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DEVELOPING SHANGHAI UNDERGROUND PEDESTRIAN SYSTEM UNDER URBANIZATION: MOBILITY, FUNCTIONALITY AND EQUITY

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Abstract. Shanghai is being transformed through a process of rapid urbanization. Urbanization has the effects of increasing urban population and the income levels of residents as well as changing the structure of transportation. Under the background, from the 1980s, Shanghai has increasingly built and extended underground pedestrian systems (UPS) within central areas to complement pedestrian networks. UPS have significantly affected urban life in Shanghai under the decades of development but to date, research on UPS usage and perceptions of UPS users has been lacking. This research conducted an on-the-spot survey in Shanghai's UPS in People's Square, Jing'an Temple and Xujiahui areas. Investigation through observation, face to face questionnaires and interviews generated qualitative and quantitative findings on the usage characteristics and perceptions of UPS users. The discussion focused on social usage and equity and the functionality of UPS. It revealed defects in the design and management of Shanghai's UPS, including deficiencies with regard to consideration of the elderly, disabled groups, management of homeless people, the range of merchandise categories and orientation (i.e. way-finding) systems. This research is a significant contribution to enriching knowledge and providing insights into the performance of UPS in a developing country under rapid urbanization.

Keywords: urbanization, urban underground space, underground pedestrian system, city centre, usage, perception, Shanghai.

Introduction

Urban underground space (UUS) has been widely recognized as a valuable resources that can largely contribute to the shortage of space aboveground for urban development (Admiraal 2006; Bobylev 2009; Sterling 1997). UUS has been developed with various functions such as transport including metro, motor tunnel and parking as well as utilities including heating, water supply and sewerage (Admiraal 2012; Bobylev 2010; Cornaro, Admiraal 2012; Durmisevic 1999; Ronka *et al.* 1998; Sterling 1996), among which, transport is the most common function of UUS development (Bobylev 2009).

In central areas of substantial cities around the world, grade separation pedestrian systems including underground pedestrian systems (UPS) and skywalk systems integrated with multiple urban functions such as transport, commerce, entertainment and social activities, extending urban life from the street level to multiple levels. The most extended UPS can be found in North American cities such as Montreal's RESO UPS, 32 km in length covering more than 41 city blocks (Besner 2007) and Chicago's Pedway UPS, extending over 8 km^2 in area and covering 40 city blocks (Wang, Liang 2010). Besides, Japan in East Asian is also a representation of UPS development. Umeda underground system in Osaka City, the largest UPS in Japan, connects 3 subway stations and 24 buildings (Zacharias, Xu 2007). Cui *et al.* (2010) selected 51 cities with UPS to conduct research, and noted that those systems were distributed across cities in North America, South America, Europe, Asia and Oceania. However, notwithstanding the apparently broad global distribution of UPS, East Asia, Europe and North America are three locations of UPS agglomeration.

UPS strategy obtained great success in a number of cities by satisfying varied needs in different urban settings such as Montreal and Toronto with their cold winters and Hong Kong and Tokyo with their high ur-

ban densities. The initial rationale in developing grade separation pedestrian systems was identified as providing protection for pedestrians in central urban locations from severe weather conditions (Belanger 2007; Robertson 1993a, 1993b; Terranova 2009; Warkentin, Vachon 2009), easing traffic congestion related to vehicle-pedestrian conflicts and improving pedestrian accessibility and safety (Bhalla, Pant 1985; Corbett *et al.* 2009; Dillon 1985; Wang, Liang 2010), and promoting transit, particularly in subway metros (Boisvert 2007; Dillon 1985; Robertson 1987b). After decades of development, the potential of grade separation pedestrian systems in stimulating economic development has become the dominant reason for investing in UPS. With increasing competition from suburban shopping centres, in a bid to minimise escape expenditure, maintain urban vitality and attract increased visits, considerable city centres have built UPS and Skywalk systems (Corbett *et al.* 2009; Robertson 1993a, 1993b).

Urbanization and urban pedestrian development in Shanghai

Shanghai's UPS has been developing under the background of rapid urbanization process, which differs from cities in the advanced economies where UPS were developed to maintain central area attractiveness as a counterbalance to the decentralizing tendencies of suburbanization (Cui *et al.* 2011). The urbanization process has had the effects of, on one hand, rapid increases in urban population and income levels of city dwellers, thereby increasing land shortages and land price in central areas; on the other hand, changing the structure of transportation, thereby providing a catalyst for UPS development.

Figure 1 indicated the growth of Shanghai's population between 2000 and 2009 that appeared to be increasing and centralizing rapidly. Continuous increases of Shanghai's population, has resulted in a shortage of urban spaces. Accordingly, underground spaces, as additional space resources for urban functions in centralised locations were gradually accepted and implemented by the authorities. Shanghai, as China's largest metropolitan municipality is an exemplar of the hyperbolic urban growth that has characterised the rapid urbanization of China and its cities.

On the other hand, the structure of transportation has also rapidly changed in unison with the surge of urbanization. Experiencing an increasingly rapid motorization process, the number of cars in Shanghai increased from 241,000 to 1,115,200 during 2001–2010 (Shanghai Bureau of Statistics 2011). Although walking is still a dominant transport mode, the rapid increase

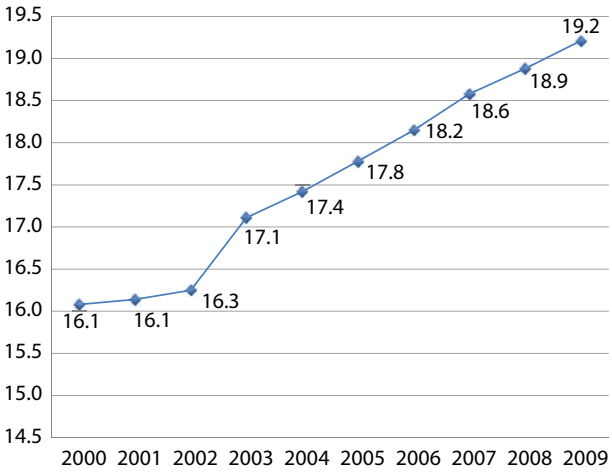

Fig. 1. Shanghai populations (2000-2009, million). *Source*: the authors, edited from Shanghai Bureau of Statistics, 2010.

of private automobiles has challenged the priority given to walking as a transport mode. Li and He (2008) studied the changing structure of transport modal shares in Shanghai from 1986–2004, with a trend away from walking (41% down to 29%) to automobiles (increasing from less than 1% to 16.5%).

