

EVALUATION OF THE EXISTING SIDEWALKS IN DUHOK CITY

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(Received: October 18, 2018; Accepted for Publication: February 28, 2019)

ABSTRACT

This study investigates the current conditions of the sidewalks in the city of Duhok, northern Kurdistan Region of Iraq, as well as their compatibility with international standard sidewalk regulations. The pedestrian paths in this city are not seen as a preferred transportation mode and therefore, the people find difficulties in walking to the destination and are sometimes obliged to walk in the roads or rather depend on automobiles for traveling to longer destinations. This could be partly attributed to lack, inefficiency or non-attractiveness of the sidewalks in most parts of the city particularly residential areas. Most the sidewalks are generally not conducive to walking in terms of poor design, used improper surface materials, poor surface levelness, increased grading, discontinuity, and the existence of obstacles, such as protruding materials. As a result, the local people do not generally use walking as the preferred mode of travel to destinations; they rather prefer the use of automobiles. On the basis of these facts, this study seeks to present an overview of the structural conditions of the existing sidewalks and to find existing shortcomings compared to the International standards. It also proposes feasible recommendations to provide better sidewalks in order to improve the pedestrian environment and mobility in the city. The study findings indicate that Duhok city needs improved sidewalks, pedestrian facilities to reduce dependence on automobiles and contribute to building a healthy and aesthetic environment.

STUDY AREA AND AN OVERVIEW OF SIDEWALK CONDITIONS

Duhok is a major city in Kurdistan Region in terms of its strategic location being a hub of movement between other Iraqi cities and Turkey or Syria, administration as it is one of the three provincial capitals, and the economy as it harbors many commercial activities at local, national and international levels. It has experienced a rapid urban growth especially over the last decade leading to an increased urban/built-up area with inadequate and inefficient infrastructure including transportation network.

Pedestrian paths including sidewalks constitute a portion of the built-up area in the study area. The sidewalks in the city center usually have tile surfaces while those in the residential areas mostly have concrete surfaces. They generally do not conform to the international standards and do not provide a conducive pedestrian environment for a variety of reasons that are discussed later in this article. Apparently, there have been no efficient regulations pertaining to pedestrian paths in Duhok city. Many of the existing sidewalks have not been constructed or surfaced according to appropriate design standards. In other words, there

are no controls to abide landlords by the standard regulations concerning the structure and use of sidewalk adjacent to their property lines. Sometimes, the landlords generally believe that the portion of sidewalks that run along their properties belong to them and impose a relatively complete right to their design and use. As a result, the sidewalks do not much facilitate pedestrian movements especially during peak travel hours or increased pedestrian traffic.

Misuse of public sidewalks is very common in Duhok. Owners of shops and stores in the city center often transgress over the sidewalks to showcase/place their goods and other items such as restaurant chicken grills or garbage bins on the travel paths due to limited space of the business facilities. Protruding materials such as shop/restaurant doors opening from outside and misplaced utility poles also affect the public right of way and sometimes cause injuries for people as result of the collision. In addition, many sidewalks lack an improved sidewalk, and there is no continuous and connected pedestrian network. In some places, the existing sidewalks are interrupted by obstructions or lack of proper, clearly marked crosswalks at their ends where they need to be

connected to the sidewalks at another side of the streets. Moreover, the sidewalks are not designed for elderly, children, and people with disabilities, especially those who use walking aids or wheelchairs. They are clearly not conducive to people with disabilities.

INTRODUCTION

Walking as a Multiple-Advantage Mode of Transport

Walking is an essential and common transport mode in societies worldwide. Generally, the public use walking as a daily basis routine to commute to work, perform life necessities to sustain their livelihood or conduct social activities especially through short strolls and longer trips. People usually walk through travel paths including sidewalks separated from vehicular roads to reach the destinations. Increased walking can reduce pressure on automobile transport towards promoting more sustainable, environmentally friendly transport with more health, environmental, economic and community benefits. Walking can lead to a reduced level of obesity-related for example and can increase the pedestrian's interaction with the physical environment and the streetscape/landscape. It can also contribute to increased environmental protection. (FHWA, 2007; GDOT, 2005; Grava, 2004; TfL, 2010)

Sidewalk Significance and Advantages

Pedestrian environments with improved safety measures and good designs can encourage walking and contribute to improved urban renewal, local economic growth, social cohesion, and a better environment, i.e., less traffic noise and fumes, and better air quality. Areas without accessible pedestrian networks discourage walking, thus contributing to an isolated and insecure community. Sidewalks are provided along one or both sides of a roadway, especially where car speed exceeds 30 km per hour or car flow exceeds 100 cars per hour. They function as vital links in the transportation network and play an important role in city life by providing access for pedestrians to all facilities and public spaces in a community. Without sidewalks, pedestrians especially people with disabilities face difficulty in accessing public rights-of-way. (Axelson et al., 1999; MoDOT, 2015)

Sidewalks can enhance connectivity, promote walking, and activate streets socially and economically. Safe, accessible and well-

maintained sidewalks function as investment catalysts for urban areas, enhance public health, and increase social capital. According to USA Institute of Transportation Engineers (1998), sidewalks "*reduce the incidence of pedestrian collisions, injuries, and deaths in residential areas and along two-lane roadways.*" Sidewalks together with streets constitute part of the human environment as they become a place for the human encounter, function as vital transportation routes for communities and facilitate travel of people from one place to another. They thus contribute to the economy by promoting shopping, stimulate and encourage leisure, and enhance the safety of communities by increasing activity on the street. Sidewalks can be considered as centers of community life; spaces for social, cultural and economic exchanges; and places for play, social interaction as people hang out or promenade, and community building. (Axelson et al., 1999; Rudofsky, 1982)

METHODOLOGY

The study was designed to introduce basic concepts regarding sidewalk mobility and the extent to which the sidewalks in the study area can be improved. It includes five main components: (i) Review of relevant literature to identify international standards and best practices, (ii) review of sidewalk standards adopted by the local municipality, (iii) field inspection (audit walks) of the existing sidewalks in the study area to identify shortcomings and gaps, (iv) interviews with responsible technical experts at Duhok Municipality to review sidewalk design process, requirements, and bottlenecks, and technical works to provide graphic images of selected sites with inefficient sidewalks using international standards.

