The Relationship Between Walkability and Environment Characteristics in Cold Region Cities: Case Study in Harbin

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Abstract. This study attempts to comprehensively and objectively understand whether the physical characteristic of urban space affect the walkability of Harbin city center. Besides, due to Harbin is located in the cold region, the temperature change a lot between winter and summer, this study also tried to find out whether the physical environment characteristics effect on walkability is different in winter and summer. Spatial feature and traffic management have been thought as the main determinate of walkability of urban space, however physical features and urban design details have been rarely mentioned. Yet, does physical quality deterioration of space decrease the walkability of urban center, does specific physical feature influence walkability differently in different season? To answer these question, users' perception toward the physical features of mix-used streets, have been examined in this study. 14 physical characteristic problems have been identified in the studied area based on the understanding of pervious researches. Through observations and questionnaire surveys, the physical characteristics of each case study were evaluated and the physical problems were discovered. Additionally, users' perception on the identified problems and their effects on walkability of the studied areas were found and defined, in both winter and summer.

1. Introduction
After new urbanism, TOD, and compact city theories were introduced to China, the domestic scholars start to focus their study on walking as a traffic mode and the quality of pedestrian space. At the same time, the high speed of cities sprawl and urban regeneration also make public space and activities in public space gain more attention than ever. More pedestrian friendly facilities were built in many Chinese cities, such as pedestrian bridges, pedestrian street and the pedestrian plaza, this reflects the governor’s willing to improve walkability in urban center, however, the actual effect is far less than expected, unfriendly walking experience are still plagued pedestrians, walkability of urban space was still need to be promoted.

In previous studies, it was found that not only the public space, but also the social activity and social behaviour in public space can also affect the vitality of the public space. Moreover, the study indicates that the social problems in most public spaces are the source of the behaviour patterns of people in the form of public space. With the pass of time, the quality of public space will impact the social activities more and more. Improving the public space environment may not be able to solve the
social problems, but at least could create a better social environment, and to prevent some social problems in the future.

There are such problems in the urban center of Harbin, not only in the traditional urban center, but also in new developed urban area: the walkability decreased, people choose walk and public transit as travel mode less and less. The main purpose of this research is to study the physical environment characteristics of Harbin, and tries to describe the impact of these characteristics on the walkability of urban center space. In order to answer these questions, the main research contents are as following:

- What kind of physical characteristics of urban space could affect walkability?
- What are the main characteristics of Harbin's urban center? What problems exist in physical environment in urban center space?
- What physical problems deteriorate walkability in Harbin urban center, does these physical problems affect on walkability differently in winter and summer?
- What kind of optimization strategy can effectively solve the physical problems, and enhance the walkability in urban center of Harbin?

‘Walkability’ is referred to and generally defined as “...the extent to which walking is readily available as a safe, connected, accessible and pleasant mode of transport”. Livi and Clifton [1] (2004) also mention other friendliness terms including; functional, safety, aesthetic and destination as well as security, comfort and convenience, continuity, system coherence, and attractiveness. It is from the last decade of the 20-century when different evaluations took place based on walkable street agenda. These studies showed that street’s walkability were influenced by spatial and traffic characteristics. In addition to spatial and traffic features, some studies examined the effects of other physical characteristics on walkability of urban center. For instance, Eyler [2] (2003) exam the landscape details such as shelter on transit station and lighting, which had provided safety and climate protection for pedestrian. Furthermore, Sallis [3] (1998) illustrated the visual damage and negative influence of commercial signage in traditional urban area. King [4] (2000) argued about the influences of seats, sculpture and planting on the walkability of an area and indicated that physical actives increase with increasing of streetscape elements. Also, Handy and Clifton [5] (2001) showed how friendly environmental design could enhance the walkability in six neighborhoods in Austin, TX. Overall, having sustainable ecology or a good quality environment is considered a major factor of walkability in cities.

Reviewed studies are based on valuations of urban space walkability from different perspectives. Yet, it is important to note that each research has only examined some of the affective factors of streets’ walkability. This study attempts to identify the physical characteristics that affect the walkability of urban space, and try to examine how these physical characteristics influence walkability in new developed and traditional urban area. Accordingly, the scope of this research is limited to physical attributes, while the concept of walkability encompasses different social and functional aspects of urban space.

2. Research Method

2.1. The Studied Streets
This study selected two commercial areas located in the center of the city, both of the streets were high-accessibility. Choosing these two areas is based on the following reasons:

- Their physical characteristic could represent Harbin’s urban center space
- This is a huge people flow, the number of visitor, no matter local people or tourists.
- They all have mixture functions of commercial office and residential

Shangzhi Street chosen in the study is from Youyi Road to Tiandi Road, with a total length of about 1.3 km, is representative of the traditional commercial area in Harbin. Shangzhi Street area near the Central Avenue – a famous commercial pedestrian street and the historic district in Harbin, this area is not only the office and residential for local people, but also popular in visitors. The buildings
and space of this area have been regenerated several times, but there are still some problems. The area of Zhongxing Road is from Youjia Street to Harbin Avenue, the total length of about 1.4 km. This area is the center of the New District of western Harbin, represent the new developed area emerging commercial and residential. The locations of two areas are showed in Fig1.

