# A STUDY OF LEVELS OF SERVICE FOR SIGNALIZED CROSSWALK IN HONG KONG URBAN AREAS

William H. K. LAM
Professor
Department of Civil and Structural Engineering
The Hong Kong Polytechnic University
Hung Hom,
Kowloon,
Hong Kong
Tel: +852-27666045
Fax: +852-23346389
E-mail: cehklam@polyu.edu.hk

Jodie Y. S. LEE
Research Student
Department of Civil and Structural Engineering
The Hong Kong Polytechnic University
Hung Hom,
Kowloon,
Hong Kong
Tel: +852-27664487
Fax: +852-23346389
E-mail: jodie.lee@polyu.edu.hk

**Abstract:** Safe pedestrian movement is essential in all cities but particularly in such densely populated cities as Hong Kong. This paper aims to investigate the levels of service (LOS) for such signalized crosswalks in Hong Kong urban areas. Space requirements and several qualitative factors were gleaned from the pedestrian preferences and behavior revealed. Six LOS design standards for signalized crosswalks in Hong Kong have been proposed. These LOS standards are based on the integration of the ranking of qualitative factors as well as area occupancy. The survey results are also compared with previous research findings. Time for pedestrians in Hong Kong is found to be the most important factor of concern with an interest in the environment being of low priority. The assessed LOS standards can be used as a basis for the design and development of pedestrian signalized crosswalks in Hong Kong urban areas and in other Asian cities with similar environments.

**Key Words:** Level of Service Standards, Pedestrians and Signalized Crosswalks

## 1. INTRODUCTION

Hong Kong, with a land area of only 1,095 $km^2$ and 6.975 million population in 1999, is one of the most densely populated cities in the world. In such a dense city, there is a great deal of conflicts between vehicles and pedestrians. Safe walking is essential for pedestrian movement in an urban area. In this paper, the Levels of Service (LOS) concept is used to assess the efficiency of pedestrians to transverse the signalized crosswalks in Hong Kong urban areas. It is known that knowledge of pedestrian needs is valuable in the planning and design of pedestrian facilities. In this regard, it is particularly important to study pedestrian preference and movement behavior. This study is believed to be the first to focus on defining the level of service standards for signalized crosswalk facilities in Hong Kong urban areas.

The LOS concept was originally established in the design of highway capacity taking into account road traffic congestion. Research work on pedestrian LOS has its foundation in Fruin (1987) in which a series of LOS design standards for walkways, stairways and pedestrian queuing were developed. Walking speed, pedestrian spacing, and the probabilities of conflict at various traffic concentrations are the major factors that determined the breakpoints for various service levels. Highway Capacity Manual HCM (1994) provides guidance in designing and developing pedestrian facilities based only on the quantitative measures of the pedestrian walking speed, flow and density in six LOS standards. Khisty (1994) found that the qualitative environmental factors appear to be as important as the quantitative flow, speed, and density factors in planning, designing, and evaluating pedestrian facilities. Henson (2000) summarized the latest research on LOS for pedestrians. He proposed that the quantitative relationship between delay and pedestrian LOS requires further research.

Seneviratne and Morrall (1985) considered the perceptions of quality of service for the ranking and design of walkways. They considered the characteristics of the trip maker, the trip and the physical features in Calgary, Canada. Sarker (1993) has proposed and defined six service levels for pedestrians according to the quality of the walkway provided: safety, security, convenience and comfort, continuity, system coherence, and visual and psychological attractiveness of the environs. Mori and Tsukaguchi (1987) conducted a study focusing on the design and evaluation of pedestrian sidewalks in Osaka, Japan. A new method for evaluating the service levels of sidewalks under different flow conditions was developed. Gerilla et al. (1995) proposed the LOS standards for walkways in Manila for evaluating the pedestrian facilities according to the behavioral characteristics of pedestrians and the preferred factors affecting their choice of route. Tanaboriboon and Guyano (1989) carried out a case study on level-of-service standards for pedestrian facilities in Bangkok.

This paper aims to investigate the levels of service for signalized crosswalks in Hong Kong urban areas. Eighteen factors were defined and incorporated into the questionnaire. Photographs were used and pedestrian preference interview surveys were conducted at selected signalized crosswalks. Stabilization check of the rank of the pedestrian preference factors was carried out for testing the sample size required. A total of 225 pedestrians responded to the questionnaire. In total, eighteen qualitative factors were initially gleaned from the pedestrian preferences and behavior revealed. In order to assess quantitatively the pedestrian responses to the various congestion levels on crosswalk, the area occupancies of each LOS were further calculated based on the pedestrian preferences on the photos provided. Six LOS design standards for signalized crosswalks in Hong Kong have been proposed. These LOS standards are based on the integration of the ranking of the seventeen qualitative factors (excluding "congestion level") and the area occupancy for each LOS. The survey results are also compared with the previous research findings. The assessed LOS standards can be used as a basis for the design and development of pedestrian signalized crosswalks in Hong Kong urban areas and in other Asian cities with similar environments.