The field inspection included an audit of the sidewalks in selected areas of Duhok – city center (downtown), minor roads in mixed-use areas (residential, commercial), and residential areas. It covered different aspects – distance, width, used surface materials, the existence of obstacles, levelness, and slope. Length and widths of the sidewalks were measured using a measuring tape. The slope was recorded using Theodolite equipment to provide more accurate data. Photos of the surface materials and existing obstacles were taken. The field work also included the calculating average flow of pedestrians, peak hour

flow and maximum activities in the clear footway path three different locations in the city centre during the peak hours to identify the Pedestrian Comfort Level (PCL). (TfL, 2010) The measurements were analyzed for compatibility with the sidewalk standards and regulations of Duhok Municipality, as well as international standards mainly AASHTO ((American Association of State Highway and Transportation Officials (1995 & 2004)). Interviews with experts included questions of Duhok Municipality such as difficulties to design and implement proper sidewalk, pedestrians' access, mobility and comfort. Photos were taken from selected sites and modified to highlight the gaps and modified to provide an expected improved situation using Photoshop and hand rendering.

REVIEW OF LITERATURE

Sidewalk Safety and Accessibility

A sidewalk should provide a safe and accessible route for all pedestrians regardless of their gender, age, and physical abilities. An accessible, wide and well-designed sidewalk with pedestrian-friendly elements (e.g. curb ramps, benches) can encourage people to walk, exercise and fewer use automobiles, help them engage more in social activities, and enrich livability of the street or the community. It can also contribute to making safer neighbourhoods where people can feel a sense of place and safety in the street with an increased number of pedestrians. Such areas can offer a wide range of business, social, and recreational opportunities like cafes that attract pedestrians. Therefore, it is important to increase safety and recreational options for pedestrians, which will eventually lead to increased physical and economic activities including walking, health well-being, and social cohesion. (MoDOT, 2015; VSCG, 2015)

Standard Sidewalk Design

An ideal sidewalk can provide essential services to the pedestrians; therefore, it should be designed to meet the needs of all pedestrians, especially elderly and disabled people, and conform to the international design principles and criteria that emphasize creating a walking environment. A proper and effective approach to designing sidewalks should accommodate, consider and balance the needs and capabilities of all pedestrians. It should allow for safe, smooth, adequate, and comfortable movement and accommodation for pedestrians, and not oblige

them to walk in the street. (ADA, 1990; FHWA, 2007; GDOT, 2005; MoDOT, 2015; TfL, 2010)

A sidewalk should have a variety of characteristics with direct impact on usability, such as width, surface type, level, grade, cross slope, lighting, and the existence of obstructions. Its usability is affected by several factors, such as changes in level; surface materials; firmness and slip resistance; dimensions of gaps/cracks, grates and openings; and visual consistency. Attractiveness, convenience, functionality, or usability of a sidewalk depends on its design and construction materials and process. Therefore, a sidewalk corridor design should have attributes, such as accessibility for all users, safety from adjacent traffic and physical environment, adequate width, continuity and connectivity with minimum street crossings, landscaping and furniture, a buffer zone between pedestrians and traffic, lighting, and adequate space for socialization. (ADA, 1990; Axelson et al., 1999; GDOT, 2005; MoDOT, 2015)

Sidewalk Capacity and Requirement

A sidewalk capacity is determined by the PCL on footways which is measured based on the pedestrian crowding, i.e. the number of pedestrians passing an area of one meter (m) of clear footway width per minute (ppm), as shown in the following formula: $PCL = \text{persons per hour} \div 60 \div \text{clear footway width in meter}$

A sidewalk with a PCL of 3-8 ppm has a comfortable pedestrian environment with a sufficient space for people to walk at the desired speed and route, while a PCL of 9-11 ppm provides the recommended level of comfort for all area types. (TfL, 2010) The pedestrian space needed for a person to meet the cultural tolerance (social distance) limit is about 45.72-60.96cm, which represents $0.28m^2$ per person or 3.6 persons per m^2 . For a person to feel comfortable while walking, the approximate size of an open umbrella ($0.74-0.93m^2$ in the area) is also needed to maintain own "private space bubble". (Grava, 2004)

Pedestrian Flow Capacity is determined based on Speed–Volume–Density relationship, which constitutes the Level of Service (LOS) that sets levels for various situations referring to the ease of operation performance (Table 1). For example, LOS A means unconstrained motion of a walker while LOS F means extensive physical contact with other pedestrians. In level LOS E, a walker continuously and physically conflicts with others

and the pedestrian speed are retarded. (Grava, 2004)

Table (1): Pedestrian Flow Characteristics on Walkways

| Level of Service | | | | | | |
|---|------|---------|---------|---------|---------|----------|
| Characteristic | A | B | C | D | E | F |
| Flow rate, pedestrians per min per Ft | <5 | 5-7 | 7-10 | 10-15 | 15-23 | Variable |
| Spacing, Ft ² per pedestrian | >60 | 40-60 | 24-40 | 15-24 | 8-15 | <8 |
| Walking speed, Ft per minute | >255 | 250-255 | 240-250 | 225-240 | 150-225 | <150 |

Source: National Research Council, 2000.

