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An Assessment of the Efficacy of Pedestrian Walkways in Dhaka City

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Abstract- Pedestrians constitute the largest single road user group in Bangladesh. From MAAP Data Base, it is observed that highest frequency of pedestrian casualties in Dhaka city occur at road side and footpath (48%) [1]. Hence pedestrian walking along the roadway in lieu of walkway is a major problem to be concerned for Dhaka city. The study aims at evaluating the current scenarios of major pedestrian walkways in Dhaka city from various category areas to determine whether there are any need to redesign those or not. Eight walkways representing eight category areas of Dhaka had been selected in this regard and level-of-services of those walkways were quantified following Highway Capacity Manual method. Walkways were investigated for two conditions (i.e. existing condition, and considering no obstruction condition) to come to a conclusion about the effectiveness of selected walkways. For simplicity of field observation, only pedestrian unit flow rate (p/min/m) was used as service measure of LOS. Pedestrians walking on both sidewalk and roadside (both directions) were taken into account in the study. From the result it is found that in existing condition, on an A (most comfortable) - F (least comfortable) scale for the walkways surveyed five out of eight are performing in LOS-C, LOS-D and LOS-E which conform to poor condition. Whereas, if there were no obstruction present in these walkways, seven walkways would provide LOS-A and LOS-B which depicts majority of the walkways in Dhaka are adequate in dimension to provide comfortable walking.

Keywords- *Pedestrian, Walkways, LOS*

I. INTRODUCTION

Over 10,000 people live per square kilometer in the city of Dhaka. In spite of being the capital, Dhaka is still one of the least motorized cities in the world. About 60% of the trips are on foot while almost half of the remaining trips are on non-motorized vehicles [2]. Pedestrians in Dhaka City walk for different purposes. Though urbanities of Dhaka are dependent highly on foot, any significant improvement of the walkways did not notice for the last decade. Besides, walkers are the most vulnerable users of the road space but lack of safety measures also offer the walkers very dangerous situation.

Accident type analysis over fifteen years (1998 to 2012) had been made in Bangladesh by Accident Research Institute, BUET (ARI). Among the total number of casualties of 81464, pedestrian casualties were 27228 which constitute the second largest casualty group for 34 percent of the total. There is also evidence that pedestrian accident occurring in road side location is the greatest problem of all. Almost 48 percent of total pedestrian casualties occur in footpath and roadside location. Pedestrian casualties assailing due to various actions of pedestrians were also investigated by the researchers. The result found that most of the pedestrian accidents occur while walking along roadside which constitutes 43% of the total [1]. The above findings and statements indicate that pedestrian's accident problems have turned into one of the most concerning problems in Bangladesh. There is a clear indication that the problem might be associated with ignorance of rights of pedestrians as well as friction in walkways. Walkways might also be inadequate in dimensions at some locations where wider areas are required for extensive pedestrian movements. The present study tries to focus the present condition of major walkways of Dhaka city emphasizing the widths and frictions available on these.

The research aims at evaluating the current situations of selected major walkways to find out whether there are deficiencies in the space of the walkways or obstructions being the main culprit. Selecting representative study sites from various category areas, and then determining the level-of-services (LOS) of chosen walkways following Highway Capacity Manual method for (i) existing condition, & (ii) assuming no obstruction condition, are the main objectives of this study. A comparative study of all the walkways surveyed is conducted in terms of the effects of obstructions. LOS determined in this way for various sidewalk and pedestrian conditions can be used to evaluate the performance of a sidewalk and determine the need to redesign it, to analyze the efficiency of a sidewalk after a proposed sidewalk change, or to design a new sidewalk in areas of proposed development.

II. LITERATURE REVIEW

A. Previous Studies

The most regular approach that is utilized to assess transportation facilities is the concept of LOS. Numerous literatures are available regarding the previous works of pedestrian LOS-determination. One of the previous studies

used Conjoint Analysis technique to measure the level-of-service of a pedestrian path. The method determines both LOS of pedestrians and the factors that contribute to low and high LOS. Unlike most of the existing methodologies of pedestrian LOS which look into account only sidewalk conditions, the study considered both sidewalk and crosswalk conditions in computing LOS [4].

In another study, a methodology was developed for estimating the overall LOS of pedestrians for sidewalks based on total utility value. Site characteristics were collected to measure the total utility values for each sidewalk. The total utility value from the conjoint analysis represents an overall value that specifies how much value a user puts on a product or service. The maximum total value indicates the best case and vice versa. This means maximum total utility is the upper limit of overall LOS and the minimum total utility is the lower limit of overall LOS [5].