## 2. DATA COLLECTION

The location of the selected site was indicated in Figure 1. The selected site is a staggered signalized crosswalk between Chatham Road South and Cameron Road. The physical characteristics such as width, length, pedestrian green signal and pedestrian red signal of the site selected were indicated in Table 1. Photographs and pedestrian preference interview surveys were used in this study. Surveys were carried out during the evening peak period on four Wednesdays in December 1999.

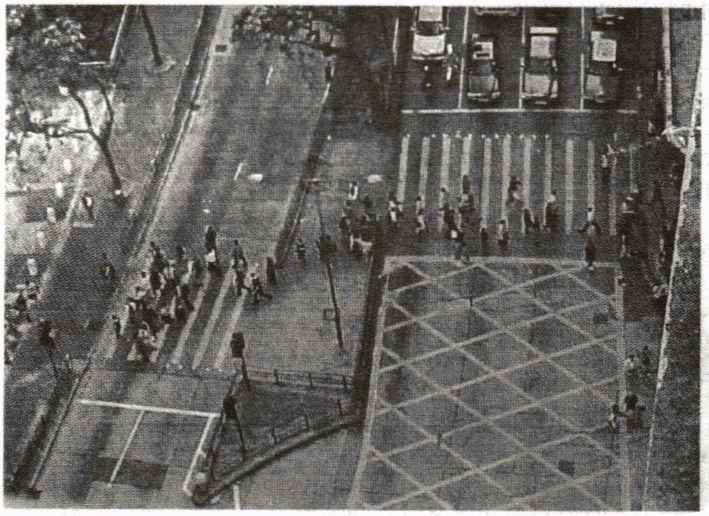

Figure 1 The selected site

Table 1 Physical characteristics of the site selected.

| Dimension | Signalized Crosswalk between Chatham Road South and Cameron Road | |
|---|---|---|
| | South Section | North Section |
| Width of signalized crosswalk (m) | 6.50 | 7.00 |
| Length of signalized crosswalk (m) | 6.85 | 12.14 |
| Pedestrian green signal (sec) | 21 | 62 |
| Pedestrian red signal (sec) | 99 | 58 |

## 2.1 Pedestrian Preference Interview Survey

The interview was conducted totally on-site. The respondents who passed over the signalized crosswalk were asked to indicate the degree of importance of each of the eighteen factors on the questionnaire.

The eighteen factors are numbered and listed as follows:
(1) Air quality
(2) Noise quality
(3) Without weather protection
(4) Presence of trees / shrubs
(5) Lighting in crosswalk area
(6) Solitary location
(7) Presence of fencing
(8) Footbridge or subway provided
(9) Width of crosswalk
(10) Length of crosswalk

(11) Size of stagger block or mid-block
(12) Green time for pedestrian signal
(13) Time for crossing carriageway
(14) Pedestrian waiting time for crossing
(15) Walking distance to crosswalk
(16) Surface condition of crosswalk
(17) Habituate to use
(18) Congestion level

The eighteen factors can be further classified into four key factors as below:

- Comfort
- Safety
- Convenience
- Level of Congestion

The degree of importance is divided into the following five levels:

- 'Not Important'
- 'Less Important'
- 'General'
- 'Important'
- 'Very Important'

The respondents were firstly asked to indicate the degree of importance of the eighteen factors in the questionnaire. Then, the Factor (18) "Congestion Level" were further divided into 6 levels (such as Level of Service A, B, C, D, E and F) for assessing the pedestrian responses to various congestion levels on crosswalk.

### 2.2 Photography

Photographs were taken at the selected signalized crosswalk site to present the degree of congestion, before the pedestrian preference interview surveys were carried out. There are six levels such as Level of Service A, B, C, D, E and F. Six photographs of each LOS A to E were generated from a total of 120 photographs and shown in Figure 2. After the respondents indicated the degree of importance of the eighteen factors on the questionnaire, they were asked to select the breakpoints or the maximum congestion boundary of each level of service. Therefore, the area occupancy of LOS A-E could be calculated. The area occupancy range of signalized crosswalks of LOS F would then be less than the maximum congestion boundary of the LOS E.