Sidewalk requirement for a roadway depends on the road classification and land use. Table 2 shows the preferred mode of sidewalk requirement

according to the sidewalk guidelines adopted by FHWA (1999).

Table (2): Sidewalk Requirement on Roadways

| Type of road | Sidewalk Requirement | Zone of area | Dwelling unit/hectare | Shoulder requirement |
|------------------------|----------------------|--------------------------------|-------------------------------|----------------------|
| Highway | 1 side of road | Rural/suburban | <2.5 hectares (4donums) | Minimum of 1.525m |
| Suburban highways | 2 sides | | 2.5-10 hectares (4-16 donums) | |
| Arterials & collectors | 2 sides | Residential areas | | |
| Local streets | 2 sides | Residential areas | >10 hectares (16 donums) | |
| Local streets | 2 sides | Residential areas | 2.5-10 hectares (4-16 donums) | |
| Local streets | 1 side | Residential areas | <2.5 hectares (4 donums) | Minimum of 1.525m |
| All streets | 2 sides | Commercial or industrial areas | | |

Sidewalk Corridor and Zones

A typical sidewalk world-wide (3.1m wide) usually has four sections/zones - curb, planter/furniture, pedestrian, and frontage/shy zone. These as a whole constitute sidewalk corridor, which is defined as “*the portion of the pedestrian system from the edge of the roadway to the edge of the right-of-way (i.e., property line), generally along the sides of streets, between street corners*” (Portland, 1998) (Fig. 1). This division helps facilitate pedestrian movement by ensuring that adequate clear space to travel is provided for pedestrians. Usually, the sidewalk corridor is the paved area from the curb to the property line. In some areas, the paved portion is set back from the street by a surface, such as grass. (Axelson et al., 1999)

The four zones with their recommended minimum widths are listed below:

Curb zone (0.152m wide) serves as a barrier between the sidewalk corridor and the roadway, contributes to improved pedestrian safety by helping protecting pedestrians from drivers and discouraging them from walking close to the roadway, and also prevents flow or accumulation of excess in the corridor. (Axelson et al., 1999)

Planter/furniture zone or planting strip (0.610m [1.22m if it includes trees]) buffer pedestrians from vehicles and contributes to pedestrian increased safety. It accommodates landscaping (e.g., trees, bushes, flower pots, grass), utilities (e.g., street lights and signs, utility poles, fire hydrants), sidewalk furniture (e.g., benches), amenities (e.g., bus shelters), trash cans, and mail/newspaper boxes. It also facilitates pedestrians’ access to the sidewalk. A vegetated buffer zone (with large canopy) trees can visually and audibly buffer pedestrians from traffic; provide a sense of enclosure, shade and aesthetic relief; beautify streetscape environment with a traffic calming effect and a more pleasant walking experience; and soften urban environments psychologically, physically, and ecologically. Sidewalk landscaping can also reduce the visual width of the roadway, encourages slower vehicular speeds, and provides an aesthetic appeal to the street, thus contributing to an increased pedestrian comfort. (Axelson et al., 1999; Carrboro Town Hall, 2014; FHWA, 2004; Wetmore, 2012)

Pedestrian zone (1.525m) is the area for pedestrian travel; therefore, it should have no obstacles and be wide enough to provide sufficient

space for travel of two pedestrians in one direction or in opposite directions. The minimum width of this zone is 0.915m, which is the minimum width required for an accessible route although this does not account for two-way travel. (ADAAG, 1991; FHWA, 2007; MoDOT, 2015; USAB, 1991)

Frontage (shy) zone (0.760m) is located between the pedestrian zone and the property line (e.g., buildings, storefronts, walls, fences). It

separates and discourages pedestrians from walking close to obstructions at the property line, thus easing pedestrian access to the sidewalk corridor and reducing safety hazards. It also provides space for protruding objects (e.g., window sills, store doorways that sling open into sidewalk corridor), and for sidewalk entertainment (e.g., street/sidewalk cafes with sitting chairs and tables). (Axelson et al., 1999)

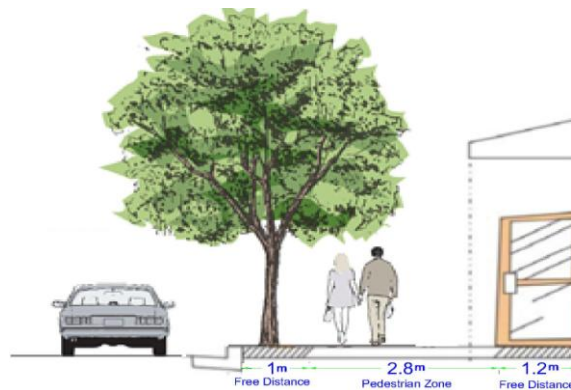


Fig.(1): Standard sidewalk design (Credit: The authors)