The phenomenon of motorization has intensified pedestrian-vehicle conflicts. The phenomenal expansion of automobile transport has negatively impacted on transportation modes of cycling and walking and eroded the urban realm for these transportation modes, with side-effects including pollution, car accidents and congestion. Additionally, the situation of inadequate pedestrian facilities and inefficient traffic management has disadvantaged pedestrians by failing to prevent conflicts between automobiles and pedestrians (Li, He 2008). Recognizing the significance of releasing pedestrian-vehicle conflicts and influenced by the increasing popularity of public transport, walking and cycling in countries around the world (such as in the U.S., France, Netherlands, Britain and Germany), Shanghai have applied the Central City of Shanghai's 2006 'Planning for Pedestrian Traffic System' (Yu *et al.* 2009). With the gradual implementation of a public transport priority strategy (with a strong focus on urban rail transport), modal paths of 'walking + public transport + walking' and 'public transport + walking + public transport' appear destined to become vital components of urban transport (Li, He 2008). Hence, walking infrastructure systems can be expected to play a vital role in the future transportation of Shanghai.

Moreover, the development and extension of Shanghai's metro provides new opportunities for UPS utilization. The Shanghai Metro in June 30th 2010 had

410 km of railway distributed across 11 lines serving 267 stations. Ultimately, Shanghai Metro Planning aims to expand the metro to 480 km of railway with 6 new lines, serving 200 underground stations concentrated within Shanghai's central area. Considerable research has identified the catalytic effects of Metro development and how transportation traffic pressures at street level encourage underground public space utilization (Boisvert 2007; Dillon 1985; Robertson 1987b). Therefore, it can be expected that the increase of urban population, recognition of the importance of pedestrian and Metro developments will facilitate the creation of UUS networks in the city (Sterling *et al.* 2010), most likely in the form of UPS development in the central areas. Current UPS may be extended, but new UPS are also expected to be developed. Accordingly, research on the usage of Shanghai's UPS has practical significance in providing guidance to the future planning, design and development of UPS, particularly in large Chinese cities.

UPS in People's Square, Jing'an Temple and Xujiahui in Shanghai

Shanghai is a pioneer of UUS utilization in China. Early use of UUS focused on Civil Air Defence purpose after the Second World War and large-scale utilization of peacetime UUS started in the 1990s with the construction of subway systems (He *et al.* 2012). Shanghai is a representative of UPS development in China considering its history of UPS development and the considerable scale of UPS. Shanghai exhibits one of the busiest (in terms of foot traffic), most comprehensive, extensive and sophisticated integrated UPS in the world, within one of the fastest developing and rapidly modernizing world's major cities. Exemplars of UPS in Shanghai located in People's Square, Jing'an Temple and Xujiahui areas. The significance of developing UUS in People's Square, Jing'an Temple and Xujiahui had been highlighted in the 'Conceptual Planning of Shanghai's Underground Space (2005)'. In each case, a large public transit transfer hub integrated with large underground concourses and underground shopping streets has formed underground pedestrian networks extending in all directions.

The Jing'an Temple area is located adjacent to a historical site, the Jing'an Temple, a traditional cultural landmark and includes a shopping centre and transit transfer centre; People's Square area, a historic city centre, is a large public activity centre that is an iconic urban landscape feature and an urban node that serves as a large public transit transfer hub (offering 42 bus lines) and a large rail transit transfer hub (with 3 subway lines); and the Xujiahui area is one of four major sub-centers of Shanghai with commercial, business and public activities and is a large rail transit transfer hub (with 3 subway lines) (Chen 2008; Dong 2005; Xu *et al.* 2006).

The structure of the underground matrix of the three UPS is characterised by axes and nodes. The locations and comparative structure and size of the three UPS are shown in figure 2. UPS in the three locations are integrated with transport, commercial, leisure and public functions. The buildings and spaces connected to these three exemplar UPS of Shanghai are listed in table 1. The three UPS have close connection with their neighbouring buildings and spaces on the surface. The arrangement of entrances and exits of the three UPS are set out in table 2.

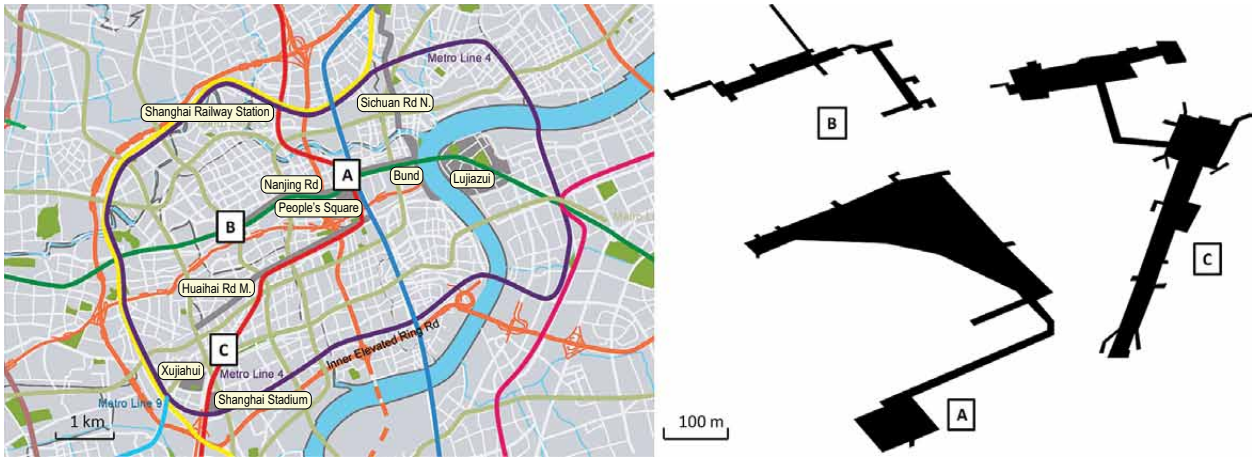

Fig. 2. Map of locations and comparative structure & size of UPS in A. People's Square, B. Jing'an Temple and C. Xujiahui. *Source*: the authors, edited from *Shanghai Municipal Government*, 2011.