## 3. DATA ANALYSIS

The degree of importance of the factors leading to pedestrian choice regarding the signalized crosswalk was evaluated. A total of 303 respondents were requested to complete the pedestrian preference questionnaire. The respondent rate is 74% (i.e. which is equal to 225 respondents). Normalized indices were used to evaluate the importance of factors for designing the LOS of a signalized crosswalk.

**Photo No. A1**

**7 pedestrians**
**6.36 m$^2$/ped**

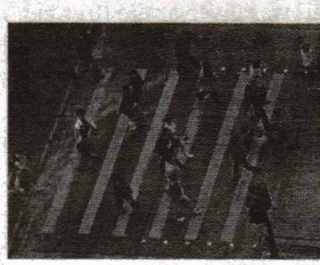

**Photo No. A6**

**16 pedestrians**
**2.78 m$^2$/ped**

**Photo No. B1**

**17 pedestrians**
**2.62 m$^2$/ped**

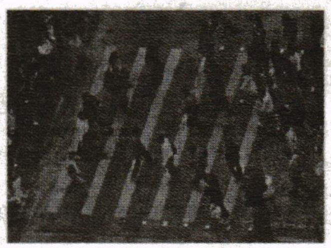

**Photo No. B6**

**25 pedestrians**
**1.78 m$^2$/ped**

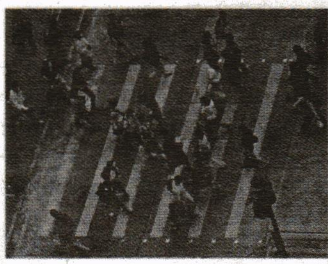

**Photo No. C1**

**26 pedestrians**
**1.71 m$^2$/ped**

**Photo No. C6**

**39 pedestrians**
**1.14 m$^2$/ped**

**Photo No. D1**

**44 pedestrians**
**1.01 m$^2$/ped**

**Photo No. D6**

**68 pedestrians**
**0.65 m$^2$/ped**

**Photo No. E1**

**70 pedestrians**
**0.64 m$^2$/ped**

**Photo No. E6**

**96 pedestrians**
**0.46 m$^2$/ped**

Figure 2 Photographs for LOS A-E

The indices of the eighteen factors were calculated based on the weights:

- 'Not Important' was given a negative two (-2) weight
- 'Less Important' was assigned a negative one (-1) weight
- 'General' was given a zero (0) weight
- 'Important' was assigned a positive one (+1) weight
- 'Very Important' was given a positive two (+2) weight

Therefore, the index of each factor can be calculated by the following equation.

$$\text{Index of factor i} = \frac{\sum_{j=1}^{5} W_j \times f_{ij}}{\sum_{j=1}^{5} f_{ij}} \qquad (1)$$

where $W_j$ = weights of the degree of importance j of factors (-2, -1, 0, 1, 2);

$f_{ij}$ = corresponding frequencies of the degree of importance j of factor i;

$\sum_{j=1}^{5} f_{ij} = 225$ (total number of respondents).

The ranks of the factors were then based on the indices calculated using equation (1). The higher the index, the higher is the ranking. Stabilization check of the rank of the pedestrian preference factors was conducted for testing the sample size required. The ranks of eighteen factors were re-calculated with different sample size (i.e. 50, 100, 150, 200 and 225). In order to assess the degree of importance of the congestion level, each respondent was asked to choose the breakpoints or the maximum congestion boundary from the six photographs of LOS A to E. The mean breakpoints of each LOS standard could then be calculated as follow:

$$\text{Mean breakpoint of LOS i} = \frac{\sum_{j=1}^{6} D_{ij} \times f_{ij}}{\sum_{j=1}^{6} f_{ij}} \qquad (2)$$

where $D_{ij}$ = corresponding area occupancy of photo j of LOS i;

$f_{ij}$ = corresponding frequencies of pedestrian preference on photo j of LOS i;

$\sum_{j=1}^{6} f_{ij} = 225$ (total number of respondents).

In order to determine which factor was significant for a particular LOS, the ranges and the weights of area occupancies of six LOS standards were calculated by the following equations respectively.

$$\text{Range of area occupancy of LOS i} \quad R_i = \text{Upper limit of area occupancy} - \text{Lower limit of area occupancy} \qquad (3)$$

Weight of area occupancy of LOS i $= \dfrac{R_i}{\sum_{i=1}^{6} R}$ (4)

The composite indices of the LOS A to F in terms of the 17 qualitative factors (except the congestion level) are calculated by the following equation. The significance of a factor to a particular LOS is then monitored.