Sidewalk Dimensions

The width of the sidewalk (corridor) determines the easy use of the travel path, as well as comfort and the aesthetic environment associated with it. A sidewalk (corridor) should be wide enough to accommodate peak pedestrian traffic, street furniture, and curb ramps with level landings in order to facilitate access of the pedestrian zone to the street and vice versa. A wide sidewalk ensures travel of people in both directions at slower speeds and comfortably, thus enhancing pedestrian movement and networks. Neighbourhoods and business districts with wide and properly designed sidewalks can have livable gathering places especially when the pathways offer adequate space for people to walk and socialize together. (MoDOT, 2015)

AASHTO pedestrian facility guide (2004 Green Book) recommends the minimum width of a sidewalk on local or collector streets to 1.525m and on a thoroughfare to 1.829m; of a back of curb sidewalk on local and collector streets to 1.829m and thoroughfares to 2.438m; and of a sidewalk in a central business district to 2.438-4.877m. It also recommends that a sidewalk on bridges and in underpasses and similar structures

have a width of 2.134m. (GDOT, 2005; MoDOT, 2015; Wetmore, 2012)

Most guidelines recommend 1.525m as the minimum clear width of a sidewalk (and also of ramps and steps within a sidewalk). This space can allow two walkers to move in opposite directions without having either of them to step off the sidewalk. The clear footway width on a path with no street furniture or other constructions does not include 0.4m which is set as a standard buffer of building edge (0.2m) and the curb edge (0.2m). (Axelson et al., 1999; GDOT, 2005; Oshtemo, 2012; MoDOT, 2015; TfL, 2010)

It is important that during construction of new buildings and facilities 2.59m of public right-of-way be allocated to create a minimum width for the sidewalk corridor. This width can be reduced to 2.285m if the available open space between the property line and the sidewalk corridor has a minimum width of 0.76m. An existing narrow sidewalk corridor can be improved provided that the pedestrian zone is increased to at least 0.915m. That requires additional space (right-of-way). A sidewalk at a four-lane road (of about 17m in width) can acquire an additional space of 2.44m (on each side of the road) by reducing each traffic lane from 3.66m to 3.05m. This option will also

help traffic calming as narrow streets slow down the speed of vehicles. Concrete sidewalks should have a minimum depth of 0.102m and 0.152m at driveways. (Axelson et al., 1999; Oshtemo, 2012; ITE, 2001)

Obstructions

Sidewalks have two basic types of obstructions: Movable (e.g., vendor stands, garbage bin/receptacles, portable signs, landscaping, rocks, tree branches, overgrown shrubs, water and snow accumulation) and immovable (e.g., lamp posts, utility poles, signs, business stalls, railings, objects projecting from buildings, phone booths). Other common obstructions are market vendors with their business stalls occupying large space on sidewalks especially when people explore and queue around the stalls, café/restaurant chairs and seats, and objects protruding vertically or horizontally from sidewalks such as those mounted on walls, building overhangs, and awnings. Obstacles within the pedestrian zone limit the clearance width of the sidewalk, i.e. reduce walking space or clear footway space/width available for pedestrians, hinder movements, and cause accidents. They also oblige pedestrians traveling in groups to walk in the street in order to stay side by side. (Axelson et al., 1999; FHWA, 2007; MoDOT, 2015; TfL, 2010)

Vertical obstructions such as posts should be relocated outside the pedestrian zone to provide a buffer of 0.200m with the travelers. Signs and other vertical objects on sidewalks should be at least 2m above the surface. Lateral objects mounted on posts and building walls should not protrude more than 0.3m into the sidewalk corridor. Surface obstacles like posts and bollards placed in the middle of a sidewalk should be aligned with other street furniture to allow for more width on the clear footway, facilitate movement, and prevent collision accidents and visual interruption. Dished drainage channels and grates, and tree roots incorporated within the sidewalk corridor can create falls and traps for pedestrians. There, grates with openings of not more than 13mm should be installed around tree stems to prevent a slip or tripping hazards. (ADAAG, 1991; Axelson et al., 1999; Grava, 2004; ITE, 2001; TfL, 2010; VSCG, 2015)

Changes in Level

Changes of level in sidewalks refer to the vertical elevation difference between adjacent surfaces. They are often caused by many elements

due to either poor construction (e.g., poor sub-base preparation which causes buckled bricks), external factors (e.g., the frost that causes heaving and settlement, trees roots), or because of topography (e.g., steps disconnecting a sidewalk). Changes in level are potentially hazardous and cause mobility difficulties for pedestrians especially when the surfaces are with abrupt or unexpected changes in level that are difficult to be recognized by pedestrians, such as steps. When a sidewalk has changed in the level of 6-13mm, its surface should have a maximum grade of 50 percent (1:2), and when it is greater than 13mm, the surface should be ramped with a maximum grade of 8.3 percent. Sidewalk surface should be even enough to also prevent accumulation of water and creation of puddles as poor drainage can create slippery surfaces and pits can cause accumulation of stagnating water. (ADAAG, 1991; Axelson et al., 1999; FHWA, 2004 & 2007)

Slopes and Cross Slopes

Steep sidewalk slope also called grade or running slope, running parallel to the direction of travel, and cross slope, running perpendicular to the direction of travel are significant barriers for movement of many pedestrians. Steep surfaces impact pedestrian stability and control especially persons with disabilities as it is harder for them to move across sloped surfaces. This requires the sidewalk slope to not exceed 5.0 percent and follow the slope of the adjacent roadway if this figure is not technically feasible. However, minimum grade in the terrain should be used when designing a sidewalk to minimize re-grading. (AASHTO, 2004; ADA, 1990; Axelson et al., 1999; FHWA, 2007; Gaskins, 2012; Oshtemo, 2012; MoDOT, 2015)

The sidewalk cross slope must range between 1 percent (minimum) and 2 percent (maximum). A cross slope of 1.5-2.0 percent also allows for effective drainage on paved surfaces. For sidewalks with steep cross slopes, a level area of minimum width of 0.915m within the pedestrian zone can be established. A slope greater than 5.0 percent is a ramp and therefore it should be equipped with handrails at one or both sides. According to Americans with Disabilities Act (ADA) Standards for Accessible Design and Americans with Disabilities Act Accessibility Guidelines (ADAAG), curb ramps should be installed on sidewalks with a maximum (running) slope of 1:12 (8.33 percent) and cross-slope of 1:50 (2 percent) and a minimum width of 0.915m.