![Figure 1. Location of case studies in Harbin urban center](image)

2.2. Research Process
This study combined a variety of research methods. In order to answer the main questions, both qualitative and quantitative approach were taken. The physical characteristics of the study areas were considered as variables. In this study, the first step was to identify physical problems of the study areas through observation. In order to describe the physical characteristics of the study areas accurately, the study areas have been observed in different times, including the daytime, evening, weekend, and special day of the year, including the hottest and coldest time in Harbin.

As the ultimate physical characteristics assessment was from the user's point of view, therefore, the study also used questionnaire, the questionnaire was designed for both cases. The purpose of the questionnaire was to explain user’s viewpoint about existing physical problems of the urban center space, and how these problems affect walkability. The basic statistical information of the questionnaire survey included four categories: gender, age, race, and the purpose to the study of areas. The target respondents of the questionnaire are the people who know the study areas very well. In this study, the sample size is 150 people.

Through data analysis of the questionnaires, this study is focus on whether respondents agree with the identified problems in urban space in the study areas. Therefore, the respondents’ opinions were set as three categories: "agree, neither agree or disagree, disagree". The identification of the physical characteristics of urban space impacts on the walkability on the urban space were analysed by applying descriptive statistics and Spearman correlation coefficient among the research variables - urban space walkability and liability as dependent variables and identified physical problems as the independent variables. These mentioned quantitative data analysis were applied for the interpretation of total result, besides illustrating the identified physical problems’ effects on the deterioration of the streets’ walkability.

3. Results
After two phase of examining, the findings are presented as follows:

3.1. Visual Examination
The results show that most of the physical environment characteristics were not of satisfied condition. Although there were some of features, such as building density, mixed degree of functions, straight-line distance to the bus station and the accessibility of public transport, and streetlights status within the two regions showed the better situation. The following problems were found in both areas and
presented as the result of the first phase of data collection: inadequate parking space, narrow sidewalk, inadequate of bike lanes, inadequate facilities for disabled people, inadequate public services and maintenance, inadequate seats and street furniture, inadequate shelter on transit station, inadequate shelter on sidewalk, inadequate lighting, irregular signs, inadequate planting and inadequate street decoration. In addition to the more common problems, some other problems, such as severe traffic congestion in Shangzhi street area were observed; low road network density and long block, space ratio (width to height) was too big were observed in Zhongxing Road area.

3.2. Questionnaire Survey

3.2.1. Basic Statistical Survey. Table 1 summarized people’s attitude of the studied areas walkability. Table 2 shows users’ agreement with the existence of these problems in both studied areas.

In fact, the results from the user’s perspective reflect the significance of these problems. The results reveal the main difference in walkability of the two studied areas and of winter and summer. In the results of winter survey, there was less than half of the respondents believed that the area is walkable and livable, about 1/3 of the people did not agree with this viewpoint. Different from Shangzhi street, the study result of Zhongxing Road showed more than half of the users think that Zhongxing road does not have the required walkability, only 26% of users agreed this area is walkable and livable. In the results of summer survey, 50.7% of the respondents in Shangzhi street agreed that the area meet the requirement of walkability about 1/4 of the respondents disagree. In contrast, in Zhongxing road, only 32% of users believed that the area is a good place with for walkability, 42% of users think the walkability do not meet the requirement.

3.2.2. Correlation Analysis. Table 3 shows the findings of Spearman correlation analysis for both studied area in winter and summer. The results indicate that there is a negative correlation between walkability and of the studied areas and their physical problems, These results are shown in Table 3 which implies that the walkability of the studied areas are deteriorated by the increase of these physical problems.