Composite index of factor i on LOS j $C_{ij}$ = Weight of factor i × Weight of LOS j (5)

## 4. RESULTS AND COMPARISONS

In order to ensure the collected samples were adequate, stabilization check of the sample size was conducted. The ranks of the eighteen factors were re-calculated with different sample size (i.e. 50, 100, 150, 200 and 225). The ranks of the factors were then based on the indices calculated using equation (1). The higher the index, the higher is the ranking. The stabilization check of the sample size required is shown in Table 2. It can be seen in Table 2 that the tendency of the priority of factors is quite stable.

Table 2 Stabilization check of the adequacy of the sample

| No. | Factors \ No. of Samples | Rank of factors | | | | |
|---|---|---|---|---|---|---|
| | | 50 | 100 | 150 | 200 | 225 |
| (14) | Waiting time for crossing | 2 | 2 | 2 | 1 | 1 |
| (12) | Green time of pedestrian signal | 1 | 1 | 1 | 2 | 2 |
| (18) | Congestion level | 3 | 3 | 3 | 3 | 3 |
| (13) | Time for crossing carriageway | 4 | 4 | 4 | 4 | 4 |
| (5) | Lighting in crosswalk area | 6 | 6 | 5 | 5 | 5 |
| (15) | Walking distance to crosswalk | 5 | 5 | 6 | 6 | 6 |
| (11) | Size of stagger block or mid-block | 8 | 7 | 8 | 7 | 7 |
| (10) | Length of crosswalk | 7 | 8 | 7 | 8 | 8 |
| (16) | Surface condition of crosswalk | 13 | 14 | 11 | 9 | 9 |
| (7) | Presence of fencing | 10 | 9 | 9 | 11 | 10 |
| (17) | Habituate to use | 9 | 10 | 10 | 10 | 11 |
| (6) | Solitary location | 15 | 13 | 13 | 12 | 12 |
| (9) | Width of crosswalk | 12 | 15 | 14 | 13 | 13 |
| (3) | Without weather protection | 11 | 11 | 12 | 14 | 14 |
| (1) | Air quality | 14 | 12 | 15 | 15 | 15 |
| (8) | Footbridge or subway provided | 17 | 16 | 16 | 16 | 16 |
| (2) | Noise quality | 16 | 17 | 17 | 17 | 17 |
| (4) | Presence of trees / shrubs | 18 | 18 | 18 | 18 | 18 |

Table 3 shows the frequency and weights for the degree of importance of each factor chosen by the 225 respondents. In total, there are eighteen factors belonged to the four key factors. Table 3 presents the ranking of these 18 factors after normalization. A total of 225 respondents were requested to complete the pedestrian preference questionnaire.

Table 3 Frequency of degree of importance and the ranking of factors after normalization

| No. | Factors \ Weight | Not Important -2 | Less Important -1 | General 0 | Important 1 | Very Important 2 | Total Frequency | Rank |
|---|---|---|---|---|---|---|---|---|
| | **Comfortability** | | | | | | | |
| (1) | Air Quality | 60 | 14 | 35 | 89 | 27 | 225 | 15 |
| (2) | Noise Quality | 48 | 47 | 67 | 51 | 12 | 225 | 17 |
| (3) | Without Weather Protection | 17 | 48 | 58 | 77 | 25 | 225 | 14 |
| (4) | Presence of Trees / Shrubs | 47 | 53 | 53 | 67 | 5 | 225 | 18 |
| | **Safety** | | | | | | | |
| (5) | Lighting in Crosswalk Area | 6 | 16 | 58 | 112 | 33 | 225 | 5 |
| (6) | Solitary Location | 35 | 27 | 47 | 64 | 52 | 225 | 12 |
| (7) | Presence of Fencing | 11 | 36 | 56 | 98 | 24 | 225 | 10 |
| (8) | Footbridge or Subway provided | 48 | 32 | 74 | 38 | 33 | 225 | 16 |
| | **Convenience** | | | | | | | |
| (9) | Width of Crosswalk | 20 | 26 | 76 | 95 | 8 | 225 | 13 |
| (10) | Length of Crosswalk | 17 | 10 | 63 | 108 | 27 | 225 | 8 |
| (11) | Size of Stagger-Block or Mid-Block | 12 | 19 | 52 | 110 | 32 | 225 | 7 |
| (12) | Green Time of Pedestrian Signal | 4 | 11 | 24 | 111 | 75 | 225 | 2 |
| (13) | Time for Crossing Carriageway | 10 | 9 | 32 | 120 | 54 | 225 | 4 |
| (14) | Pedestrian Waiting Time for Crossing | 2 | 7 | 39 | 99 | 78 | 225 | 1 |
| (15) | Walking Distance to Crosswalk | 16 | 9 | 69 | 83 | 48 | 225 | 6 |
| (16) | Surface Condition of Crosswalk | 20 | 19 | 80 | 58 | 48 | 225 | 9 |
| (17) | Habituate to use | 15 | 4 | 107 | 77 | 22 | 225 | 11 |
| | **Level of Congestion** | | | | | | | |
| (18) | Congestion Level | 8 | 11 | 23 | 134 | 49 | 225 | 3 |