Table 1. Buildings and spaces connected to People's Square, Jing'an Temple and Xujiahui UPS

Building/Space	People's Square	Jing'an Temple	Xujiahui
Underground Railway Station	Line 1 Station; Line 2 Station; Line 8 Station.	Line 2 Station; Line 7 Station.	Line 1 Station; Line 9 Station.
Department Store/ Shopping Mall Connecting with UPS	New World Shopping Center; Raffliers Plaza.	Jiu Guang Department Store	Oriental Department Store; Pacific Department Store; Metro City; Grand Gateway Plaza; Pacific Digital Plaza II; Buynow.
Underground Shopping Mall	Dimei Shopping Mall	Email Fashion Plaza	
Underground Shopping Street/ Retailing Shop	Hong Kong Street (300 m in length); Shanghai 1930 Street; Huasheng Street; Retailing Shops.	Retailing Shops	Retailing Shops
Temple/Park/ Square/Atrium	People' Square; People's Park; Underground Atrium; Underground Concourse (12,000 m^2).	Jing'an Temple; Jing'an Square (Underground Concourse, 3,000 m^2); Jing'an Park.	
Other Building Connecting to UPS	Shanghai Urban Planning Exhibition Center	Shanghai Airport City Terminal; Park Place Shanghai (constructing).	
Underground Walkway		Underground walkways to Jiang'an Temple Public Transportation Interchange (255 m in length); Huashan Road Underground Walkway (about 50 m in length); Jing'an Temple Underpass (21 m in length).	Shanghai Metro Culture and Art Walkway (about 350 m in length)

Table 2. Arrangement of entrances and exits of Shanghai three UPS

Entrance/ Exit Number	Towards		
	People's Square	**Jing'an Temple**	**Xujiahui**
1	Street level	Street level	Street level
2	Street level	Department store	Street level
3	Street level	Street level	Street level
4	N/A	Street level	Digital store & Street level
5	Underground concourse	Underground concourse	Digital store & Street level
6	Underground concourse	N/A	N/A
7	Department store & Underground concourse	N/A	Street level
8	Street level	N/A	Street level
9	Street level	Street level	Shopping mall & Street level
10	Street level	Street level	Digital store & Street level
11	Street level	N/A	Department store & Street level
12	Department store & Street level	N/A	Shopping mall & Street level
13	N/A	N/A	Department store & Street level
14	Street level	N/A	Street level
15	Department store & Street level	N/A	Street level
16	Street level	N/A	Street level
17	Underground concourse	N/A	Street level
18	Street level	N/A	Street level
19	Underground concourse	N/A	N/A
20	Street level	N/A	N/A

Literature review

Shanghai's implementation of UPS has resulted from concerns by the city's planners of pedestrian transport inefficiencies, the need to optimize transport infrastructure, the need to stimulate commercial development, redeveloping the city centre and marketing a better image for the city centre. What is uncertain is the extent to which the government has completed a sufficient assessment of the service quality of UPS and positive and negative influence of UPS development. Effective exploration of the aforementioned issues requires review of previous research and in-depth analysis of Shanghai's UPS usage, together with users' assessments and opinions about the development prospects of UPS.

However, research on the usage and perception of functionality of Shanghai's UPS is limited. Notable research on the usage and users' perception of UPS has been undertaken for grade separation pedestrian systems (including skywalks and UPS) in cities of developed countries especially in North American cities. Research has focused on the aspects of accessibility, the ease of orientation, comfort, convenience, safety, security and social issues of the usage and perceptions of grade separation pedestrian systems (Barker 1986; Belanger 2007; Benz, Lutin 1983; Byers 1998; Maitland 1992; Robertson 1987a, 1987b, 1988). In comparison, the research of the usage of Shanghai's UPS has concentrated on the pattern of usage, commerce structure, orientation, psychology, pedestrian flow, walking speed, pedestrian density, behaviour of transportation, shopping and way-finding (Ding *et al.* 2008; Kong *et al.* 2007; Mi *et al.* 2007; Wang *et al.* 2001; Zhang, Huang 2008). The main shortcoming of past research on Shanghai's UPS is that general pedestrian activity within UPS are not the object of their research, rather, the object of their research was on certain groups such as users of the metro rail systems located by subway stations or of shoppers near underground commercial facilities. In addition, when comparing research on Shanghai's UPS with international research, the latter has greater variety and scope while the Shanghai research tends to focus on basic statistics on the characteristics of users and usage, which has limited value in yielding conclusive findings that reflect the effects of UPS on the transport, commercial and social functions of the city.

The ease, with which people can access a system and orient themselves within a system, was one of the essential keys to a successful second level pedestrian network (Robertson 1987b). The importance of accessibility and the ease of orientation issues were discussed in the previous research of UPS and Skywalk systems from the aspects of opening hours, street level accessibility, the signage system and the requirements of elderly and disabled people (Barker 1986; Belanger 2007; Cui *et al.* 2012; Fruin 1987; Robertson 1988). Safety and security are other major issues in the design and management of a successful pedestrian system in terms of the indicators of documented crime statistics and perceived safety (Forusz 1980; Robertson 1988).

With regard to the comfort and convenience of the system, the issues of continuity of the system, transport integration, amenities and atmosphere (including weather protection, lighting and decoration) were reviewed. Robertson (1988) explored how skywalks coordinated with other redevelopment strategies and his research found that the dilemma with pedestrian malls is whether they complement or compete with other systems. How well the system linked to other movement systems such as parking ramps, buses and light rail transit (LRT) system was an important consideration of pedestrians' convenience (Eady 1990; Robertson 1987a, 1987b, 1993a). Discussion of pedestrian satisfaction of amenities includes the quality of the design and the functionality of the system. Forusz (1980) criticized the failure of Cincinnati Skywalk in only physically integrating with bus systems and pedestrian streets at ground level but not systematically in terms of design styles and the absence of public service such as toilets, mailboxes, telephone booths, newsstands and refuse cans. With regard to protection from weather and noise, UPS are generally unaffected because they are underground.

