PEDESTRIAN SAFETY: INFRASTRUCTURE AND MODELLING

‘International Course on Transportation Planning and Road Safety’
05-12 Dec 2019

K Ramachandra Rao
MoUD Chair Professor
Department of Civil Engineering and Transportation Research and Injury Prevention Programme (TRIPP)
Indian Institute of Technology Delhi
Outline

• Pedestrian - who?
• Safety
• Design guidelines
  • IRC (Indian Roads Congress)
  • ITDP (Institute for Transportation & Development Policy)
  • UTTIPEC (Unified Traffic and Transportation Infrastructure {Plg. & Engg.} Centre) → Design Toolkit
• Other Design Practice
  • HCM
  • NZTA
• Best Practices
• Way forward
Pedestrian – Who?

• Every person living on earth – a pedestrian
• The World Health Organization (WHO, 2013) defines “A pedestrian is any person who is travelling by walking for at least part of his or her journey.
• In addition to the ordinary form of walking, a pedestrian may be using various modifications and aids to walking such as wheelchairs, motorized scooters, walkers, canes, skateboards, and roller blades.
• The person may carry items of varying quantities, held in hands, strapped on the back, placed on the head, balanced on shoulders, or pushed/pulled along. A person is also considered a pedestrian when running, jogging, hiking, or when sitting or lying down in the roadway.”
Pedestrian – Who?

- A favourable environment for pedestrians would mean a favourable environment for ALL.
- The integration of the concept of universal design is desired.
- Street design has to answer inclusivity and accessibility for ALL.
- Walking is slowest of all other modes of transport, this slow pace has a lot of advantage as at this pace we can see distinguish between people, feel and understand the environment nearby.
Pedestrian – Who?

• In order to serve the above requirements and make walking a pleasurable experience there are 3 basic principles
  • Coherence and directness,
  • Attractiveness & comfort and
  • Safety & security

• Walking is the basis of human movement, it is while walking we observe, connect, interact and learn

• The benefits of walking can be classified into Economic, Environmental, Social and Health benefits, all of these benefits lead to a better quality of life for people
Background - safety

- Road accidents are a leading cause of death of young people between the age of 10 – 24 years. (WHO)
- In the year 2018 about 1,51,417 people died in road crashes in India while the number of injured were 4,69,418 (MoRTH, 2019).
- However, the actual number of injuries requiring hospital visits are 20,00,000 to 30,00,000
- MoRTH report shows that 15% pedestrian deaths
- On average 40% of the total fatalities are pedestrian fatalities (NCRB figures show this figure around 10%), where the highest is 78% in Mumbai and the lowest is 11% in Udaipur
Taxonomy of road safety

- There are four ways of reducing the number of persons killed or injured in road accidents (Elvik, 2009):
  - By reducing exposure to the risk of accident, that is, by reducing the amount of travel
  - By shifting travel to means of transport that have a lower level of risk
  - By reducing the accident rate for a given amount of travel
  - By reducing accident severity, that is, by protecting people better from injury
Risk of accident - pedestrian

Figure 3.10: Relative injury rates for different means of transport – mean for five countries.

Elvik, 2009 (Data: Sweden, Denmark, Norway, UK, Netherlands)
Measurement of Pedestrian safety

- High Pedestrian safety is defined as few pedestrian crashes per million crossing (or passing) pedestrians at an intersection or per million pedestrian-kilometres walked (Garder, 2018).
- To obtain a sustainable environment, pedestrians should not only be allowed to walk more or less everywhere but also be encouraged to do so.
- A sidewalk is more attractive if it is set back from the roadway by a grass or vegetation strip.

Fig. 1. Paved Sidewalk along an Exurban Arterial Highway in Readfield, Maine, US.
Design of Pedestrian Facilities

Pedestrian fatalities as proportion of total road traffic deaths

Share of cyclists and pedestrians in road accidents

Source: MoUD, 2009

Pedestrian fatalities of Delhi as proportion of total road traffic deaths. (WHO, 2013)
34% of the population engages in "Walk-only" trips for their daily travels, needs or errands.

Only 14% population of Delhi rives private cars.