### Table 1. Users’ attitude of the walkability of the studied areas

|                | Agree | Neither | disagree | Mean | Std. Deviation |
|----------------|-------|---------|----------|------|----------------|
|                | Frequency | Percent (%) | Frequency | Percent (%) | Frequency | Percent (%) |       |
| Shangzhi street | 62     | 41.3  | 45       | 30.0 | 43             | 28.7       | 1.80  | 0.830 |
| Zhongxin road   | 39     | 26.0  | 31       | 20.7 | 80             | 53.3       | 2.27  | 0.851 |

### Table 2. Users’ attitude of the identified physical problems in the studied areas

| The identified physical problems | Shangzhi street | Zhongxin road |
|--------------------------------|-----------------|---------------|
| Inadequate parking space       | Mean 2.12       | Mean 2.31     |
|                                | Std. deviation 0.825 | Std. deviation 0.811 |
| Heavy traffic congestion       | Mean 2.25       | Mean 2.14     |
|                                | Std. deviation 0.817 | Std. deviation 0.784 |
| Narrow sidewalk                | Mean 2.02       | Mean 2.14     |
|                                | Std. deviation 0.805 | Std. deviation 0.784 |
| Inadequate of bike lanes       | Mean 1.82       | Mean 2.37     |
|                                | Std. deviation 0.844 | Std. deviation 0.857 |
Table 3. Correlation coefficient analysis: physical problems and walkability of the studied areas

| Identified physical problems                                      | Winter - Shangzhi Street | Winter - Zhongxing road | Summer - Shangzhi Street | Summer - Zhongxing road |
|------------------------------------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Inadequate parking space                                        | -0.688** (P<0.001)      | -0.629** (P<0.001)      | -0.465** (P<0.001)      |                          |
| Heavy traffic congestion                                        | -0.583** (P<0.001)      | -0.642** (P<0.001)      | -0.539** (P<0.001)      |                          |
| Narrow sidewalk                                                 | -0.498** (P<0.001)      | -0.529** (P<0.001)      | -0.476** (P<0.001)      |                          |
| Inadequate of bike lanes                                        | -0.212 (P=0.12)         | -0.304* (P=0.021)       | -0.189 (P=0.276)        | -0.377* (P=0.017)       |
| Inappropriate space proportion                                 | -0.326* (P=0.031)       | -0.397* (P=0.023)       | -0.210* (P=0.041)       | -0.169* (P=0.039)       |
| Long block                                                      | -0.217 (P=0.088)        | -0.139 (P=0.091)        | -0.163 (P=0.105)        | -0.081 (P=0.323)        |
| Inadequate public services and maintenance                      | -0.304 (P=0.074)        | -0.625** (P<0.008)      | -0.246 (P=0.083)        | -0.467** (P<0.001)      |
| Inadequate shelter on transit station                           | -0.598** (P<0.001)      | -0.672** (P<0.001)      | -0.604** (P<0.002)      | -0.281* (P=0.081)       |
| Inadequate shelter on sidewalk                                  | -0.561** (P<0.001)      | -0.616** (P<0.001)      | -0.474** (P<0.001)      | -0.539** (P<0.001)      |
| Inadequate lighting                                             | -0.527** (P<0.001)      | -0.623** (P<0.001)      | -0.623** (P<0.001)      | -0.389* (P=0.033)       |
| Irregular signs                                                  | -0.215 (P=0.164)        | -0.307 (P=0.053)        | -0.089 (P=0.372)        | -0.382* (P=0.026)       |
| Inadequate planting                                             | -0.521* (P=0.011)       | -0.573* (P=0.018)       | -0.472* (P=0.024)       | -0.380** (P=0.000)      |
| Inadequate streetscape elements                                 | -0.588** (P<0.001)      | -0.435** (P<0.001)      | -0.509** (P<0.001)      | -0.377** (P<0.001)      |

*P<0.05, **P<0.01

4. Discussion
In order to further understand the impact of the physical problems of Harbin on the walkability of the urban center space, the researchers make a comparison of the results of two case studies. In the summer survey results, among all the identified problems, 12 of them had negative correlation. In the summer survey results, there are 11 identified problems show negative correlation in the two studied areas in total. Compared to the results of the summer survey, 9 problems show the same result, however, 3 problems do not show negative correlation. When the researchers classified all the identified problems into different categories, they also find difference on impact of walkability of each category. Table 3 shows that people perceive all the physical problems about traffic conditions and the proportion of space could strongly affect the walkability in both studied areas in both winter and summer. Among summer survey results, the correlation coefficient of narrow sidewalks, heavy traffic congestion and inadequate parking space are ranked in the 1st, 2nd, and 4th in Shangzhi Street. In addition, inadequate of bike lanes also shows significant result. Meanwhile, in Zhongxing road survey, narrow sidewalks and inadequate parking space also show strongly correlation. The effect of inappropriate space proportion and long block on walkability could be attribute to user’s visual and psychological feelings, lacking visual focus and losing interest and willing to walk when stay in such area. People perceive inadequate bike lanes in summer indicate user’s willing to travel by bike, so cycling might be a supplement to current travel mode in summer.