Ramps with a maximum grade of 8.3 percent and a minimum distance of 9.1m should have a level landing (1.5m x 1.5m) with a slope of less than 3 percent. If the grade is more, then a level rest area should be provided for the level landing. Level landings at regular intervals and in a color contrasting with that of the sidewalk can be used to reduce the impact of steep terrain and other factors, such as cross-slope, narrow widths, and changes in level. (AASHTO, 2004; ADA, 1990; ADAAG, 1991; Axelson et al., 1999; Gaskins, 2012; MoDOT, 2015)

Surface and Paving Materials

The function and appearance of a sidewalk are determined by the paving materials. Sidewalks usually have paved surfaces (e.g., concrete, asphalt, brick, tiles, stones) or unpaved surfaces (e.g., dirt, gravel). The surface should be paved, flat and even, compact and firm, non-slip/slip-resistant, and free from sudden or unexpected changes in level, wide seams between slabs, wide cracks, and gaps or pits. It should not contain slippery, reflective, decorative materials (e.g., paints, slippery tiles, polished stones, exposed aggregate rock). It should have good slip resistance and roughness - a Slip Resistance Value of 35-45 in wet and dry conditions. Wet and slippery surfaces are hazardous for pedestrians. Sidewalks with poor surfaces, such as dirt, gravel or any other loose materials obstruct movement of pedestrians, especially in wet seasons. Smooth surfaces are preferable for all pedestrians; however, soft surfaces are difficult for people with mobility impairments. (AASHTO, 2004; Axelson et al., 1999; Carrboro Town Hall, 2014; Portland, 1998; VSCG, 2015)

Concrete, stone, bitumen macadam, brick/paving, timber, and grass are suitable surface materials, while sand, loose gravel, woodchips and cobbles are unsuitable materials. Concrete (slab) is most durable and requires less maintenance. Carved stone in large blocks is suitable. Stamped concrete (pavers) with a variety of colors and shapes can add a different look to the sidewalk. Asphalt is most suitable in areas with cold or moderate climates, but it is often not preferable for aesthetic reasons. Concrete and asphalt surfaces are firm or stable but are in most cases fairly slip resistant under dry conditions. Asphalt and crushed granite are acceptable in park settings. Loose gravel and rock flour are not suitable for sidewalks used by people using

wheelchairs or strollers. (Carrboro Town Hall, 2014; Guan 2001; MoDOT, 2015; VSCG, 2015)

Sidewalks with decorative textured surface materials (e.g. bricks, cobblestones, pavers) can provide a variety of aesthetically pleasing surfaces. However, they may not efficiently facilitate mobility and require frequent maintenance. Bricks, pavers and cobblestones surfaces are not suitable as they become slippery when they are wet. They also become uneven as they buckle creating changes in level, thus causing tripping hazards and hazards for pedestrians with mobility difficulties. In addition, decorative surfaces are not conducive to pedestrians with vision impairments in identifying detectable warnings for the transition from sidewalk to the street. Detectable warnings can be provided by establishing brick trims for smooth walkways and using colored concrete for sidewalk surfacing to help pedestrians with vision impairments identify detectable warnings for the transition from the sidewalk to the street. (Axelson et al., 1999; FHWA, 2007; MoDOT, 2015)

A surface with not tightly spaced tiles or stones can create groves, joints, and bumps – a major source of trips, falls and bumpy rides for pedestrians with mobility difficulties especially those using strollers, walkers, wheelchairs, or canes. Concrete joints on a sidewalk should be no wider than one-half inch (1/2”) and no deeper than one-quarter inch (1/4”). (FHWA, 2007; Gaskins, 2012; ITE, 2001)

Connectivity to Pedestrian Network

A sidewalk should be designed as part of a consistent and connected network of safe, accessible and comfortable pedestrian pathways network. It should be free of interruptions and provide connectivity along direct routes to major pedestrian traffic generators, residential areas, or transit facilities. Continuous and accessible sidewalks promote walking, encourage the use of the pedestrian network, and help keep pedestrians away from possible conflicts with vehicles on roadways. Sidewalks with interruptions may direct pedestrians to walk into and cross the roadway at unexpected points, such as midblock locations. (FHWA, 2007)

Lighting

Street lighting illuminates sidewalks and can thus improve pedestrian visibility and accessibility at night and create a sense of comfort and security for them by creating a safe environment. Thus, it

can also enhance a nighttime urban experience. (Axelson et al., 1999; FHWA, 2007; ITE, 2001)