40% of the total Road Length of Delhi has NO Sidewalks! *

And the ones having sidewalks, lack in quality in terms of surface, width and geometrics. *

* Source: RITES Transport Demand Forecast Study: May 2008

Pedestrian Infrastructure - Nomenclature

• Off-street facilities - Walkways
• On-street Sidewalks/Footpath
• Crosswalks
  • Un-signalized
  • Signalized
  • Mid-block
Footpaths

- A footpath is the part of road or other public place that is laid out or built for pedestrian use.
- Footpaths may run alongside the road or through parks and other open spaces, and include overbridges and subways.
- Footways are those parts of access roads which are intended for use by pedestrians, and which generally are parallel with the carriageways and separated by curb or verge and the curb.
- Footpaths are those pedestrian routes which are located away from carriageways and not associated with routes of motor vehicles.
Policy and design guidelines - India

- National Urban Transport Policy (NUTP), 2006
- National Mission on Sustainable Habitat (NMSH)
- UTTIPEC (Unified Traffic and Transportation Infrastructure. {Planning & Engineering} Centre), Delhi Development Authority (DDA), 2009
- IRC Guidelines addressing pedestrians
  - IRC: 103-2012 - Guidelines for pedestrian facilities
- Master plan of Delhi-2021, 2007
- Institute for Transportation and Development Policy (ITDP), 2013
## Comparison of guidelines

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>UTTIPEC</th>
<th>IRC</th>
<th>ITDP</th>
<th>IUT CODES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Streets valuable urban spaces.</td>
<td>Reduce pedestrian conflicts to vehicular traffic to a minimum.</td>
<td>Comfort, continuity, and safety are the governing criteria for the design and construction of pedestrian facilities</td>
<td>The primary purpose of IUT is to provide code of practice for various urban components.</td>
<td></td>
</tr>
<tr>
<td>Increase comfort of current walking population</td>
<td>More equity in space allocation of roads.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>More equity in space allocation of roads.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SIDEWALK</td>
<td>Sidewalks to be of 3 pavement zones, which are Dead width, pedestrian zone and planting zone.</td>
<td>Provide guidelines for sidewalk.</td>
<td>Footpaths designed as per the zoning system (frontage, pedestrian, furniture zone) to provide uninterrupted walking space for Pedestrians.</td>
<td>Exclusive, continuous lanes for slow modes.</td>
</tr>
<tr>
<td></td>
<td>Clear walking zone of min width 1.8m</td>
<td>Minimum side walk width should be 1.5 m. Which should vary from 2-4 according to pedestrian volume. (obstructed width not included)</td>
<td></td>
<td>Shaded path with facilities like hawking, benches etc.</td>
</tr>
<tr>
<td></td>
<td>Kerb height should not exceed 150mm.</td>
<td></td>
<td></td>
<td>Sidewalk width ranging from 1.5 to 5.5 as per the road type.</td>
</tr>
<tr>
<td></td>
<td>Maximum corner curb radii 12m.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Continuous pavement.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Universal accessibility.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Footpath standards (IRC 103-2012)

- Primary area used by all pedestrians
- Provided at all major trip generating points
- Constructed above the carriageway separated by kerbs
- Minimum 1.8 m (width) x 2.2 m (height) clear from all obstructions
- All footpaths have three zones: frontage zone, pedestrian zone and furniture zone

https://www.itdp.org/footpath-basics/
The minimum width of footpath varies with type of adjacent land use

<table>
<thead>
<tr>
<th>Type of facility</th>
<th>Footpath width (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential/mixed land use</td>
<td>1.8</td>
</tr>
<tr>
<td>Commercial</td>
<td>2.5</td>
</tr>
<tr>
<td>Shopping</td>
<td>3.5 to 4.5</td>
</tr>
<tr>
<td>Bus stops</td>
<td>3</td>
</tr>
<tr>
<td>High intensity commercial areas</td>
<td>4</td>
</tr>
</tbody>
</table>

https://www.itdp.org/footpath-basics/
Footpaths are designed for level of service B and level service C (under resource constraint).

The width of the footpath should be designed based on expected pedestrian traffic.