In the facilities and streetscape problems categories, among summer survey results, people perceive that the inadequate public services and maintenance, inadequate streetscape elements, inadequate street furniture and inadequate planting are important factors which affect the deterioration of walkability in both studied area. In Shangzhi street, except inadequate street furniture, all the other problems are not as significant as traffic condition and space proportion problems, in Zhongxing road all these problems have similar correlation significant, what is more, irregular signs shows significant here, which may indicate this problem should gain more attention here than in Shangzhi street where the result of is different. In winter survey results, respondents thought that the walkability of the studied areas are deteriorated by inadequate public services and maintenance, inadequate planting and inadequate streetscape elements, and the impacts are similar to the results in summer survey. Inadequate facilities for disabled people show the same result as summer survey; however, inadequate street furniture and irregular signs show different results. This may indicated in winter time, people’s willing to stay on street is not as strong as in summer, so the street furniture, such as seats, are not so important; but user’s need of visual abundant are as same as summer, so they need more artificial
streetscape elements, that could explain why irregular signs is accepted by users in winter and inadequate planting and inadequate is not as influential as summer.

Among all the identified problems, problems related to security and climate protection - inadequate shelter on transit station, inadequate shelter on sidewalk and inadequate lighting - show the strongest different results in summer and winter survey, and old & new developed areas. This may be because in summer the new developed area can not provide enough tree shade as the trees are all new and young ones, so people feel inadequate shelter when they walk on sidewalks, and as the space proportion is more empty, so the sightline density is lower on street, even the luminance on sidewalks is the same as Shangzhi street, people still more lighting at night to meet the need of safety.

In general, in the results of the comparative study of the winter and summer of two areas, the researchers find three major and common problems of the studied areas – inadequate parking space, narrow sidewalks, inadequate public services and maintenance, inadequate planting and Inadequate streetscape elements- which reveals poor urban environment characteristics are the main reason of the deterioration of the walkability in Harbin urban center area. The findings of this research reinforce the results of former studies, especially the research about walkability city [7], [8] (Appleyard, 1981; Appleyard &Lintell, 1972), which revealed traffic effects on the deterioration of streets’ walkability. In addition, these results also confirmed the conclusions of other early studies such as Sauter and Huettenmoser 2008[9], on the Swedish streets, as well as the results of the study of Canadian contemporary cities and research in California. Besides the impact of traffic condition, there are other research results shows the similar impact of physical characteristics on urban space’s walkability. Although most of the results of this study confirm the results of previous studies, they do not corroborate all of them. For example, result of 2007 Portella’s study [10] on urban visual pollution, irregular signs in traditional urban area shows significant, but in the studies in Shangzhi street, also traditional urban area, no significant correlation is discovered between streets’ walkability and irregular signs in both winter and summer. The occurred contrast might be in relation to with people’s unawareness of the issue’s negative impacts. Despite the above-mentioned previous researches have different approaches, but the comparison to them and discussion still revealed common results that verify the findings of this study.

5. Conclusions
The main purpose of this research was to examine whether the physical problems could influence walkability of urban center area, with a special focus on new and old urban center, in winter and summer. Since the physical environment of the two studied area could represent the physical characteristics of most part of Harbin, the recommended strategies could be applied to enhance the walkability of all Harbin urban center area.

5.1. Improve traffic condition and space proportion.
First of all, clear all the unnecessary facilities and parking vehicles on sidewalk, set street vendors at place where the sidewalks are wider than needed, give the sidewalks back to pedestrian. Secondly, provide more parking spaces, set the road parking, underground parking spaces to solve the car-parking problem. Thirdly, control of traffic congestion in traditional urban center such as only allows public transportation but not private cars. Furthermore, establish bicycle system, including bike lanes, bike parking place and maintenance facilities, reinforce the connective of bike travel and transit travel, especially in summer. Last but not least, redesign or regenerate urban space with space proportion problems, such as use plant or other streetscape elements to change space proportion, and add thoroughly pedestrian road in long block if possible.

5.2. Improve street facilities and streetscape elements
Street facilities and streetscape elements problems show little difference in the two studied areas in winter and summer, therefore, the improvement should consider priority to improving the common problems, and then adjust according to the differences. Firstly the governor should strengthen the
maintenance and cleaning of the public facilities. Secondly, pay attention to the construction maintenance of facilities for the disabled, in Harbin’s example, not only pay attention to set blind tracks, but also crosswalk ramps, building entrance ramp and other facilities for wheels. Thirdly, increase street furniture such as seats, from not only function but also visual abundant, and improve the aesthetic aspects of the urban space, leading to more activities on streets, especially in winter.

5.3. Improve climate protection and safety elements
The results of the research reveal climate protection and safety elements’ affect on walkability is very different in winter and summer, and also different in new developed and traditional urban area. So the improvement scheme should be determined by different space types in different seasons. In traditional urban area, set temporary facilities might be a better way to optimize walkability. Meanwhile in the new developed area, the problem of climate protection and safety could deteriorate walkability in both winter and summer, therefore more permanent facilities should be a more reasonable way to optimize space’s walkability.

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