Safety and Wayfinding Information/Signage

Well-designed signage on multiple formats (e.g. audible, visual, (vibro) tactile) can provide important safety and wayfinding information to both drivers and pedestrians. For example, it helps to protect pedestrians from car accidents, slip and tripping hazards by making them aware of the imminent dangers, topography or conditions of the upcoming sidewalk or better alternative routes in case the sidewalk has a steep grade or slippery surface. Similarly, it helps drivers to reduce vehicle speed at crossings and other pedestrian passages, and pedestrians to walk through crossings at the right time. (Axelson et al., 1999; Carrboro Town Hall, 2014; FHWA, 2007)

Sidewalk Furniture and Amenities

Sidewalk furniture and landscaping including trees contribute to creating an attractive place for people to walk, hang out, shop, etc. Well-furnished sidewalks can also create safe, pleasurable, and accessible walking environments,

especially if they are well designed and installed. For the purpose of pedestrian rest, it is important that benches be placed along sidewalks especially in areas with steep slopes - along level landings outside pedestrian zone with distance intervals of 25m in downtown areas, 100m in residential areas, and 250m in large park areas. Sidewalks with shade and drinking fountains can also act as rest areas to relieve pedestrians from prevailing grades and provide them with an opportunity to rest from hard walking or exertions. (ADA, 1990; Axelson et al., 1999; Carrboro Town Hall, 2014; MoDOT, 2015)

RESULTS AND DISCUSSIONS

Sidewalk Dimensions

Duhok Municipality is responsible for the provision and maintenance of local roads and sidewalks in the study area and has developed special standard specifications for the sidewalks as shown in Table 3. These dimensions were also confirmed by the interviewed municipality experts.

Table (3): Standard Sidewalks Dimensions currently applied by Municipality of Duhok

| Road Width | Sidewalk Width | Buffer Width | Traffic Lane Width | Island/Median Width |
|------------|----------------|-----------------------|--------------------|---------------------|
| 10 m | 1.50 m* | 0.45 m** | 6.10 m | N/A |
| 12 m | 2.00 m* | 0.45 m** | 7.10 m | N/A |
| 15 m | 2.25 m* | 0.50 m** | 9.50 m | N/A |
| 20 m | 4.00 m* | 0.50 m** | 11.00 m | N/A |
| 20 m*** | 5.00 m* | 0.45 m** | 9.10 m | N/A |
| 30 m | 3.50 m* | 0.50 m**** | 9.50 m***** | 2 m |
| 40 m | 5.00 m* | 0.50 m & 0.40 m ***** | 11.10 m***** | 6 m |

* For each sidewalk on both sides ** for each buffer on both sides *** Service road

**** each buffer out of total 4 ***** each lane out of total 2

***** 0.5 m for outer buffer next to sidewalk and 0.4 m for inner buffer next to island

However, there is no effective enforcement system to abide by the landlords to the sidewalk specifications during the land development process. There are no standard dimensions for the existing sidewalks. Actually, the sidewalks within each land use or zone are of different widths. For example, the widths of the sidewalks in the city centre range between 1.4m and 5.1m; in the farther commercial districts or major roads, 2.45m –6.7m; and in residential areas, 1.8m–4.8m. High pedestrian flow has been observed in some parts of the city especially in the city center during the peak hours 4:00pm-6:00pm with a PCL reaching 8ppmm (1,600 (persons per hour) ÷ 60 seconds ÷ 3.45m (clear footway width)) (Fig. 2). This necessitates

the establishment of wider sidewalk corridors with four zones wherever possible particularly along the roads that lead to the city centre or constitute the main vehicular network. For this end, widths of the existing narrow, congested sidewalks may be increased by borrowing from the street width and reducing the width of vehicular traffic lanes (Fig. 3&4). Also, more right-of-way or easement may be obtained from owners of adjacent properties. It is also necessary that when new buildings are constructed, the owners should be made responsible for providing standard sidewalks to accommodate the increased pedestrian traffic the buildings will generate.



Fig. (2): Narrow & crowded sidewalks in the city centre (Source: The authors)



Fig. (3): Left - A narrow sidewalk in the city centre; Right - Post-processing rendering of the same image (Credit: Ali Hussein)



Fig. 4: Left - A narrow sidewalk in a residential area; Right - Post-processing rendering of the same image (Credit: Ali Hussein)

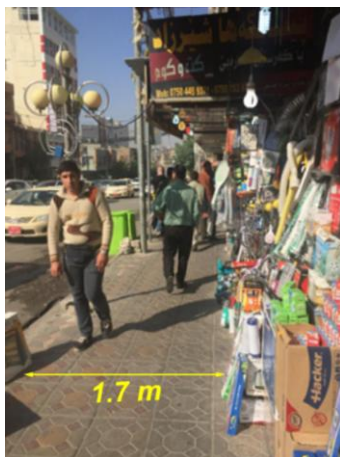
Obstructions

Obstructions in the travel path and lack of respect for the pedestrian's right of way are the

most common problems of the sidewalks especially in the city centre where the small businesses (e.g., shops, restaurants) are the main transgressors. Occupation of a sidewalk portion for showcasing the goods or for placing business furniture or equipment (e.g., air-conditioning units, chicken grills, garbage bins) is widely practised in the city centre. In some locations, the sidewalk area occupied by the business items represents 20–35% of the total area of the sidewalk portion in front of that business. Meanwhile, the sidewalks, especially the portion adjacent to the road, are often riddled with obstructions (e.g., power/telephone poles, signposts). In some places especially where there are ramps, cars are parked on the sidewalks. This can be due to lack of efficient sidewalk use regulations and awareness at the part of transgressors. (Fig. 4)