<table>
<thead>
<tr>
<th>Sidewalk width (m)</th>
<th>Design flow in number of pedestrians/hour</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In both directions</td>
</tr>
<tr>
<td></td>
<td>LOS B</td>
</tr>
<tr>
<td>1.5</td>
<td>1350</td>
</tr>
<tr>
<td>2.0</td>
<td>1800</td>
</tr>
<tr>
<td>2.5</td>
<td>2250</td>
</tr>
<tr>
<td>3.0</td>
<td>2700</td>
</tr>
<tr>
<td>3.5</td>
<td>3150</td>
</tr>
<tr>
<td>4.0</td>
<td>3600</td>
</tr>
</tbody>
</table>
Footpath standards (IRC 103-2012)

<table>
<thead>
<tr>
<th>Side walk width (m)</th>
<th>Design flow in number of pedestrians/hour</th>
<th>In both directions</th>
<th>In one direction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In both directions</td>
<td>In one direction</td>
<td>In both directions</td>
</tr>
<tr>
<td></td>
<td>LOS B ped/min/m</td>
<td>LOS C ped/min/m</td>
<td>LOS B ped/min/m</td>
</tr>
<tr>
<td>1.5</td>
<td>1350 15</td>
<td>1890 21</td>
<td>2025 22.5</td>
</tr>
<tr>
<td>2</td>
<td>1800 15</td>
<td>2520 21</td>
<td>2700 22.5</td>
</tr>
<tr>
<td>2.5</td>
<td>2250 15</td>
<td>3150 21</td>
<td>3325 22.2</td>
</tr>
<tr>
<td>3</td>
<td>2700 15</td>
<td>3780 21</td>
<td>4050 22.5</td>
</tr>
<tr>
<td>3.5</td>
<td>3150 15</td>
<td>4410 21</td>
<td>4725 22.5</td>
</tr>
<tr>
<td>4</td>
<td>3600 15</td>
<td>5040 21</td>
<td>5400 22.5</td>
</tr>
</tbody>
</table>

Exhibit 18-3 (HCM, 2000)/Exhibit 23-1 (HCM, 2010)

EXHIBIT 18-3. AVERAGE FLOW LOS CRITERIA FOR WALKWAYS AND SIDEWALKS

<table>
<thead>
<tr>
<th>LOS</th>
<th>Space (m²/p)</th>
<th>Flow Rate (p/min/m)</th>
<th>Speed (m/s)</th>
<th>v/c Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>&gt; 5.6</td>
<td>≤ 16</td>
<td>&gt; 1.30</td>
<td>≤ 0.21</td>
</tr>
<tr>
<td>B</td>
<td>&gt; 3.7–5.6</td>
<td>&gt; 16–23</td>
<td>&gt; 1.27–1.30</td>
<td>&gt; 0.21–0.31</td>
</tr>
<tr>
<td>C</td>
<td>&gt; 2.2–3.7</td>
<td>&gt; 23–33</td>
<td>&gt; 1.22–1.27</td>
<td>&gt; 0.31–0.44</td>
</tr>
<tr>
<td>D</td>
<td>&gt; 1.4–2.2</td>
<td>&gt; 33–49</td>
<td>&gt; 1.14–1.22</td>
<td>&gt; 0.44–0.65</td>
</tr>
<tr>
<td>E</td>
<td>&gt; 0.75–1.4</td>
<td>&gt; 49–75</td>
<td>&gt; 0.75–1.14</td>
<td>&gt; 0.65–1.0</td>
</tr>
<tr>
<td>F</td>
<td>≤ 0.75</td>
<td>variable</td>
<td>≤ 0.75</td>
<td>variable</td>
</tr>
</tbody>
</table>
Footpath standards (IRC 103-2012)-Kerb height and surface quality

- Kerb height should not exceed 150 mm
- Even paved surfaces are important to people using sticks and wheel chairs
- The gap between paving slabs should not exceed 5 mm

![Incorrect example of kerb height](image1)

![Correct example of kerb height](image2)
Footpath elements (IRC 103-2012)

- Footpaths should provide continuous space for walking of pedestrians
- Bus stops, services, vendors, access to several types of properties, cross walks etc. are common on footpath
- Well use of a footpath depends on successful integration of different footpath elements

https://www.itdp.org/footpath-basics/
Footpath elements - (IRC 103-2012)

A tabletop pedestrian crossing should be provided at an interval of at least every 200 m. The crossing should be at the same level as the footpath.