Figure 3 shows the prioritized pedestrian preferred factors for all respondents, together with the normalized index of each factor. Weights were normalized to be able to compare with other factors. It can be seen that the pedestrians were concerned more with the waiting time for crossing the signalized crosswalk and also the green time of the pedestrian signal. Congestion level and the time for crossing the facility were also given much importance being the third and fourth highest along the ranking of all factors respectively. Respondents considered the environmental factors such as weather protection, air quality, noise quality and presence of trees or shrubs to be less important. The respondents showed disinterest in the provision of an adjacent footbridge or subway. It appears that pedestrians in Hong Kong are less conscious of the environment and more concerned about the time.

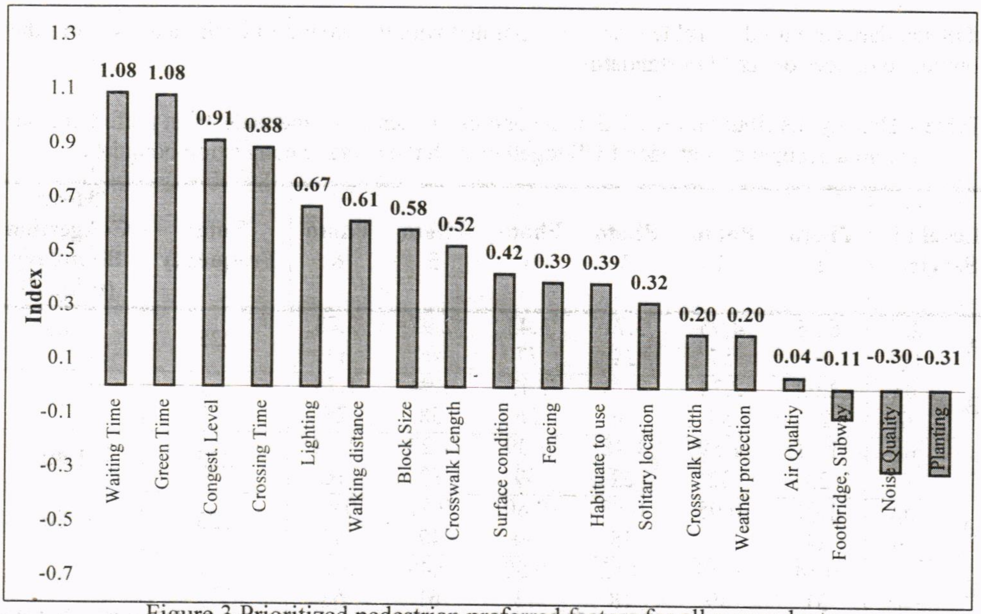


Figure 3 Prioritized pedestrian preferred factors for all respondents

Table 4 summarizes the density distribution revealed in the six photos of the five LOS standards for signalized crosswalks. It also indicated the pedestrian preference on the area occupancies of each LOS standard. The total frequency is 225 respondents. The mean congestion boundary of each service standard level was also calculated using equation (2) and is also shown in Table 4.

A comparison of six LOS standards proposed for signalized crosswalks in Hong Kong was made against the LOS standards for walkways proposed by Fruin (1987), Gerilla (1995) in Manila and Tanaboriboon et al. (1989) in Bangkok. The comparison is shown in Figure 4. It can be seen that the six LOS standards for signalized crosswalks in Hong Kong are slightly different from those of Fruin's and Gerilla's but quite different from Tanaboriboon's. Especially in LOS A, the area occupancy of signalized crosswalk facilities in Hong Kong was much higher than that of walkways studied by Fruin, Gerilla and Tanaboriboon. Pedestrians in Hong Kong possibly expect a walking area with more space and more comfort environment when they cross the signalized crosswalk under LOS A. The area occupancies of LOS B, C, D, E and F standards in signalized crosswalks in Hong Kong are quite close to the one proposed by Fruin but significantly different from the one in Manila and in Bangkok. This can be partially explained by the fact that pedestrians in Hong Kong have limited green time to transverse the signalized crosswalk due to the heavy vehicular traffic in urban areas. It is believed that pedestrians would have different perception on various LOS under different circumstances. There is a need to carry out similar study for assessing LOS for different walking facilities.