The social equity aspects of UPS refer to whether or not the users of UPS have equitable access and use of the UPS. The limitations of many grade separation pedestrian systems in being inaccessible to handicapped people were reflected in pedestrian systems users' profiles, particularly during adverse weather (Robertson 1988). It is essential to examine the extent to which all people would use grade separation pedestrian systems in response to adverse various weather conditions, given that such pedestrian systems are most likely to be used during poor weather. Interestingly, Robertson (1988) found that skywalks were welcomed by pedestrians not only during periods of poor weather when the ambient temperature fell below zero degrees Celsius but also during warm (25 degrees Celsius) and sunny days. Thus, skywalks became so intrinsic to people's lives that they used them regardless of the weather conditions. It is the habit to use skywalk and the habit is so strong that it conquered the resistance from weather conditions. On the other hand, Robertson's (1988) research identified that it was generally the social elite that were the dominant users. People perceived that the typical

Skywalk user was a female white-collar worker earning a high income of over 50,000 U. S. dollars (USD) a year (1988 values). Robertson (1988) was therefore critical of the social inequities apparent in grade separation pedestrian systems because they exclude lower socio-economic classes of people.

There has been only little attention given to the usage and perceptions of UPS in cities in developing countries in investigating the aspects of accessibility, the ease of orientation, comfort, convenience, safety, security and social issues. To address these gaps, the objectives of this study aim to answer the following questions, using UPS in People's Square, Jing'an Temple and Xujiahui in Shanghai as cases studies:

1. What are the social-economic characteristics of UPS users? How do people's use of the UPS vary with weather conditions and time periods? Are there social inequities in the use of UPS by the general public?
2. How do users perceive the functionality of the UPS? What are the shortcomings and problems of the functionality of the UPS?

Methodology

The case study is an appropriate methodological approach when a project or program in an evaluation study is not readily distinguishable from its context, and what can be obtained from the case study stands a good chance of advancing knowledge and understanding of a given topic (Yin 2003). Considering that previous literature is lacking on UPS in China with little revealed on the characteristics of its usage and users' perception about the functionality of UPS, the case study appears to be the most appropriate method to investigate the usage of Shanghai's UPS and users' perception about service quality of UPS. Additionally, Robertson (1991) stated that a careful selection of a small sample of case studies would allow a detailed site visit and thus an in-depth treatment of the subject. The UPS in People's Square, Jing'an Temple and Xujiahui, as exemplars of UPS in metropolitan Shanghai, were selected to be the cases used in this study.

The questionnaire survey is a comparatively easy research tool to apply and administer and can yield reliable statistically representative information from a large number of people quite quickly (Gillham 2000). A questionnaire survey was developed according to a review of references regarding UPS usage, which was then used in a survey of UPS users. Before the questionnaire survey was implemented, a pilot survey was undertaken to test the effectiveness of the questionnaire. The questionnaire for pilot survey were distributed a couple of days before the formal questionnaire in People's Square, Jing'an Temple and Xujiahui UPS. The questionnaire was refined and finalised based on feedback from 20 respondents. The questionnaire targeted adults 18 years of age or older and contained open- and close-ended questions to provide generalised representative population data (both quantitative and qualitative in nature) on how respondents utilised the UPS. The questionnaire applied Almond's method (after the British traffic engineer who devised it) as the sampling strategy to achieve a randomised sample, with targeting by polite invitation to participate in the survey of every second pedestrian passing by after the interviewer had completed a questionnaire. This strategy was applied because the pilot survey indicated that only a small proportion of pedestrians (about one respondent in every ten pedestrians) agreed to participate in the survey. This survey sampling strategy was the most efficient at maximising the survey sample size, and guaranteed that the survey sampling reflected the general usage of UPS. The survey was conducted in January and February of 2011 face to face in three locations by the lead researcher, which yielded 208 completed questionnaires: 145 respondents (69.7%) on weekdays and 63 (30.3%) on weekends. The collected data were systematically coded and arranged using Excel and SPSS for analysis.

Before the face to face questionnaires were undertaken, an observation study was conducted of Shanghai's UPS regarding the pedestrian systems' features, design, use, and problems as well as inventories of activities occurring in the UPS spaces. In the final study phase, the lead researcher conducted four face to face, detailed qualitative, open-ended interviews to collect in-depth views, rich in explanatory value, from several interviewees including an academic, a coordinator of a UPS project and two UPS managers. In addition, useful relevant information was provided from secondary published sources as a result of searches of Shanghai's local libraries and with an emphasis on reviewing government documents and local documents/articles about the planning and development of the UPS. Content analysis was conducted of these secondary sources of data and compared with findings from a review of evidence based literature on UPS from around the world. When taken in aggregate, the research process therefore included an amalgam of qualitative and quantitative analytical techniques that provide the most illuminating answers to the research questions posed in this research. Detailed information regarding the survey instruments that used in the questionnaires and interviews are available in the thesis of doctoral degree of the lead author.

Data analysis

Profiles of respondents

Gender

A detailed sample profile of the 208 respondents was shown in table 3. There was an unavoidable gender bias with 55.8% of respondents being female compared to 44.2% of male respondents. This finding possibly reflected the attractiveness to women of shopping streets and malls connected by the UPS.

Ages

When examined according to age, the great majority of respondents (84.1%) were aged between 18 and 34 years. With older age cohorts, the number of users tended to decline quite dramatically. Respondents aged over 65 years only accounted for 0.5% of the total survey cohort. Comparing this phenomenon to the age structure of Shanghai's population (see table 4), it is obvious that seniors tend to be reluctant to use UPS. This could be because of crowding problems in central areas of Shanghai, especially in the places associated with public transport (i.e. subways) usage, which can cause considerable inconvenience and stress to seniors thereby reducing their travel frequency (Deng, Nelson 2012). From observations within the UPS by the researcher and reflection from users, it can be concluded that facilities for the elder and disabled are very scarce within the Shanghai UPS. Massive stairways, equivalent to climbing 3–5 storeys, limited provision of escalators and elevators results in Shanghai's UPS being inconvenient and difficult for the elderly and disabled.