Parallel parking for cars uses space efficiently and increases safety for vehicles exiting the parking bay. The same space can be used for perpendicular parking of two wheelers. Material for the parking bay should be different from that used for the carriageway.

Space for vendors can be given in the furniture zone. Wherever there is any shortage of space, the parking slots can be replaced with bulbouts for vendors.

Dedicated space should be provided for trees and utilities away from the path of travel of pedestrians.

Bulbouts at pedestrian crossings reduce the walking distance across the carriageway.

https://www.itdp.org/footpath-basics/
Access to properties (IRC 103-2012)

A footpath that constantly changes levels discourages pedestrians from using it. Pedestrians prefer to walk on the carriageway instead.

Footpaths that maintain a constant level through property entrances are convenient for pedestrians to use. Vehicles use a ramp, helping to reduce speeds.

https://www.itdp.org/footpath-basics/
Vending

If streets do not provide designated zones for vending, these activities can become obstructions to the movement of pedestrians.

Footpaths should be designed such that there is sufficient space for vending outside of the pedestrian zone (IRC:103-2012, 6.11.2).

https://www.itdp.org/footpath-basics/
Kerb ramps (IRC 103)

- Kerb ramp is useful for providing smooth transition between carriageway and footpath, at each pedestrian crossing on opposite site of the street and in the vicinity of building entrances.
- Standard gradient not greater than 1:12
- Width should not be less than 1200 mm
Tactile pavers (IRC 103)

- To guide the pedestrians with vision impairment
- It is important that, whichever tactile pavers are used for guiding or warning, they should be used consistently used to avoid confusion.

Guide blocks indicate the correct route to follow, bus stops, property etc.

Configuration of floor tactile paving

tactile paving to avoid obstacles

warning blocks to screen off the obstacles
Tactile paving - UTTIPEC
Level of service guidelines for walkways (IRC 103-2012)

**LOS A**
Pedestrian Space > 4.9 m²/p. Flow Rate ≤ 12 p/min/m
At a walkway LOS A, pedestrian move in desired paths without altering their movements in response to other pedestrian. Walking speeds are freely selected, and conflicts between pedestrian are unlikely.

**LOS B**
Pedestrian Space > 3.3-4.9 m²/p. Flow Rate ≤ 12-15 p/min/m
At LOS B, there is sufficient area for pedestrian to select walking speeds freely, to bypass other pedestrian, and to avoid crossing conflicts. At this level, pedestrian begin to be aware of other pedestrian, and to respond to their presence when selecting a walking path.

**LOS C**
Pedestrian Space > 1.9-3.3 m²/p. Flow Rate ≤ 15-21 p/min/m
At LOS C, space is sufficient for normal walking speeds, and for bypassing other pedestrian 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 > 1.3-1.9 m²/p. Flow Rate ≤ 21-27 p/min/m
At LOS D, freedom to select individual walking speed and to bypass other pedestrian 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 pedestrian is likely.

**LOS E**
Pedestrian Space > 0.6-1.3 m²/p. Flow Rate ≤ 27-45 p/min/m
At LOS E, virtually all pedestrian restrict their normal walking speed, frequently adjusting their gait. At the lower range, forward movement is possible only by shuffling. Speed is not sufficient for passing slower pedestrian. Cross- or reverse-flow movements are possible only with extreme difficulties. Design volumes approach the limit of walkway capacity, with stoppages and interruption to flow.