Table 5 shows the ranges and weights of area occupancy of six LOS standards, which were calculated using equations (3) and (4) respectively. Note that the upper and lower limits of the area occupancy of LOS F replicated the maximum congestion boundary of LOS E and the body ellipse proposed by Fruin (1987) respectively. The weights of area occupancy of six

LOS standards are used in Table 6 and incorporated with the weight of each factor to form the composite indices of six LOS standards.

Table 4 Density distribution revealed in the photos of each LOS and pedestrian preference on the area occupancies at each LOS together with the average congestion boundary

| Level of Service | | Photo 1 | Photo 2 | Photo 3 | Photo 4 | Photo 5 | Photo 6 | Total Frequency | Mean Congestion Boundary ($m^2$/ped) |
|---|---|---|---|---|---|---|---|---|---|
| A | $d_A$* | 6.36 | 4.95 | 3.71 | 3.43 | 2.97 | 2.78 | 225 | 3.85 |
| | $f_A$* | 10 | 57 | 24 | 77 | 46 | 11 | | |
| B | $d_B$ | 2.62 | 2.34 | 2.23 | 2.12 | 1.94 | 1.78 | 225 | 2.16 |
| | $f_B$ | 25 | 55 | 36 | 26 | 58 | 25 | | |
| C | $d_C$ | 1.71 | 1.59 | 1.48 | 1.39 | 1.27 | 1.14 | 225 | 1.40 |
| | $f_C$ | 23 | 32 | 22 | 49 | 83 | 16 | | |
| D | $d_D$ | 1.01 | 0.95 | 0.87 | 0.80 | 0.71 | 0.65 | 225 | 0.80 |
| | $f_D$ | 24 | 27 | 35 | 50 | 47 | 42 | | |
| E | $d_E$ | 0.64 | 0.59 | 0.52 | 0.50 | 0.48 | 0.46 | 225 | 0.52 |
| | $f_E$ | 31 | 39 | 18 | 13 | 61 | 63 | | |

Notes: $d_A$ is the area occupancy ($m^2$/ped) at each photo for Level of Service A.
$f_A$ is the frequency of each photo chosen for Level of Service A.

Table 6 illustrates the composite indices of the six LOS standards by factors. Columns one and two in the table show the 17 prioritized factors and the normalized indices or weights extracted from Figure 4 respectively. The weights of the six LOS standards are shown in the 1st row of Table 6. Therefore, the composite index of each factor of each LOS can be calculated using the equation (5).

In order to determine the significant factors for each LOS, a 99% confidence interval of the mean of the composite index of the six LOS standards is used.

The mean of the composite index of six LOS standards $\bar{x} = 0.0654$
The standard deviation of the composite index of six LOS standards s = 0.1025

A 99% confidence interval of the mean of the composite index of the six LOS standards are as follows:

$$\bar{x} - t_{\alpha,n-1}\frac{s}{\sqrt{n-1}}$$

$$= 0.0654 - 2.69 \times \frac{0.1025}{\sqrt{17 \times 6 - 1}}$$

$$= 0.0379$$

Therefore, for each design level, a minimum value of 0.0379 is the recommended standard breakpoint and marked by a dark bold line in Table 6. All the composite indices above 0.0379 in each LOS are the minimum proposed qualities at the particular design level. Table 6 illustrates the minimum proposed qualities of each LOS. They are highlighted in grey. They should be considered when designing a LOS standard for signalized crosswalks since their effects with respect to the level of congestion of the signalized crosswalk facilities are significant.

