view that pedestrians were "in the way" and that the drivers had little patience for them. Taxi drivers—and many pedestrians—viewed bicycling as old-fashioned but not disruptive. Pedestrians did, however, express some resentment toward automobile users, whom they saw as arrogant violators of traffic laws. In this sense, the balance between the mobility function of an urban arterial and the convenience for crossing pedestrians is couched in a cultural context. The high social status of many auto users and the automobile's important role in China's pursuit of rapid economic growth and modernity give it social priority over other modes. Those on foot push back by ignoring the rules for pedestrians, crossing streets at will, climbing over barriers, and ignoring the formally designated infrastructure (Figure 10).

Figure 10: Jumping over one-meter barriers is a common practice in Fushun.

What could change this pattern of negatively reinforcing behaviors? Both survey and focus group results indicate that better enforcement and fines would be more effective at stopping midblock crossing than the installation of pedestrian infrastructure (barriers or overpasses). To ensure maximum efficacy of the pedestrian facilities built, driver behavior could be changed through investment in technology such as automatic red-light cameras and control of driver awareness using countdown lights. In the focus groups conducted in Fushun, the theme of traffic enforcement was a strong sentiment throughout discussions.

Major remarks included that "monitoring pedestrians is not as important as enforcing motor vehicles," "civilian traffic coordinators are not strict enough," "traffic police work hard, but the city needs more of them," and "enforcement is not strict enough for motor vehicles." Dealing with pedestrian and driver attitudes and norms is critical in order to ensure effective returns on major infrastructure improvements to the urban landscape.

Pedestrian Overpasses and Underpasses are neither Well-liked nor Well-used

One way to build out of the danger of pedestrian midblock crossings at street level is to install grade-separated facilities such as pedestrian overpasses and underpasses, and Fushun has done this (Figure 11). Many Chinese cities have followed this route, and Beijing alone has over 400 pedestrian overpasses (Li 2006).

Figure 11: Grade separation is an investment in urban form affecting pedestrian behavior.

Research has shown that the Chinese public is unreceptive toward these types of pedestrian infrastructure (Pan *et al.* 2007). In fact, in a World Bank urban transportation project in Xinjiang, overpasses have been torn down due to pedestrians running across wide trunk roads rather than using the pedestrian-only overpass right above them (World Bank 2000).

If policy makers do not understand pedestrian behavior, they are prone to invest in expensive infrastructure few people use, a phenomenon prevalent in Fushun. For instance, the pedestrian overpass on Zhongyang Road was recently torn down and replaced with an underpass due to underutilization and "unattractiveness" (Yang 2006). Currently, there are 12 pedestrian overpasses in Fushun (Fushun Municipal Government Facilities Management Bureau 2004). Costing approximately 500,000 RMB ($62,500 USD) each, the cost of these overpasses totals $750,000 USD (in 2005 dollars).

Figure 12: Midblock crossing occurs despite overpass infrastructure.

The typical current Fushun resident does not have a high opinion of pedestrian overpasses; in a typical walker focus group, none of the 10 participants said they used overpasses on a regular basis. In fact, in one of the busiest parts of town, Xiyi Road, only 10 percent of people within 150 m distance used the pedestrian overpass to cross the road despite barriers along the sidewalks. Figure 12 shows typical pedestrian behavior, despite the presence of barriers to crossing under a pedestrian overpass.

5 Conclusion

Fushun, like many medium-sized Chinese cities, is in an "adolescent" period of economic growth and infrastructure expansion. The bones of Fushun's transportation system are developing almost too quickly for the city's land use skin, as miles of wide arterials are laid out in anticipation of future growth. The economic, engineering, design, and social ramifications of this are many, including a threat to the traditional "great street" and the culture of walking that has remained an important form of daily interaction. Despite an overall national sentiment favoring the notion of a drivable city, planners have both an opportunity and a responsibility to maintain walkability in Chinese cities.

China has rare opportunities to integrate pedestrian concerns into large-scale transportation and land use planning—the visioning and implementation of a city structure in a high-level way—for instance, determining whether a city should be laid out with streets in a grid design or with a ring road design There are currently 183 cities in China with populations between 500,000 and two million (National Bureau of Statistics of China 2005). Although many Chinese cities have their own structural legacies, significant rebuilding and reorganizing has occurred in medium-sized Chinese cities over the last decade. Planners and engineers can now design for pedestrian comfort and safety proactively at the large-scale level rather than at the micro-level where every decision is a reactive one.

By considering the pedestrian at the beginning stages of the building cycle, medium-sized cities such as Fushun have tremendous opportunities to create an environment that accommodates typical pedestrian behavior. A variety of factors influence midblock crossing behavior, and in order to reduce this, the city can employ a combination of strategies. The highest level strategy is to focus on land use. Other strategies, such as building grade-separated infrastructure for complete mode separation, may be necessary in some parts of the urban area, but carpeting the entire city with such facilities creates a layer of inconvenience and risk for pedestrians. Models such as the vibrant centers of historic European cities such as Munich and Rome, as well as the tightly gridded island of Manhattan in New York, can provide alternative examples of "great streets" and land use patterns that are designed primarily for pedestrians and secondarily for other modes.