Current methods of assessing pedestrian level-of-service (PLOS) were reviewed in one of the past studies. Capacity based methods use the principles of highway capacity which have been suitably adjusted to evaluate pedestrian facilities. Whereas, Roadway characteristics based methods are based on the characteristics of the walkways or pedestrian facilities. Some new concepts have also been proposed in that research to evaluate pedestrian environment in a better way [6].

B. Performance Measure of Walkways

The primary performance measure for walkways and sidewalks is space, the inverse of density. Space can be directly observed in the field by measuring the sample area of the facility and determining the maximum number of pedestrians at a given time in that area. Speed also can be observed readily in the field, and can be used as a supplementary criterion to analyze a walkway or sidewalk. For simplicity of field observation, pedestrian unit flow rate is used as a service measure [3].

Determination of the peak 15-min count and the effective walkway width is required to compute pedestrian unit flow rate according to following equation [3].

$$V_p = \frac{V15}{15 * WE} \quad (1)$$

Where,

V_P = pedestrian unit flow rate (p/min/m),

V_{15} = peak 15-min pedestrian flow rate (p/15-min), and

W_E = effective walkway width (m)

C. Pedestrian LOS on Walkways

The criteria for pedestrian LOS includes service measure of space and supplementary criteria of unit flow rate, speed, v/c ratio. LOS summarized in the table given below do not account for platoon flow [4].

TABLE I. AVERAGE FLOW LOS CRITERIA FOR WALKWAYS AND SIDEWALKS

LOS	Space (m2/p)	Flow Rate(p/min/m)	Speed(m/s)	v/c Ratio
A	>5.6	≤16	>1.3	≤0.21
B	>3.7-5.6	>16-23	>1.27-1.3	>0.21-0.31
C	>2.2-3.7	>23-33	>1.22-1.27	>0.31-0.44
D	>1.4-2.2	>33-49	>1.14-1.22	>0.44-0.65
E	>0.75-1.4	>49-75	>0.75-1.14	>0.65-0.1
F	≤0.75	Variable	≤0.75	Variable

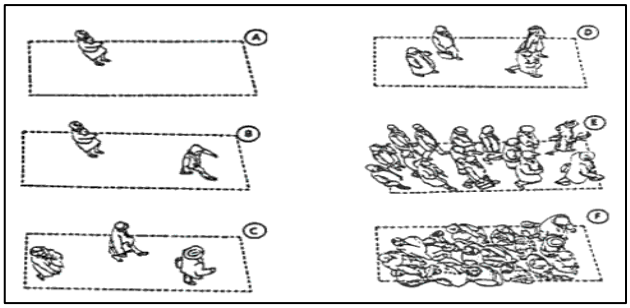


Figure 1. Illustration of Pedestrian Walkways LOS thresholds

TABLE II. PEDESTRIAN WALKWAYS LOS (HIGHWAY CAPACITY MANUAL 2000)

LOS A	*Pedestrian Space* > 5.6 m^2/p *Flow Rate* 16 p/min/m At a walkway LOS A, pedestrians move in desired paths without altering their movements in response to other pedestrians. Walking speeds are freely selected, and conflicts between pedestrians are unlikely.
LOS B	*Pedestrian Space* > 3.7–5.6 m^2/p *Flow Rate* > 16–23 p/min/m At LOS B, there is sufficient area for pedestrians to select walking speeds freely, to bypass other pedestrians, and to avoid crossing conflicts. At this level, pedestrians begin to be aware of other pedestrians, and to respond to their presence when selecting a walking path.
LOS C	*Pedestrian Space* > 2.2–3.7 m^2/p *Flow Rate* > 23–33 p/min/m At LOS C, space is sufficient for normal walking speeds, and for bypassing other pedestrians in primarily unidirectional streams. Reverse-direction or crossing movements can cause minor conflicts, and speeds and flow rate are somewhat lower.
LOS D	*Pedestrian Space* > 1.4–2.2 m^2/p *Flow Rate* > 33–49 p/min/m At LOS D, freedom to select individual walking speed and to bypass other pedestrians is restricted. Crossing or reverse flow movements face a high probability of conflict, requiring frequent changes in speed and position. The LOS provides reasonably fluid flow, but friction and interaction between pedestrians is likely.
LOS E	*Pedestrian Space* > 0.75–1.4 m^2/p *Flow Rate* > 49–75 p/min/m At LOS E, virtually all pedestrians restrict their normal walking speed, frequently adjusting their gait. At the lower range, forward movement is possible only by shuffling. Space is not sufficient for passing slower pedestrians. Cross- or reverse flow movements are possible only with extreme difficulties. Design volumes approach the limit of walkway capacity, with stoppages and interruptions to flow.
LOS F	*Pedestrian Space* 0.75 m^2/p *Flow Rate* varies p/min/m At LOS F, all walking speeds are severely restricted, and forward progress is made only by shuffling. There is frequent, unavoidable contact with other pedestrians. Cross- and reverse-flow movements are virtually impossible. Flow is sporadic and unstable. Space is more characteristic of queued pedestrians than of moving pedestrian streams