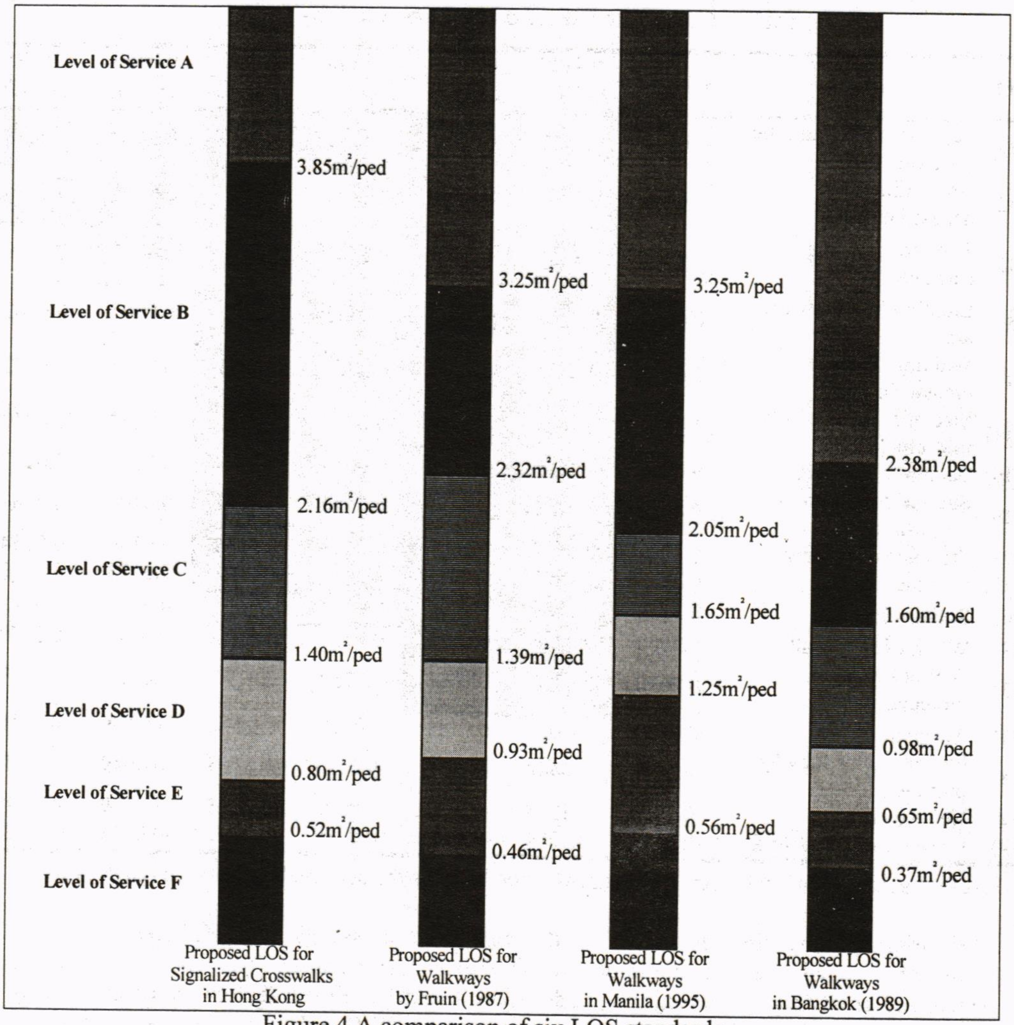


Figure 4 A comparison of six LOS standards

Table 5 Weights of area occupancy for each LOS standards

| Level of Service | Area Occupancy from Table 2: Upper Limit ($m^2$/ped) | Area Occupancy from Table 2: Lower Limit ($m^2$/ped) | Range of Area Occupancy $R_i$ ($m^2$/ped) | Weight of Area Occupancy |
|---|---|---|---|---|
| A | 6.36[a] | 3.85 | 2.51 | 0.4128 |
| B | 3.85 | 2.16 | 1.69 | 0.2780 |
| C | 2.16 | 1.40 | 0.76 | 0.1250 |
| D | 1.40 | 0.80 | 0.60 | 0.0987 |
| E | 0.80 | 0.52 | 0.28 | 0.0460 |
| F | 0.52 | 0.28[b] | 0.24 | 0.0395 |

Note: (a) 6.36 $m^2$/ped is the area occupancy extracted from Photo A1.
(b) 0.28 $m^2$/ped is the body ellipse proposed by Fruin(1987).