**LOS F**
Pedestrian Space ≤ 0.6 m²/p. Flow Rate varies
At LOS F, all walking speeds are severely restricted, and forward progress is made only by shuffling. There is frequent, unavoidable contact with other pedestrian. Cross- and reverse-flow movements are virtually impossible. Flow is sporadic and unstable. Space is more characteristic of queued pedestrian than of moving pedestrian streams.
Speed-density-flow relationship for walkways (IRC 103-2012)

- Speed –flow-density fundamental diagrams produced here are used for the development of level of service values.
Figure 9.12: Flow-Density-Speed-Space relationships for Pedestrian Movement for Various Land uses
Pedestrian Level of Service (PLOS) for footpaths

<table>
<thead>
<tr>
<th>LOS</th>
<th>Commercial</th>
<th>Institutional</th>
<th>Terminal</th>
<th>Recreational</th>
<th>Residential</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>≤ 13</td>
<td>≤ 13</td>
<td>≤ 15</td>
<td>≤ 12</td>
<td>≤ 16</td>
</tr>
<tr>
<td>B</td>
<td>&gt; 13-19</td>
<td>&gt; 13-19</td>
<td>&gt; 15-26</td>
<td>&gt; 12-20</td>
<td>&gt; 16-23</td>
</tr>
<tr>
<td>C</td>
<td>&gt; 19-30</td>
<td>&gt; 19-27</td>
<td>&gt; 26-32</td>
<td>&gt; 20-32</td>
<td>&gt; 23-34</td>
</tr>
<tr>
<td>D</td>
<td>&gt; 30-47</td>
<td>&gt; 27-36</td>
<td>&gt; 32-68</td>
<td>&gt; 32-54</td>
<td>&gt; 34-47</td>
</tr>
<tr>
<td>E</td>
<td>&gt; 41-69</td>
<td>&gt; 36-42</td>
<td>&gt; 68-78</td>
<td>&gt; 54-91</td>
<td>&gt; 47-59</td>
</tr>
<tr>
<td>F</td>
<td>Variable</td>
<td>Variable</td>
<td>Variable</td>
<td>Variable</td>
<td>Variable</td>
</tr>
</tbody>
</table>
HCM (2000, 2010)

- A sidewalk is a paved walkway that is provided at the side of the roadway.
- It is assumed that pedestrians will walk in the street if a sidewalk is not present.
- An indication of sidewalk presence is needed for each side of interest for each segment on the facility.

Exhibit 18-3 (HCM, 2000)/Exhibit 23-1 (HCM, 2010)

<table>
<thead>
<tr>
<th>LOS</th>
<th>Space (m²/p)</th>
<th>Flow Rate (p/min/m)</th>
<th>Speed (m/s)</th>
<th>v/c Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>&gt; 5.6</td>
<td>≤ 16</td>
<td>&gt; 1.30</td>
<td>≤ 0.21</td>
</tr>
<tr>
<td>B</td>
<td>&gt; 3.7–5.6</td>
<td>&gt; 16–23</td>
<td>&gt; 1.27–1.30</td>
<td>&gt; 0.21–0.31</td>
</tr>
<tr>
<td>C</td>
<td>&gt; 2.2–3.7</td>
<td>&gt; 23–33</td>
<td>&gt; 1.22–1.27</td>
<td>&gt; 0.31–0.44</td>
</tr>
<tr>
<td>D</td>
<td>&gt; 1.4–2.2</td>
<td>&gt; 33–49</td>
<td>&gt; 1.14–1.22</td>
<td>&gt; 0.44–0.65</td>
</tr>
<tr>
<td>E</td>
<td>&gt; 0.75–1.4</td>
<td>&gt; 49–75</td>
<td>&gt; 0.75–1.14</td>
<td>&gt; 0.65–1.0</td>
</tr>
<tr>
<td>F</td>
<td>≤ 0.75</td>
<td>variable</td>
<td>≤ 0.75</td>
<td>variable</td>
</tr>
</tbody>
</table>
Urban street facilities – HCM (2010)

**Step 1:** Determine Pedestrian Space

**Step 2:** Determine Pedestrian Travel Speed

**Step 3:** Determine Pedestrian LOS Score

**Step 4:** Determine Pedestrian LOS
Urban street segments – HCM (2010)

- **Step 1**: Determine Free-Flow Walking Speed
- **Step 2**: Determine Average Pedestrian Space
- **Step 3**: Determine Pedestrian Delay at Intersection
- **Step 4**: Determine Pedestrian Travel Speed
- **Step 5**: Determine Pedestrian LOS Score for Intersection
- **Step 6**: Determine Pedestrian LOS Score for Link
- **Step 7**: Determine Link LOS
- **Step 8**: Determine Roadway Crossing Difficulty Factor
- **Step 9**: Determine Pedestrian LOS Score for Segment
- **Step 10**: Determine Segment LOS
Pedestrian Sidewalks on Urban Streets, HCM (2000)

- Basically, there are three sources of input data:
  1. Default values found in this manual;
  2. Estimates or locally derived default values developed by the user; and
  3. Values derived from field measurements and observation.