The sidewalk surface, especially in the city centre, should be made free of lateral and vertical

obstructions and slight surface protrusions to improve narrow pedestrian zones and allow for an acceptable clear footway width. Removable obstacles including surface and lateral protruding objects should be eliminated. Permanent surface objects (e.g. poles, posts) should be relocated outside the travel path to be aligned with the street furniture or should be high enough to prevent pedestrians stumbling over them. Objects mounted on posts or walls should be reduced in terms of the protruding height or length. Slight protrusions on a concrete surface can be reduced by removing a thin layer of concrete through grinding. Effective regulations should be in place for preventing encroachment on the sidewalks. One of the feasible measures could be applying financial penalties - imposing financial fines on the violators.



a) Shop goods showcased on the sidewalk



b) Cafes furniture, utility poles & people hanging out on sidewalk



c) Store ascending steps & traffic signs

Fig. (4): Sidewalks with different types of obstructions (*Source: the authors*)



d) Utility poles, bus stop & car parking on the sidewalk



e) utility poles



f) Ascending stairs & building protruding structures



g) Power poles; garbage bins; parked cars; uneven level



h) Sudden/unexpected descending steps



i) Restaurant chicken grills & garbage bins

Fig. (4): Sidewalks with different types of obstructions (*Source: the authors*)

Changes in Level

Changes in level of the sidewalk surface in the study area are caused by different elements, including buckled bricks (due to poor sub-base preparation), cracks, grooves, non-ramped curbs, drainage grates, tree roots, small steps, gutters, and uneven transitions (i.e. different levels) between different sections of the sidewalk or between streets. (Axelson et al., 1999) Sidewalks with abrupt changes in level and steps should be treated through levelling with a gentle slope, and other changes per technical standards. (Fig. 5)

Slopes and Cross Slopes

The sidewalks in the city are generally of acceptable slope (less than 4%), except in the

areas located at the bottom of the northern mountain range where the slope reaches 12%. Sidewalks with steep slopes should be provided with level landings at both ends and at regular intervals or converted into stairs with handrails at both or either sides as needed. However, long steps in the sidewalks can be substituted by gradual ramps with consistent slope and level landings installed at top and bottom ends, and at intermediate intervals. Wide sidewalks with stairs at intermediate connections or at connections to building entrances should be partially ramped to allow people with wheelchairs to access both structures. (Fig. 6&7)



Fig. (5): Left –A sidewalk with sudden, vertical changes in level a commercial area;
Right - Post-processing rendering of the same image (*Credit: The authors*)



Fig. (6): Left –A sidewalk with high slope percentage on a minor road in a residential area;
Right - Post-processing rendering of the same image with gentler slope(*Credit: Ali Hussein*)



Fig. (7): Left –A sidewalk with high slope percentage on a minor road in a residential area;
Right - Post-processing rendering of the same image with a gentler slope (*Credit: Ali Hussein*)

Surface and Paving Materials

Different surface materials, mainly concrete, pavers (Steiger) are used for the sidewalks in the city; brick is rarely used. However, most of these surfaces lack standard specifications like smoothness, slip resistance, uncomfortable, non-firm and non-stable (Fig. 8). Since the temperature in Duhok is high in summer, it is recommended that pervious materials be used wherever possible especially on the sidewalks along major and minor roads in order to reduce heat. Brick paver is most recommended; the seams joining the bricks better allow for permeability and for under soil water infiltration, thus mitigating temperature of the ground and possibly reducing heat on the surface, and also help in draining the storm. Oppositely, impervious, darker and rougher materials like asphalt and concrete absorb more heat, increasing air temperature through heat convection. Smooth, slippery concrete surfaces can be improved by increasing the slip resistance through making them coarser, i.e. by having brushed concrete (broom finishing) during construction. The sidewalks can also be improved by using stamped concrete or concrete pavers with

a variety of colors and shapes that can add a different more pleasing look to the sidewalk. (Buyantuyev & Wu, 2009; Doulos et al., 2004)

Deteriorated Sidewalk Infrastructure

Sidewalks in many areas are deteriorated in infrastructure. Surfaces of some sidewalks are not completely paved, and they often contain cracks with wide gaps and lengths or pits that allow for the accumulation of stormwater which sometimes become stinky swamps especially in warm and hot seasons (Fig. 9). Sidewalks with such infrastructure cause obstructions for the pedestrians especially persons with wheelchairs or baby strollers, and at nighttime, and discourage use of sidewalks.

The existing deteriorations in the sidewalks should be fixed according to the international standards and by skilled workmanship. The purpose is to make the travel path have a smooth, even and obstruction-free surface to allow for safe and easy movement of pedestrians and contribute to the aesthetic environment of the sidewalk. The best option is to use environmental friendly-materials such as brick pavers that are more conductive and attractive to pedestrians.



Fig. (8): Sidewalk with poor concrete surface (Source: the authors)



Fig. (9): Left - Sidewalk surface with pits & wide cracks
Right - Rendering of the sidewalk after pavement (Credit: the Authors)



Connectivity to Pedestrian Network

In some areas of the city, the sidewalks lack continuity; they are interrupted, thus causing obstruction of travel of pedestrians. This obliges the travelers either to either walk on the adjacent road as the most frequent case in the city center or

use shortcut roads as the common case in the residential neighbourhoods (Fig. 10).