D. Effective Walkway Width

Effective walkway width is the portion of a walkway that can be used effectively by pedestrians. Several types of walkway obstructions tend to make pedestrians shy away [3].

$$W_E = W_T - W_O \quad (2)$$

Where,

W_E = Effective walkway width (m),

W_T = Total walkway width (m), and

W_O = Sum of widths and shy distances from obstructions on the walkway (m)

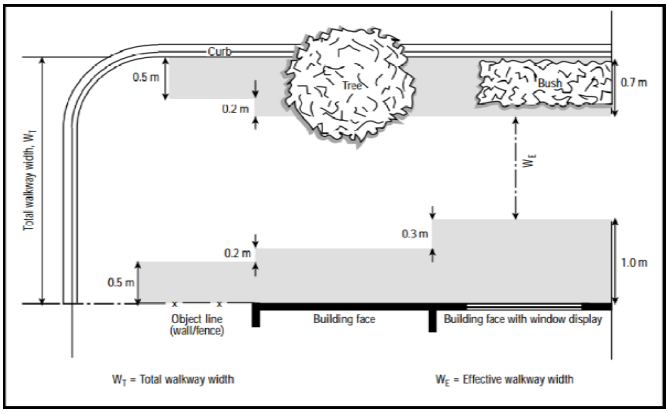


Figure 2. Width Adjustments for ixed Obstacles

If there are roadside appurtenances on the sidewalk adjacent to the curb, additional width is necessary to secure the clear width. Default values listed in Table III may be used in the absence of local data [9].

TABLE III. DEFAULT SIDEWALK WIDTHS

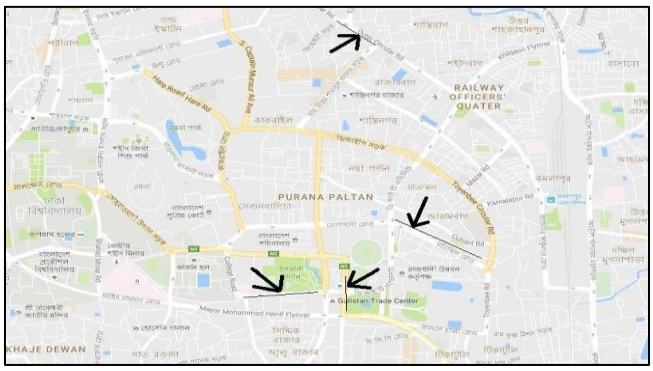
Condition	Width (m)
Buffer zone between curb and sidewalk	1.5
No buffer zone between curb and sidewalk	2.1

III. METHODOLOGY

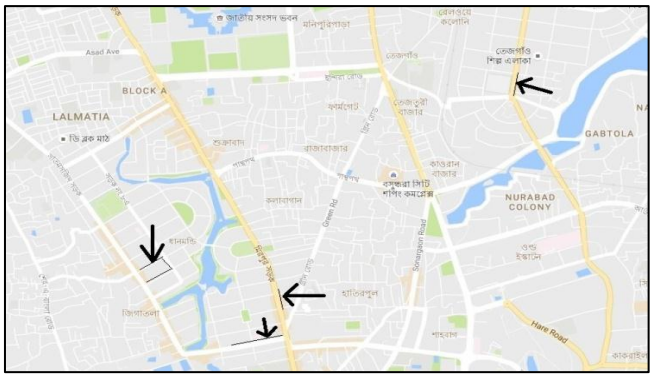
A. Selection of Study Sites

Eight study sites representing eight category areas of Dhaka were chosen. The selected sites are listed below:

- Commercial Area: Motijheel Road
- Industrial Area: Tejgaon Industrial Road
- Market Place Area: Malibagh Mor-Mouchak Market Road
- Hospital Area: Labaid Hospital Road
- Residential Area: Dhanmondi 9A- Dhanmondi 10A road
- Terminal Area: Gulistan Bus Terminal Road
- Educational Area: Dhaka City College adjoining walkway
- Recreational Area: Usmani Uddayan Lake Road



(a)



(b)

Figure 3. (a) and (b) Survey Sites for Sidewalks. (Source: https://www.google.com/maps/place)

B. Reconnaissance Survey

A walkover reconnaissance survey on the selected sites was carried out first. Before final survey the reconnaissance survey was conducted to realize the actual condition of the survey sites and to design the survey [7]. LOS is determined on the basis of peak flow. To know the possible peak flow time of pedestrians on the selected sidewalks preliminary survey was essential. As there were enumerators and apparatus constraints, local people (e.g. vendors, traffic police) helped to predict the possible peak hour of pedestrians flow at those areas during reconnaissance survey. Structural condition of the walkways was also observed during the study. The types and nature of the obstructions present on the walkways were marked during the preliminary survey so that final survey could be conducted dividing the walkways in several segments.

C. Final Field Survey

Span of time starting from 10th February, 2015 to 7th May, 2015 was used for the pedestrian count survey. Peak one hour pedestrian volume data was taken from all the selected walkways. Volume of pedestrians can be counted in three ways, (i) Manual counts using counting devices, (ii) Analysis of time-lapse movies and (iii) Study of a series of timed, sequentially overlapping photographs [8]. From all the methods, manual counting method was used in this study. Odometer, stopwatch, manual counting devices etc. were used to carry out the field survey.

The steps followed in field survey are described below:

- Total lengths of selected walkways were measured first using odometer. The length of a sidewalk can be approximately equal to the length of an urban street [3]. Each of the study sites was divided into various segments afterwards depending on the average effective widths available.
- In the next step, total sidewalk widths (m) of different segments were measured using odometer. Sum of widths and shy distances from obstructions on the walkway (m) were then obtained for all the segments using the same device. For a respective segment, average values for both the total walkway width and obstructions width were taken. Effective walkway width was then determined using (2).
- Pedestrian volumes count surveys in all the segments of a specific walkway were then conducted concurrently using counting devices for the peak hour. Pedestrians walking in both directions on sidewalk and roadside were observed and measured simultaneously during the survey. And finally peak 15-min pedestrian volume counts were taken into consideration for the data analysis of this study.

IV. Results & Discussion

Pedestrian unit flow rate (p/min/m) in each segment was measured using (1). Then weighted average method was employed to combine each segment's unit flow rate (p/min/m) to give a representative value of the whole walkway (3). The results obtained for both existing condition and assuming no obstruction condition.

$$\bar{x} = \frac{\sum_{i=1}^{n} w_i x_i}{\sum_{i=1}^{n} w_i} \quad (3)$$

TABLE IV. Pedestrian unit flow rate and Level-of-Service of all sidewalks for total pedestrian volume on both sidewalk and roadside are represented below

Walk-way No.	Walkway Location	Existing Condition		No Obstruction Condition	
		Unit Flow Rate (p/min/m)	*LOS*	*Unit Flow Rate (p/min/m)*	*LOS*
1	Commercial Area	47.76	D	17.56	B
2	Industrial Area	44.69	D	17.75	B
3	Market Place Area	40.96	D	22.41	B
4	Hospital Area	24.03	B	11.75	A
5	Residential Area	15.03	A	11.47	A
6	Terminal Area	71.10	E	23.95	C
7	Educational Institute Area	17.23	B	13.18	A
8	Recreational Area	33.66	C	17.04	B