Education level

UPS users tended to have high education levels. UPS users that graduated from junior colleges and those that hold undergraduate degrees are the two largest survey cohorts. The percentage of those that had a junior college level of education or higher was 75.9% of the total survey cohorts. When comparing the figure with the average education level of Shanghai residents (see table 5), the phenomenon of high-education-level-UPS-users is much more obvious.

Table 3. Detailed profiles of UPS users in the Shanghai UPS survey

	Respondents	% of Total
Total	208	100%
Gender		
Male	92	44.2%
Female	116	55.8%
Age		
18–24 years	67	32.2%
25–34 years	108	51.9%
35–44 years	16	7.7%
45–54 years	9	4.3%
55–64 years	7	3.4%
65+ years	1	0.5%
Highest level of education		
Primary School	1	0.5%
Junior School	10	4.8%
Senior School/Secondary Professional School	39	18.8%
Junior College	60	28.8%
Undergraduate Degree	88	42.3%
Postgraduate Degree	10	4.8%
Employment status		
Full time employment	166	79.8%
Part time employment	12	5.8%
Retired	7	3.4%
Students	13	6.2%
Home worker	3	1.4%
Unemployed	7	3.4%
Type of occupation		
Manager/administrator	27	14.9%
Professional	38	21.0%
Clerk	28	15.5%
Commercial and service people	75	41.4%
Other	13	7.2%
Personal income per month		
Up to 1,000 Yuan (up to 147 USD)	1	0.5%
1,000–2,000 Yuan (147-295 USD)	19	10.1%
2,000–3,000 Yuan (295-442 USD)	47	24.9%
3,000–4,000 Yuan (442-590 USD)	50	26.5%
4,000–5,000 Yuan (590-737 USD)	26	13.8%
5,000–6,000 Yuan (737-884USD)	12	6.3%
6,000–7,000 Yuan (884-1,032 USD)	7	3.7%
7,000–8,000 Yuan (1,032-1,179 USD)	8	4.2%
8,000–9,000 Yuan (1,179-1,326 USD)	2	1.0%
9,000–10,000 Yuan (1,326-1,474 USD)	1	0.5%
Over 10,000 Yuan (Over 1,474 USD)	16	8.5%

Note: Exchange rates from Chinese Yuan to USD is 6.7852 in 2010 (Central Intelligence Agency, 2010)

Table 4. Age proportion of Shanghai residents (2009)

	Up to 18	18–34	35–59	Over 60
Percentage	10.4%	24.1%	43.0%	22.5%

Sources: the authors, edited from Shanghai Bureau of Statistics, 2010.

Table 5. Proportion of education level of Shanghai residents (2010)

	Illiterate (Over 15 years old)	Primary School	Junior School	Senior School	Junior College, Undergraduate Degree and Above
Percentage	2.7%	13.5%	36.5%	21.0%	22.0%

Sources: the authors, edited from Shanghai Bureau of Statistics, 2011.

Employment status and occupation

The UPS users were a combination of full time employees, part time employees, retired people, students, home workers and unemployed people. Overwhelmingly, 80% of respondents were full time employees while only 3.4% of respondents were unemployed, which is 0.9 percentage points lower than Shanghai registered unemployed level in 2009 (Shanghai Bureau of Statistics 2010). Students, part time employees, retired people and home workers accounted for 6.2%, 5.8%, 3.4% and 1.4% of respondents, respectively.

The majority of respondents' (41.4%) work related to the commercial and service industry sectors. This was followed by professional job holders accounting for 21.0% of respondents while manager/administrator, clerk and other types of occupation accounted for 14.9%, 15.5% and 7.2% of respondents, respectively.

Personal income per month

With regard to income, the dominant income cohorts were in the 295–442 USD per month (24.9%) and 442–590 USD per month (26.5%) categories. According to Shanghai Bureau of Statistics (2010), the average monthly income of residents was 354 USD per month in 2009. But respondents whose income was over 442 USD per month accounted for 64.5% of the total survey cohort. Additionally, the median income obtained for the survey was 442–590 USD per month while the median income group of Shanghai residents was 304 USD in 2009 (Shanghai Bureau of Statistics 2010). The UPS users that participated in the survey appear to have comparatively high income levels. The phenomenon of high-income-UPS-users possibly reflects a high level of education attainment and a low unemployed level, which would appear to be associated with the youthful age cohort of users in the UPS Shanghai survey.

UPS usage according to weather and time

Usage in different weather conditions

Respondents of Shanghai residents were asked about their preferences of usage from three options ((1) walkways at street level, (2) within the UPS, and (3) either), according to five weather conditions: (1) at night, (2) raining days, (3) in the winter, (4) in the summer, and (5) in the spring and autumn (see figure 3).

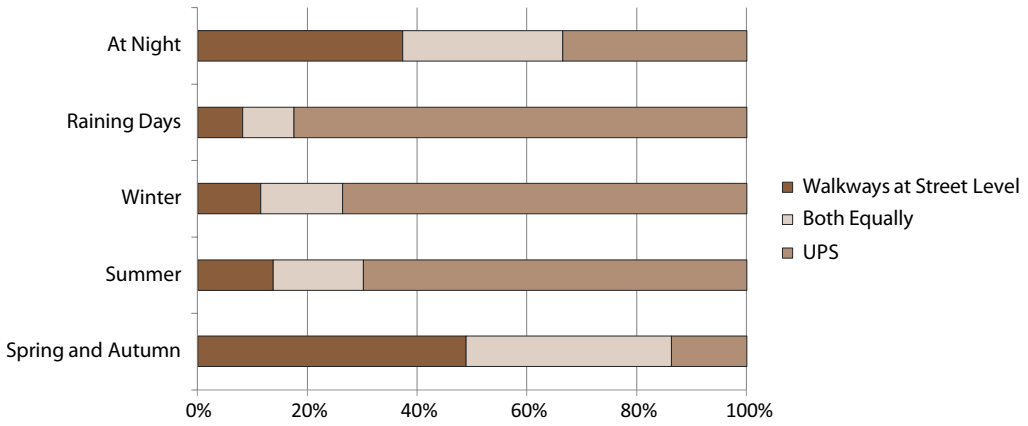

Fig. 3. Preferences in different weather conditions (N = 182)

Perhaps unsurprisingly, the UPS was greatly welcomed on rainy days, in winter and in summer. 70%–82% respondents preferred using the UPS in these three weather conditions. But in spring and autumn, about a half of the respondents expressed a liking for using outdoor walkways at street level while only 14% preferred using the UPS. The result indicates the effects of weather conditions on people's preferences for walking environments and the inherent advantages of indoor walking environment during inclement weather. There is an even split about the merits of UPS usage at night when compared with using walkways at street level.