Fushun builds its large wide roads and pursues motorization as signs of modernity as well as for purposes of economic development. The city has chosen to address transportation issues through both "hard" infrastructure investments and "soft" policy interventions, but not to question the fundamentals of space allocation and use. As a result, Fushun's "intricate sidewalk ballet"[3] is conducted on a reorganization of street hierarchies and operating rules that give priority to the regional and city-wide, the long distance, and the motorized. In turn, a reordering of everyday practices on the street is occurring as the relationship between the driver and the pedestrian becomes less negotiated and more planned.

The negotiations are not just about who gets what space and what infrastructure, but also about who gets priority and respect. Midblock street crossings, barrier-hopping, and the disre-

[3] With reference to Jane Jacobs in *The Death and Life of Great American Cities*.

gard of overpass facilities are partly explained by convenience, but are more fully understood by acknowledging that urban arterials are social and cultural spaces as well as physical, engineered ones. Through their actions, pedestrians are resisting policies that relegate them to a secondary or second-class role.

Policy makers, engineers and planners should evaluate whether large arterials provide benefit to all users, including pedestrians. Preservation and rehabilitation of current road infrastructure could serve as an alternative to the six- to eight-lane arterial road building efforts.

In a larger sense, a broad rethinking of space allocations also might be in order. Future work following from this research should examine multimodal signal timing and "complete streets"—multimodal designs—as ways of rebalancing the priorities given to all modes in the city.

References

World Bank. 2000. Project appraisal document on a proposed loan in the amount of $100 million to the People's Republic of China for the Urumqi Urban Transport Improvement Project. The World Bank.

Appleyard, D. 1981. *Livable Streets*. Berkeley: University of California Press.

Cao, X., S. L. Handy, and P. L. Mokhtarian. 2006. The influences of the built environment and residential self-selection on pedestrian behavior: Evidence from Austin, TX. *Transportation*, 33(1):1–20. doi: 10.1007/s11116-005-7027-2.

Chen, Y. and S. Mehndiratta. 2007. Involve the long-neglected mass in urban transportation: Bicycle user survey in Fushun, China, 2005. In *TRB 86th Annual Meeting Compendium of Papers CD-ROM: Transportation Research Board Annual Meeting 2007*. Washington, DC: Transportation Research Board.

Chu, X. 2004. Measuring the risk of walking. Technical report, Center for Urban Transportation Research, University of South Florida, Tampa, FL.

Clarke, A. and M. Dornfeld. 1994. National bicycling and walking study, fhwa case study no. 19: Traffic calming, auto-restricted zones and other traffic management techniques—their effects on bicycling and pedestrians. Technical Report FHWA-PD-93-028, Federal Highway Administration, Washington DC.

de Certeau, M. 1984. *The Practice of Everyday Life*. Berkeley: University of California Press.

Frame, G. 2004. Thematic review of traffic management in world bank urban transport projects in china. Unpublished, Final Draft version 2, Washington, DC: World Bank.

Frank, L. D. and P. O. Engelke. 2001. The built environment and human activity patterns: Exploring the impacts of urban form on public health. *Journal of Planning Literature*, 16(2):202–218. doi: 10.1177/08854120122093339.

Fushun Municipal Government Facilities Management Bureau. 2004. *Handbook of on Inventory of Roads and Facilities*. Fushun Publications Office.

Gong, J., C. Jing, X. K. Yang, and K. M. Williams. 2007. Safety investigation of pedestrian crossing at wide signalized intersections in Beijing China. In *TRB 86th Annual Meeting Compendium of Papers CD-ROM: Transportation Research Board Annual Meeting 2007*. Washington, DC: Transportation Research Board.

Greenwald, M. J. and M. G. Boarnet. 2001. The built environment as a determinant of walking behavior: Analyzing non-work pedestrian travel in Portland, Oregon. Technical Report

UCI-ITS-AS-WP-01-4, Institute of Transportation Studies.

Handy, S. L., M. G. Boarnet, R. Ewing, and R. E. Killingsworth. 2002. How the built environment affects physical activity: Views from urban planning. *American Journal of Preventive Medicine*, 23(2, Supplement 1):64 – 73. ISSN 0749-3797. doi: 10.1016/S0749-3797(02)00475-0.

Jacobs, A. B. 1995. *Great Streets*. Cambridge: MIT Press.

Li, Y. 2006. Urban administrative bureau: Entire city, hundreds of skybridges and underground tunnels must be renovated. *Beijing Daily*.

Liaoning Statistical Bureau. 2005. Liaoning statistical yearbook 2005.