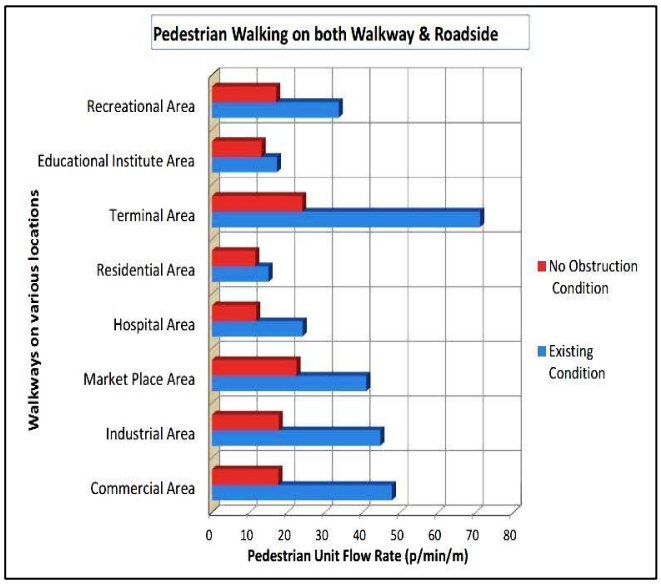


Figure 4. Bar chart showing the comparison of unit flow rates in all walkways

By analyzing the data obtained from the study sites, it is observed that:

- In existing condition, out of 8 walkways surveyed in this study, walkway from residential area is found performing in LOS-A. While walkways from hospital area and educational institute area are in LOS-B and recreational area walkway is in LOS-C. Walkways in heavy areas like in commercial, industrial and market place areas, the LOS are found D. Terminal area walkway gives LOS-E in existing condition.
- When it is assumed that there is no obstruction present in the walkways, 3 sites which are in LOS-B and LOS-C condition (i.e. hospital, educational, recreational area walkways) currently would perform in LOS-A. The corresponding widths of these walkways are adequate to provide free walking speeds for peak volume of pedestrians if all the current obstructions can be removed from these footpaths. Conflicts between pedestrian are unlikely at this stage [10].
- Among the other 4 walkways, 3 sites which are in LOS-D condition (i.e. commercial, industrial and market place area walkways) would be in LOS-B condition if no obstructions are assumed to be on the walkways. In LOS-B condition, there is sufficient area for pedestrian to select walking speeds freely, to bypass other pedestrian and to avoid crossing conflicts. But at this level, pedestrian begin to be aware of other pedestrian [10].
- The walkway surveyed in Terminal area (Gulistan) which is in LOS-E condition would only reduce to LOS-C condition if all the obstructions can be eradicated from the walking path.

V. CONCLUSION

Walkways are major and crucial components for pedestrian maneuver. To find out whether the dimension of the selected walkways is inadequate or it's the obstructions which are making these walkways ineffective is the main purpose of this research. Current conditions and effect of obstructions on walkways were analyzed by quantifying LOS of representative walkways from various category areas of Dhaka.

At a walkway in LOS-A, pedestrians move in desired paths without altering their movements in response to other pedestrians and walking speeds are freely selected. This is the most comfortable stage on a scale of A to F. At LOS-B, there is sufficient area for pedestrians to select walking speeds freely, to bypass other pedestrians and to avoid crossing conflicts. While at LOS-C, minor conflicts begin to appear and flow rate becomes somewhat lower. Walking comfort starts to degrade from this LOS [3].

In this study, 3 out of 8 walkways found performing in 'A' and 'B' in existing condition (1 in LOS-A and 2 in LOS-B). Whereas, the remaining others are performing in LOS-C and below LOS conditions. From this result, it can be uttered that widths of the walkways in residential, hospital and educational institute areas which are in LOS-A and LOS-B conditions are sufficient even with the presence of various obstructions. Again when it is considered there were no obstructions present in the walkways, 7 out of 8 walkways would give LOS-A and LOS-B. Hence, it can be concluded that majority of the walkways in the megacity of Dhaka are currently sufficient in terms of space/width. Only the frictions available in the form of vendors' occupancy, illegal vehicle parking, tea-stall etc. reduce the space of walkways, thus making a large number of walkways inefficient in terms of dimension. Consequently, obstructions play a significant part in inducing people to walk on the roadsides which is responsible for most pedestrian accidents in Bangladesh.

VI. RECOMMENDATION

To improve the current condition of majority of pedestrian walkways in Dhaka and thus to accomplish greater pedestrian safety, following recommendations are given:

- Attractive and user friendly walkway facility should be attained by eliminating retailer traders and hawkers gradually.
- Haphazard parking on road side, illegal bicycle-motorcycle parking on footpath, building material should be wiped out.
- Pedestrian fencing or other barricade types should be installed on the approaches and departures from signalized and other pedestrian facilities.
- Designated bus stoppage with properly designed layout at appropriate places should be provided.

VII. ACKNOWLEDGMENT

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