Usage in lunch time

Literature determined that UPS were welcomed by people during the lunch time period. Since office buildings are usually connected with the UPS, employees could eat, entertain and conduct business without going outside of UPS (Byers 1998). As shown in figures 4 and 5, nearly half of respondents of Shanghai residents never use the UPS during lunch time while users that often use the UPS occupy just 10% of the total. Approximately half of respondents used the UPS during lunch-time mainly for the purpose of eating. The options of other choices, multiple choices, working related and shopping applied to 18% to 10% of respondents.

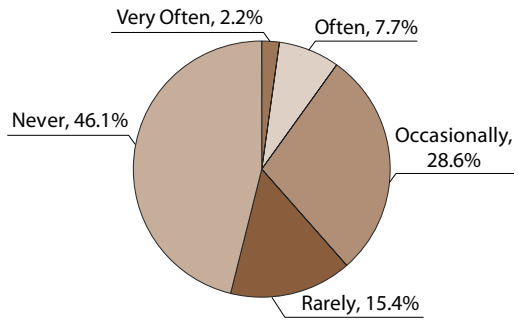

Fig. 4. UPS usage frequencies during the lunch-time period (11.30am–1.30pm) (N = 182)

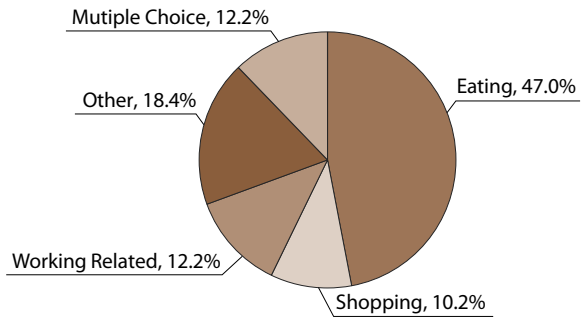

Fig. 5. Purposes of UPS usage during the lunch-time period (11.30am–1.30pm) (N = 182)

Perception on the service quality of UPS

Orientation

Regarding 'way-finding' or orientation within the UPS, 78.4% respondents believe it is easy to orient themselves while only 10.1% found it difficult and 11.5% expressed a neutral attitude. The satisfaction level towards the ease of orientation in the UPS was high.

Safety

With regard to safety, similar results were obtained for both in daytime and night-time. The overwhelming majority considered the UPS to be safe (i.e. from the threat posed by physical assault). The sense of safety was found to be better in day-time (94.2%) than at night (83.2%).

Favourite advantage(s)

The favourite advantage(s) of UPS (identified in figure 6), indicated that approximately 28.9% of respondents opted for multiple choices, whilst 28.9% focused on convenient transport. Respondents selected safety from poor weather conditions (22.6%) and isolation from automobiles (12.0%), suggesting that collectively 34.6% of respondents were in the UPS to seek relief and refuge from a hostile outdoor urban environment.

A few of the respondents believed that department stores, shops and express food service are their favourite features of the UPS. By contrast, in the Montreal UPS, users had nominated shops, indoor environment and commercial categories as their favourite UPS features (Boisvert 2004), which is dissimilar with that of users of the Shanghai UPS. Although 39.4% of users in the Shanghai UPS were shoppers, the shops and merchandise in the UPS appears to be relatively unattractive when compared to the feature of access to convenient transport.

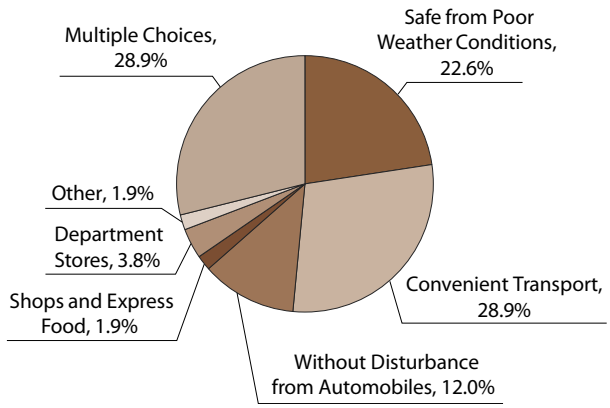

Fig. 6. Most favourite advantage(s) of the UPS (N = 208)

Improvements needed

Eleven options were presented in the questionnaire to UPS users of Shanghai residents regarding possible improvements. The respondents were asked about their views regarding whether or not they agreed that it was necessary to improve the UPS by being given the following options: (1) inconsistent opening hours; (2) entrances/exits scale; (3) design and landscape; (4) merchandise categories; (5) cleanliness; (6) the scale of walking corridors; (7) safety and security; (8) multiple service functions; (9) public transport; (10) signage system; and (11) facilities for senior and disabled people.

The majority of respondents believed that two options – facilities for the elderly and/or disabled and orientation or 'way-finding' facilities – need to be advanced. Five options – more entrances/exits, more walking corridors connecting to the system, increased commercial categories, uniform opening hours in the system and better architectural design and 'landscape' – were viewed as unnecessary measures requiring improvement by more than half of the respondents. There is no obvious trend towards the necessity of improvement of the remaining four options: more service functions; better security; more convenient public transport system; and cleanliness.

Discussion

Social usage and equity

The usage of UPS in western countries has raised considerable issues regarding equal usage by the general public, public space usage and equity of usage in different time periods. One of the major criticisms regarding grade separation pedestrian systems was that it furthered the segregation of class and race of people in the city centre as the walkway systems were reserved for white-collar workers and to accommodate expensive retail establishments while poor minorities were shifted to the street level where retail has tended to languish (Terranova 2009). UPS were perceived to be used by wealthy people due to the locations of many of their entrances within office buildings, hotels, luxury stores and department stores. The pedestrian connection patterns of UPS were perceived as delivering explicit psychological signals to people on low and moderate incomes who were unwilling or unable to afford goods and services in shops within the UPS. Accordingly, separation of people by social class occurred (Robertson 1987b). This tendency of separation of people according to their economic class was observed in Skywalk systems in Calgary and U.S. cities (Robertson 1987b).