Lynch, K. 1960. *The Image of the City*. Cambridge, MA: Technology Press.

National Bureau of Statistics of China. 2005. China statistical yearbook 2005. Technical report, National Bureau of Statistics of China. URL http://www.stats.gov.cn/tjsj/ndsj/2005/indexeh.htm.

National Bureau of Statistics of China. 2006. China statistical yearbook 2006. Technical report, National Bureau of Statistics of China. URL http://www.stats.gov.cn/tjsj/ndsj/2006/indexeh.htm.

Oakes, J. M., A. Forsyth, and K. Schmitz. 2007. The effects of neighborhood density and street connectivity on walking behavior: The Twin Cities walking study. *Epidemiologic Perspectives & Innovations*, 4(1):16. doi: 10.1186/1742-5573-4-16.

Pan, H., Q. Shen, and Z. Ming. 2007. Influence of urban form on travel behavior in four neighborhoods of Shanghai. In *TRB 86th Annual Meeting Compendium of Papers CD-ROM: Transportation Research Board Annual Meeting 2007*. Washington, D.C.: Transportation Research Board.

Pucher, J. 1998. Urban transport in Germany: Providing feasible alternatives to the car. *Transport Reviews*, 18(4):285–310. doi: 10.1080/01441649808717020.

Pucher, J., Z. Peng, N. Mittal, Y. Zhu, and N. Korattyswaroopam. 2007. Urban transport trends and policies in China and India: Impacts of rapid economic growth. *Transport Reviews*, 27(4):379–410. doi: 10.1080/01441640601089988.

Reguero, M. and B. Finn. 2005. *Analysis of Secondary Itineraries in Fushun, China*. Beijing: World Bank.

Shay, E., Y. Fan, D. A. Rodriguez, and A. J. Khattak. 2006. Drive or walk? Utilitarian trips within a neotraditional neighborhood. Technical Report 1985, Transportation Research Record, Washington, D.C.

Shi, J., Y. Chen, F. Ren, and J. Rong. 2007. Research on pedestrian behaviors and traffic characteristics at unsignalized midblock crosswalk: A case study in Beijing. In *TRB 86th Annual Meeting Compendium of Papers CD-ROM: Transportation Research Board Annual Meeting 2007*. Washington, DC: Transportation Research Board. doi: 10.3141/2038-04.

Sisiopiku, V. P. and D. Akin. 2003. Pedestrian behaviors at and perceptions towards various pedestrian facilities: An examination based on observation and survey data. *Transportation Research Part F*, 6(4):249 – 274. doi: 10.1016/j.trf.2003.06.001.

Southworth, M. and E. Ben-Joseph. 1997. *Streets and the Shaping of Cities and Towns*. New York: McGraw-Hill.

Tanaboriboon, Y. and Q. Jing. 1994. Chinese pedestrians and their walking characteristics: Case study in Beijing. *Transportation Research Record*, 1441:16–26.

Tao, W. 2007. Purely a matter of convenience? Safety implications for pedestrians on large arterials in Fushun, China. Technical report, University of California, Berkeley.

Transportation Research Board. 2000. *Highway Capacity Manual*. Transportation Research Board, Washington D.C.

United States Department of Transportation. 2003. *Manual on Uniform Traffic Control Devices for Streets and Highways*. Federal Highway Administration, Washington, D.C.

Wang, W. 2003. *Urban Transportation Management and Planning Handbook*. Beijing: China Communications Press.

Wei, H., F. Lu, G. Hou, and A. Mogharabi. 2003. Non-motorized disturbances and control measures at signalized intersections in China. In *TRB 82nd Annual Meeting Compendium of Papers CD-ROM: Transportation Research Board Annual Meeting 2003*, 03-2304. Washington, DC: Transportation Research Board.

Whyte, W. H. 1971. *The Social Life of Small Urban Spaces*. New York: Anchor Books.

World Bank. 2006. Project appraisal document on a proposed loan in the amount of $218 million to the People's Republic of China for a Liaoning medium cities infrastructure project. The World Bank.

Yang, M. 2006. Conversations with Madame Yang, director of the World Bank Project Management Unit, summer 2006. Interview.

Yang, X. K., K. M. Williams, and Y. J. Shi. 2006. Analysis of median use on Beijing urban roadways. In *TRB 85th Annual Meeting Compendium of Papers CD-ROM: Transportation Research Board Annual Meeting 2006*. Washington, DC: Transportation Research Board.

Zegeer, C. V., J. R. Stewart, H. H. Huang, P. A. Lagerwey, J. Feaganes, and B. Campbell. 2005. Safety effects of marked vs. unmarked crosswalks at uncontrolled locations. Technical Report FHWA-RD-04-100, Federal Highway Administration.

Zhao, J. and J. Wu. 2003. Analysis of pedestrian behavior with mixed traffic flow at intersection. In *Proceedings of the Intelligent Transportation Systems Conference*. Shanghai.