- For each of the input variables, a value must be supplied to calculate both the primary and secondary outputs.

The analyst must address two fundamental questions:

- First, the primary outputs must be identified; these include LOS and effective width ($W_E$)
- Second, the default values or estimated values must be identified for use as input data for the analysis.
Pedestrian Sidewalks on Urban Streets, HCM (2000) - Steps

- Determine width adjustments (shy distance) to walkway (use Exhibit 18-1)
- Determine effective width \( W_E \) (use Equation 18-1)
- Find \( v_p \) (use Equation 18-2)
- Determine LOS for average condition (use Exhibit 18-3)
- Determine LOS within platoon condition (use Exhibit 18-4)
LOS – Width adjustments

\[ W_E = W_T - W_o \]  \hspace{1cm} (18-1)

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).
LOS – unit flow rate (specific flow)

\[ v_p = \frac{v_{15}}{15 * W_E} \]

where

- \( v_p \) = pedestrian unit flow rate (p/\text{min/m}),
- \( v_{15} \) = peak 15-min flow rate (p/15-min), and
- \( W_E \) = effective walkway width (m).

Exhibit 18-3 (HCM, 2000)/Exhibit 23-1 (HCM, 2010)

<table>
<thead>
<tr>
<th>LOS</th>
<th>Space (m²/p)</th>
<th>Flow Rate (p/min/m)</th>
<th>Speed (m/s)</th>
<th>v/c Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>&gt; 5.6</td>
<td>( \leq 16 )</td>
<td>&gt; 1.30</td>
<td>( \leq 0.21 )</td>
</tr>
<tr>
<td>B</td>
<td>&gt; 3.7–5.6</td>
<td>&gt; 16–23</td>
<td>&gt; 1.27–1.30</td>
<td>&gt; 0.21–0.31</td>
</tr>
<tr>
<td>C</td>
<td>&gt; 2.2–3.7</td>
<td>&gt; 23–33</td>
<td>&gt; 1.22–1.27</td>
<td>&gt; 0.31–0.44</td>
</tr>
<tr>
<td>D</td>
<td>&gt; 1.4–2.2</td>
<td>&gt; 33–49</td>
<td>&gt; 1.14–1.22</td>
<td>&gt; 0.44–0.65</td>
</tr>
<tr>
<td>E</td>
<td>&gt; 0.75–1.4</td>
<td>&gt; 49–75</td>
<td>&gt; 0.75–1.14</td>
<td>&gt; 0.65–1.0</td>
</tr>
<tr>
<td>F</td>
<td>\leq 0.75</td>
<td>variable</td>
<td>\leq 0.75</td>
<td>variable</td>
</tr>
</tbody>
</table>
Platoon adjusted LOS

<table>
<thead>
<tr>
<th>LOS</th>
<th>Space (m²/p)</th>
<th>Flow Rate (p/min/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>&gt; 49</td>
<td>≤ 1.6</td>
</tr>
<tr>
<td>B</td>
<td>&gt; 8–49</td>
<td>&gt; 1.6–10</td>
</tr>
<tr>
<td>C</td>
<td>&gt; 4–8</td>
<td>&gt; 10–20</td>
</tr>
<tr>
<td>D</td>
<td>&gt; 2–4</td>
<td>&gt; 20–36</td>
</tr>
<tr>
<td>E</td>
<td>&gt; 1–2</td>
<td>&gt; 36–59</td>
</tr>
<tr>
<td>F</td>
<td>≤ 1</td>
<td>&gt; 59</td>
</tr>
</tbody>
</table>

Note:
a. Rates in the table represent average flow rates over a 5- to 6-min period.
Pedestrian Sidewalks on Urban Streets, HCM (2000) - Speeds

\[ S_A = \frac{L_T}{\sum \frac{L_i}{S_i} + \sum d_j} \]  

(18-22)

where:

- \( L_T \) = total length of the urban street under analysis (m),
- \( L_i \) = length of Segment i (m),
- \( S_i \) = pedestrian walking speed over Segment i (m/s),
- \( d_j \) = pedestrian delay at Intersection j (s), and
- \( S_A \) = average pedestrian travel speed (m/s).