The Shanghai UPS users' survey (see table 3) confirmed the phenomenon of people with high-incomes being the dominant cohort using the UPS. However, this finding may also relate to other issues such as inadequate facilities for elderly and disabled people within the Shanghai UPS, resulting in the younger cohort of the population being dominant within the UPS. The high investment in education in China in recent years has resulted in a younger cohort of the population having a much higher education attainment than the general population. This dominant young cohort is largely responsible for UPS users' characteristics being skewed towards higher income persons.

Grade separation pedestrian systems have been criticized for not encouraging public life. Gehl (1987) outlined three levels of human activity in public spaces, which is helpful in the evaluation of the public space qualities of skywalks and UPS: (1) necessary or compulsory activities, such as walking to work, shopping, or waiting for a bus; (2) optional activities (i.e., strolling, sitting, sunbathing) chosen only if the conditions and the place are inviting; and (3) social activities, such as talking, people watching, and community events, which depend on the presence of other people. According to Gehl (1987), the best designed public spaces are those that successfully encourage the most optional and social activities. In the cases of Cincinnati, Des Moines, Duluth, Minneapolis and St. Paul, Skywalks were designed primarily to accommodate pedestrian flow and convenience shopping and provide few opportunities for sitting and people watching (Robertson 1993a). The replacement of public amenities in such settings with fast food courts and lottery kiosks has resulted predominantly from commercial and security concerns (Maitland 1992). This approach to the design of Skywalks had displaced the democratic potential of public spaces at street level, thereby reducing the possibility for accidental interaction between people (Daniels 2005).

The observation component of this survey research indicated that the main activities in the public spaces of UPS such as Jing'an underground plaza were short duration activities with a transit oriented focus. Mid- to long-duration activities such as leisure were very rare. Besides inadequate availability of amenities in the plaza such as benches, water fountains, telephone booths, signs, information kiosks, public toilets, litter baskets (Grava 2002), the phenomenon of short-term activities, in the case of Jing'an underground plaza may be due to the design of the plaza being poorly integrated with its surrounding environment. Lynch (1960) indicated that a successful node not only has to be special in some aspects, but it should epitomise its surroundings. The de-

sign of Jing'an Plaza lacks an effective entry/exit point to introduce pedestrians entering from street level or nearby buildings into the underground concourse. The boundary of the Plaza is too straightforward to be harmonized with its surroundings. The underground concourse is also difficult for pedestrians to detect from the immediate environment at street level.

Low utilisation of grade separation pedestrian systems for activities other than transiting on foot have also been a significant limitation, ultimately challenging the necessity of such systems. Terranova (2009) criticized the absence of urban vitality of an UPS in Dallas (U.S.) established in the 1960s, because activities were restricted to the lunch period (between 11.30 a.m. and 1.30 p.m.). Although Dallas' UPS appeared to be clean, diverse, unique and beautiful with respect to its internal design and aesthetics, one could question its existence given the lack of use. A similar situation had occurred in Cincinnati where the installation of a Skywalk system was found to be inadequate in contributing to functionality for pedestrians, utilisation by pedestrians for purposes other than transit and the quality of public spaces. Unlike in Minneapolis, where the severe winter climate had resulted in high levels of pedestrian activity and pedestrian satisfaction levels, in Cincinnati, the Skywalk became a threatening and hostile place for pedestrians when the department stores and other retail stores closed (Gosling 1992).

In the case of Shanghai's UPS, pedestrian activity levels did not appear to peak at noon. This could be because Shanghai's UPS does not have many connections with office buildings. The Shanghai UPS development is largely based on subway stations and the design layout of connections were determined by economic considerations and the principle of ensuring quick evacuation of pedestrians to street level and to commercial facilities. However, with the development of a new connection between Jing'an Temple UPS with Park Place Shanghai (a new office building under construction) there is now greatly improved integration of more functions, thereby facilitating increased usage by employees. Additionally, the basement or lower level of department stores generally functions as food courts, although overall, food services were not the dominant activity within Shanghai's UPS. Approximately half of respondents used the UPS during lunch-time for the purpose of eating because the UPS connected to food establishments or services in the basement level of some of the department stores.

In addition, the usage of UPS appears to be influenced by the prevailing ambient weather conditions. The usage of Shanghai's UPS was moderate overall, but with increased usage occurring during poor weather conditions such as during days of extreme heat or cold or when raining. The extended operation times of the subway (normally from 5.00 a.m. to mid-night) and department stores that connected to UPS (normally from 10.00 a.m. to 10.00 p.m.) increased the usage of UPS between 5 a.m. and 10 p.m.

Functionality of Shanghai's UPS

Although the overall satisfaction levels towards the ease of orientation in the Shanghai UPS was high, orientation or 'way-finding' facilities were nominated by the users as needing further improvement. Through observation by the researchers, it was noted that there are various orientation facilities such as an information board, electronic signage and an electronic map. But the problem is that the numerous entrances and connections in all directions make it hard to distinguish specific locations or routes then relate these to the surrounding street level environs. Added to that, unlike the urban environment at street level, within the UPS it is difficult to provide outstanding visual cues such as with an iconic urban design element (i.e. a unique, highly visible building, sculpture, public open space or townscape setting). Moreover, huge pedestrian flows can easily result in visual confusion, particularly if a person is physically short in stature and unable to see past the crowd around them. Perhaps then, it is not surprising that on further considered reflection, respondents conceded that they would like to see orientation facilities further improved especially if there is physical expansion of the UPS.

Some of the respondents had nominated department stores, specialty shops and express food service stores as their favourite features of the UPS. However, overall, respondents appeared to favour access to convenient transport over shopping and merchandise as preferred features within the UPS. The research highlighted commercial facilities within the UPS as having an inherent advantage of transport convenience when compared with other non-UPS commercial areas. Notwithstanding this finding, this advantage is offset by the lack of competitiveness of merchandise offerings within the UPS. This may be because many of the retailers within the UPS tend to be very small independent businesses, whereas flagship department stores or stores with iconic brands, whilst often located in centres linked to the UPS, were not actually within the UPS.