Table 6 Composite indices of the LOS A to F by factors

| No. | Factors | Weight | 0.4128 LOS A | 0.2780 LOS B | 0.1250 LOS C | 0.0987 LOS D | 0.0460 LOS E | 0.0395 LOS F |
|---|---|---|---|---|---|---|---|---|
| (14) | Pedestrian waiting time for crossing | 1.0844 | 0.4477 | 0.3014 | 0.1356 | 0.1070 | 0.0499 | 0.0428 |
| (12) | Green time for pedestrian signal | 1.0756 | 0.4440 | 0.2990 | 0.1344 | 0.1061 | 0.0495 | 0.0425 |
| (13) | Time for crossing carriageway | 0.8844 | 0.3651 | 0.2458 | 0.1106 | 0.0873 | 0.0407 | 0.0349 |
| (5) | Lighting in crosswalk area | 0.6667 | 0.2752 | 0.1853 | 0.0833 | 0.0658 | 0.0307 | 0.0263 |
| (15) | Walking distance to crosswalk | 0.6133 | 0.2532 | 0.1705 | 0.0767 | 0.0605 | 0.0283 | 0.0242 |
| (11) | Size of stragger block or mid-block | 0.5822 | 0.2404 | 0.1618 | 0.0728 | 0.0575 | 0.0268 | 0.0230 |
| (10) | Length of crosswalk | 0.5244 | 0.2165 | 0.1458 | 0.0656 | 0.0518 | 0.0242 | 0.0207 |
| (16) | Surface condition of crosswalk | 0.4222 | 0.1743 | 0.1174 | 0.0528 | 0.0417 | 0.0194 | 0.0167 |
| (7) | Presence of fencing | 0.3911 | 0.1615 | 0.1087 | 0.0489 | 0.0386 | 0.0180 | 0.0154 |
| (17) | Habituate to use | 0.3867 | 0.1596 | 0.1075 | 0.0483 | 0.0382 | 0.0178 | 0.0153 |
| (6) | Solitary location | 0.3156 | 0.1303 | 0.0877 | 0.0394 | 0.0311 | 0.0145 | 0.0125 |
| (9) | Width of crosswalk | 0.2000 | 0.0826 | 0.0556 | 0.0250 | 0.0197 | 0.0092 | 0.0079 |
| (3) | Without weather protection | 0.2000 | 0.0826 | 0.0556 | 0.0250 | 0.0197 | 0.0092 | 0.0079 |
| (1) | Air quality | 0.0400 | 0.0165 | 0.0111 | 0.0050 | 0.0040 | 0.0018 | 0.0016 |
| (8) | Footbridge or subway provided | -0.1067 | -0.0440 | -0.0297 | -0.0133 | -0.0105 | -0.0049 | -0.0042 |
| (2) | Noise quality | -0.3022 | -0.1248 | -0.0840 | -0.0378 | -0.0298 | -0.0139 | -0.0119 |
| (4) | Presence of trees/shrubs | -0.3111 | -0.1284 | -0.0865 | -0.0389 | -0.0307 | -0.0143 | -0.0123 |

Note: Factor (18) Congestion level is now referred to as the six levels of service (LOS A to F).

Pedestrian waiting time for crossing the signalized crosswalk and the green time for pedestrian signal are the minimum requirements for consideration when designing a signalized crosswalk. Interestingly, under LOS A and B, thirteen factors are considered by the respondents. The minimum proposed qualities of LOS C and LOS D are very close that the respondents consider eleven and ten factors respectively. Similarly to LOS E and LOS F, there are only three and two factors were considered by the respondents. It can also be seen that the composite index for each factor at LOS E and F are also very close. This implies that the degree of importance concerning these factors in a signalized crosswalk facility for the previously mentioned levels of service are very similar.

## 5. CONCLUSIONS

Safe walking is of prime importance in the design and development of pedestrian facilities particularly signalized crosswalk. Thus, an examination of the pedestrian behavior and preference is of major initial concern. An efficient walk for pedestrians to transverse the signalized crosswalk also relates to the LOS standards. With this mind, this paper was undertaken with the aim to investigate the LOS for signalized crosswalks in Hong Kong urban areas.

Time for pedestrians in HK was found to be the most important factor of concern with an interest in the environment being of low priority. Pedestrian waiting time to cross the signalized crosswalk, green time for pedestrian signal, level of congestion and the time taken to cross the carriageway were the top four qualitative factors to emerge from pedestrian preference interview surveys. It can be concluded that pedestrian waiting time for crossing and green time for pedestrian signals were found to be the two minimum requirements for consideration in design of a signalized crosswalk facility. The proposed LOS standards incorporated with the pedestrian preferences is significant in the design of signalized crosswalk facilities.

This study has revealed that the proposed LOS standards (except LOS A) for signalized crosswalks in Hong Kong are quite close to the one proposed by Fruin but significantly different from the one in Manila and Bangkok. It is believed that pedestrians would have different perception on various LOS under different circumstances. There is a need to carry out similar study for assessing LOS for different walking facilities.

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