Sidewalks should be provided across all roads in the city to ensure the connectivity of the pedestrian network (Fig. 11). In addition, clearly marked, well-designed pedestrians crossings with

distinct colors, or speed calming measures (e.g. visibly marked and raised crosswalks or speed tables “flat top hump”) should be provided at street intersections and other crossings because they connect pedestrian routes at the same level as the sidewalks and slow vehicle speeds. Thus, they will help the continuity of pedestrian flow line, facilitate their travel, and enhance the street environments. (Axelson et al., 1999; Carrboro Town Hall, 2014)

Lighting

Many sidewalks, especially in the areas off the city center, lack adequate lighting which creates a state of insecurity for the pedestrians especially women and girls at a dark time. It is important to provide the streets together with the adjacent sidewalks with solar-powered lighting. Illuminating the streets at night time will add a sense of security and activity to the sidewalks. The more the sidewalk is safe, the more secure the

people will feel and the more vivid the sidewalk will be.

Safety and Wayfinding Information/Signage

Most sidewalks in the study area lack safety measures due to inefficient designing or poor construction. There is a general lack of safety/wayfinding information and signs associated with the use of sidewalks, for example, signs for the existence of sidewalks on the road. To improve safety of the pedestrians, it is important to minimize the physical conflicts with the vehicular traffic through buffering - Setting back sidewalk corridor from the street by a green surface; contrasting the street with the sidewalk through coarse construction materials, and establishing physical barriers between the two based on the speed of passing vehicles (curbs for low-speed roadways and guardrail or concrete barriers for high-speed roadways).



Fig. (10): An interrupted sidewalk on a minor road in a residential area

Fig. (11): Left - An interrupted sidewalk on a minor road on a commercial road
Right-Post-processing rendering of the same image with a gentler slope
(Credit: Ali Hussein)

Pedestrian signs should also be provided at all sidewalk-street connection points like intersections, midblock (raised) crossing points, speed tables, and other pedestrian travel sections with changes in slope or level. Pedestrian push buttons, known as High-Intensity Activated Crosswalk (HAWK), must be made available comfortably at pedestrian crossings and at traffic sign poles. HAWK allows pedestrian movement across the road when illuminated giving a green signal. It is also necessary that the sidewalks have well-designed and formatted signage including pedestrian signs on the sidewalk surface,

detectable warnings in different formats (e.g. texture, colour, raised directional tiles, pavers), and pedestrian actuated signal devices. (Axelson et al., 1999; FHWA, 2007; MoDOT, 2015; Peacock, 2012)

Safety Measures

Lack of safety measures during the construction or renovation of buildings poses considerable risks to the safety of pedestrians (Fig. 12). As there are no sidewalk sheds or no alternative routes, the pedestrians are usually exposed to the danger of falling construction materials or to further risk by walking in the road.

To allow for the easy and safe flow of pedestrians, landlords of new buildings should be committed during construction/renovation works to establish temporary, appropriate makeshift paths including narrow plywood, sheet metal, or concrete scaffolding tunnels around construction sites. The tunnels can shield the pedestrians from the debris of the construction/renovation works. The parallel pedestrian pathways can keep pedestrians away from the construction debris. If both options not feasible, the pedestrians can be re-routed across the street to a

parallel sidewalk. (ATSSA, 2012)



Sidewalk Furniture and Amenities

The sidewalks in Duhok generally lack furniture, an essential element that can promote walking and enhance pedestrians' experience of travel. It is important that the sidewalks, especially along the broadways, have benches. This will make the sidewalks more vivid and attractive to the pedestrians.



Fig. (12) – Left & right: Sidewalks with obstructions & hazards due to (falling) debris
(Source: The authors)

Municipality Interviews Findings

The results of the interviews with Duhok Municipality experts do not indicate existence or plans for corrective or preventive measures to be taken against the existing transgressions on the sidewalks in residential and commercial areas. Meanwhile, no action has been taken for improving the sidewalks with uneven levels or for with steep slopes. However, the municipality has plans in the pipeline that will ensure establishing sidewalks with even levels and with standard surface materials alongside vacant land plots on the commercial roads, provided that the cost by burdened by the plot building owners. No plans are also in place for providing safety measures for pedestrian movements alongside buildings under constructions, or for inspecting and improving the sidewalks in deteriorated conditions or for the disconnected sidewalks. Lighting and safety signs are provided for main roads only and not for the residential streets.

CONCLUSIONS

Pedestrian paths which mainly include sidewalks in many urban areas of the world are essential an essential element of pedestrians' movement, mobility, daily life requirements, socialization, and work. Sidewalk network is an important and integrated part of the transportation system that contributes to facilitating mobility of people and making it easier by encouraging them to walk rather than use vehicles and other transportation means. Therefore, the inefficiency of sidewalks or lack of well-designed and proper sidewalks can have a negative impact on the whole transportation system and affects the mobility of people to the desired destinations.

This research has presented a general overview of the international sidewalk standards and a field audit of the existing sidewalks in the study area. Generally, the sidewalks in Duhok city, lack the minimum requirement of the international standards and accessible sidewalk requirements in

terms of whole aspects – dimensions, pavement materials, continuity, slope degrees, obstacle-freeness, lighting, etc. This shortcoming is attributed to a combination of factors, including lack of efficient sidewalk regulations and compliance system, and lack of community awareness on the public-of-right and the citizens' right to travel using different modes of transport basically walking. The study has also presented a number of recommendations that address each major gap in the existing sidewalks. It is very important to apply these recommendations in order to provide a favourable and attractive pedestrian environment in every part of the city and contribute to improving environment/atmosphere of the urban area, social interaction, economic activity, and health well-being of the residents. To achieve this, combined remedial and development efforts are needed at the level of the local government – public infrastructure/service delivery and law enforcement agencies, as well as the local community.

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