However, the assessment of the functionality of the UPS suggested that shoppers tended to have no further requirement of additional commercial categories, particularly if they are just passing through and shopping is not the focus of their use of the UPS. This does not

mean that the quality of merchandise available in the UPS has reached a high level of quality and product range, because shoppers were aware of the merchandise positioning of UPS to capture incidental impulse of buying. In addition, there are sufficient shoppers using the UPS to confirm a reasonable degree of success for the commercial facilities currently within UPS, even if these businesses are small in scale with low to moderate value consumer products and services on offer. Nevertheless, the extent to which the UPS commercial activities rely on department stores connected to the UPS as magnets for attracting passing trade remains unknown.

The satisfaction level towards safety in the UPS in Shanghai was high. UPS were perceived to be safer in daytime than at night, which was similar with research findings for grade separation pedestrian systems in other cities. In Cincinnati, police crime statistics demonstrated that the Skywalk experienced less vandalism or crimes of violence than had occurred in the commercial streets below it. Hence, perceptions of crime were greater than the actual level of crime occurring. Users perceived night-time to be dangerous because of a lack of activities at night and because the groups of youths that loitered and intimidated users of the system were perceived to be dangerous (Forusz 1980). Real and perceived fears of crime included shoplifting, purse snatching, package theft, and harassment of women and senior citizens by groups of teenagers. The sense of feeling unsafe was particularly acute during off-peak hours and on less frequented outer linkages due to the sense of enclosure, resulting in there being less chance to be heard in raising an alarm or in seeking out a possible escape route are limited (Robertson 1988).

In the case of Shanghai, the possible reasons for high satisfaction in relation to personal safety in the UPS and comparatively lower satisfaction at night than during the day time are that firstly, the UPS has plenty of users and hence there is a safety in numbers. Secondly, respondents may perceive night-time to have a lower level of safety because with the greatly reduced pedestrian activity levels, some homeless people use the UPS as a place to sleep. In winter, the temperature outdoors can drop to zero degrees of Celsius. The UPS indoor environment has a comparatively comfortable temperature. Hence, when there is adverse weather, the problem of homeless people occupying the UPS can be quite noticeable. Research of pedestrian systems in cities of western countries had suggested that the perception of safety by users could be achieved through increased usage, closed circuit television for surveillance, improved architectural design to allow for informal surveillance by other pedestrians and police, brighter lighting levels, improved signage, unobstructed sight lines, optimal location of police facilities, emergency phones and the avoidance of building and landscape configurations that allow concealment of potential criminals (Forusz 1980).

Conclusion

Increased investment and interest in UPS has occurred in response to rapid urbanization in Shanghai. The social problems that have emerged from rapid urbanization have provided opportunities for extending UPS and utilizing them better. As a pioneer of UPS development of China, Shanghai has provided an exemplar of what UPS can contribute to the transport, economic and social life of a city's urban environment. Crucially, this research has also uncovered issues that have restricted expansion of Shanghai's UPS. They include:

- The phenomenon of high-income users of Shanghai's UPS. This was evident from the majority of UPS users belonging to a young age cohort possibly reflecting a lack of facilities for elderly and disabled people. The design of Shanghai's UPS lacked adequate consideration of the access needs of elderly and disabled people seeking fuller engagement in urban life. This problem could be solved by providing lifts to assist mobility challenged persons to move between levels with minimal assistance.
- The failure of Shanghai's UPS to function as effective public spaces that is facilitative of spontaneous social activities. This has arisen as a result of a focus on commercial interests and security concerns in UPS design and management at the expense of the public realm.
- Underutilised use of Shanghai's UPS. Although the poor provisioning of food retailing services in Shanghai UPS (in terms of service being restricted to the lunchtime peak period and the limited availability of food service establishments) contributed to underutilisation by UPS, the extended operation time of subway and UPS linked department stores offset this problem to some extent.
- The problem of orientation or 'way-finding' cannot be solved through exclusive reliance on facilities such as signs and information boards. The extension of Shanghai's UPS without addressing this issue would create problematical underground environments that fail to attract activities and become little more than sterile passageways. Innovative architectural solutions that offer UPS users the thrill of surprise and memorable public spaces and activities that people want to visit, together with strong integration with street level and above street level

uses may offer solutions, but more research is required to determine the best solutions for particular local circumstances.

– Limited and unappealing merchandise categories. Optimizing merchandise categories is necessary because the competitiveness of UPS commerce substantially relies on its inherent advantage that being transport convenience. Failure to address this issue in future may constrain opportunities for future development and expansion of Shanghai's UPS. Additionally, determining retail and commercial strategies that achieve complementary activities instead of destructive competition with commerce at street level is also a significant aspect to be considered. Not only is the survival of underground commerce at stake, but this issue potentially affects the vitality of future urban commerce in Shanghai's city centres, and hence requires a comprehensive response. Addressing these concerns would ensure urban vitality and benefit the long-term development of Shanghai's UPS.
– Poor management of homeless people. This reflects a wider social problem, which may be beyond the remit of UPS managers to resolve its root causes. A coordinated city-wide response would be needed that provides homeless shelters together with a compassionate UPS management response of redirecting homeless people to appropriate social services.

Shanghai's UPS is the hallmark of a 21st century megapolis grappling with rapid technological and social change. Furthermore, Shanghai's UPS adds new positive dimensions to urban life as well as adding to the efficiency of its subway system and it provides better physical integration of access to the city's buildings. However, UPS also permits automobile traffic to be tolerated and to co-exist with pedestrians in city centre locations, which is not ideal from the perspective of pedestrian amenity, safety, air quality, noise and the quality of the public domain at street level. Through a review of international experience on grade separation pedestrian systems and in providing useful insights into understanding challenging issues afflicting Shanghai's UPS, the findings of this research have suggested how Shanghai's UPS can be improved. Addressing these issues would result in richer, more varied public realm with greater functionality. Without good pedestrian systems such as Shanghai's UPS, there is a risk of abandoning the public realm of the central areas of Chinese cities to traffic, particularly as the many of the residents of Chinese cities race to embrace automobility.

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