### Exhibit 18-14. LOS Criteria for Pedestrian Sidewalks on Urban Streets

<table>
<thead>
<tr>
<th>LOS</th>
<th>Travel Speed (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>&gt; 1.33</td>
</tr>
<tr>
<td>B</td>
<td>&gt; 1.17–1.33</td>
</tr>
<tr>
<td>C</td>
<td>&gt; 1.00–1.17</td>
</tr>
<tr>
<td>D</td>
<td>&gt; 0.83–1.00</td>
</tr>
<tr>
<td>E</td>
<td>≥ 0.58–0.83</td>
</tr>
<tr>
<td>F</td>
<td>&lt; 0.58</td>
</tr>
</tbody>
</table>
### EXHIBIT 18-2. PREEMPTION OF WALKWAY WIDTH*

<table>
<thead>
<tr>
<th>Obstacle</th>
<th>Approx. Width Preempted (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Street Furniture</strong></td>
<td></td>
</tr>
<tr>
<td>Light pole</td>
<td>0.8–1.1</td>
</tr>
<tr>
<td>Traffic signal poles and boxes</td>
<td>0.9–1.2</td>
</tr>
<tr>
<td>Fire alarm boxes</td>
<td>0.8–1.1</td>
</tr>
<tr>
<td>Fire hydrants</td>
<td>0.8–0.9</td>
</tr>
<tr>
<td>Traffic signs</td>
<td>0.6–0.8</td>
</tr>
<tr>
<td>Parking meters</td>
<td>0.5</td>
</tr>
<tr>
<td>Mail boxes (0.5 m x 0.5 m)</td>
<td>1.0–1.1</td>
</tr>
<tr>
<td>Telephone booths (0.8 m x 0.8 m)</td>
<td>1.2</td>
</tr>
<tr>
<td>Waste baskets</td>
<td>0.9</td>
</tr>
<tr>
<td>Benches</td>
<td>1.5</td>
</tr>
<tr>
<td><strong>Public Underground Access</strong></td>
<td></td>
</tr>
<tr>
<td>Subway stairs</td>
<td>1.7–2.1</td>
</tr>
<tr>
<td>Subway ventilation gratings (raised)</td>
<td>1.8+</td>
</tr>
<tr>
<td>Transformer vault ventilation gratings (raised)</td>
<td>1.5+</td>
</tr>
<tr>
<td><strong>Landscaping</strong></td>
<td></td>
</tr>
<tr>
<td>Trees</td>
<td>0.6–1.2</td>
</tr>
<tr>
<td>Planter boxes</td>
<td>1.5</td>
</tr>
<tr>
<td><strong>Commercial Uses</strong></td>
<td></td>
</tr>
<tr>
<td>Newsstands</td>
<td>1.2–4.0</td>
</tr>
<tr>
<td>Vending stands</td>
<td>variable</td>
</tr>
<tr>
<td>Advertising displays</td>
<td>variable</td>
</tr>
<tr>
<td>Store displays</td>
<td>variable</td>
</tr>
<tr>
<td>Sidewalk cafes (two rows of tables)</td>
<td>2.1</td>
</tr>
<tr>
<td><strong>Building Protrusions</strong></td>
<td></td>
</tr>
<tr>
<td>Columns</td>
<td>0.8–0.9</td>
</tr>
<tr>
<td>Stoops</td>
<td>0.6–1.8</td>
</tr>
<tr>
<td>Cellar doors</td>
<td>1.5–2.1</td>
</tr>
<tr>
<td>Standpipe connections</td>
<td>0.3</td>
</tr>
<tr>
<td>Awning poles</td>
<td>0.8</td>
</tr>
<tr>
<td>Truck docks (trucks protruding)</td>
<td>variable</td>
</tr>
<tr>
<td>Garage entrance/exit</td>
<td>variable</td>
</tr>
<tr>
<td>Driveways</td>
<td>variable</td>
</tr>
</tbody>
</table>

**Note:**

a. To account for the avoidance distance between pedestrians and obstacles, 0.3 to 0.5 m must be added to the preemption width for individual obstacles. Widths are from curb to edge of object, or building face to edge of object.

Source: Pushkarev and Zupan (9).
Problem

- **The Sidewalk** 4.3-m-wide sidewalk segment bordered by curb on one side and stores with window-shopping displays on the other.
- **The Question** What is the LOS during the peak 15 min on the average and within platoons?
- **The Facts**
  - 15-min peak flow rate = 1,250 p/15-min;
  - Total sidewalk width = 4.3 m;
  - Curb on one side;
  - Window-shopping displays on one side; and
  - No other obstructions.
- **Comments**
  - Assume building buffer (i.e., preempted width) for window displays is 0.9 m.
Planning for pedestrians

- Integrate walking into neighbourhood planning processes
- Determine the appropriate mix of programmes that affect walking
- Coordinate with school and workplace travel plans
- Review district plan provision for walking and resource consent processes
Footpaths – design goals

- Provide footpaths wherever pedestrians will use them
- Use footpath dimensions and geometry that provides access for all
- Choose surface materials for safety, convenience and aesthetics
- Manage design and location of street furniture
- Locate and design driveways appropriately
- Manage conflict on shared paths by good design and operation
- Provide quality connections to public transport
Footpaths – design elements (NZTA, 2009)

- Where to provide footpaths
- Widths
- Overhead and protrusion clearances
- Gradient
- Crossfall
- Surfaces
- Grates and covers
- Landscaping
- Street furniture

- Ramps and steps
- Driveways
- Shared paths
- Public transport interface
Footpaths – some important issues (NZTA)

• Provide footpaths wherever pedestrians will use them
• Use footpath dimensions and geometry that provides access for all
• Choose surface materials for safety, convenience and aesthetics
• Manage design and location of street furniture
• Locate and design driveways appropriately
• Manage conflict on shared paths by good design and operation
• Provide quality connections to public transport
Design guidelines – scientific evidence

• From Fig. I.2 (Speed-Flow-Density Relationships for Directional Movements) of IRC 103-2012, it is evident that the maximum flow for bidirectional flow (1.75(m.s)$^{-1}$) is more than that of unidirectional flow (1.33(m.s)$^{-1}$) situation.

• In contrast, the experiments conducted by Zhang et al. (2011) shows that the maximum flow value for uni-directional flow is 2.0 (m.s)$^{-1}$ and for bidirectional flow 1.5 (m.s)$^{-1}$.
Speed-density-flow relationship for walkways-directional movement (IRC 103-2012)
Pedestrian needs

XIV. STAKEHOLDERS’ REFERENCES (SOME EXAMPLES)

040303 Footpaths should be improved to be more beautiful and convenient.
040303 Improve pavement to promote walking instead of using cars and there should be activities held in communities to urge for public participation.
050102 Make this area a "walking area". No cars will be allowed except buses. Move the central market out. This will help solve the traffic and environmental problems.
070310 Houses and buildings should not be built near the street in order to have more space for people to walk and to grow trees. Building owners should devote some space to extend the walkways.
070509 Establish car free zones to allow easy flow of people and have many kinds of activities together.
100101 Prepare a useful and clear city plan for this area. Promote entering this area by foot and improve pavement to be more beautiful and provide a lot of tourist facilities such as toilets and souvenir shops.
120103 Construct more walkways.
020503 Go by foot if it's not too far.
021001 Keep pavement always clean.
060208 Walking streets have the atmosphere of the old city with a walkway along the river, coffee shop, shops and places for relaxing which are peaceful like Singapore, Santa Monica.
Counter measures

Table 9
Summary of promising countermeasures.

<table>
<thead>
<tr>
<th>Problem area</th>
<th>Exposure</th>
<th>Risk</th>
<th>Consequences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedestrians and other non-motorists in urban areas</td>
<td>Separation of motorized and non-motorized traffic on arterial roads</td>
<td>Speed control</td>
<td>Pedestrian-friendly front ends of vehicles</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Roundabouts</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Restrictions on free left turns</td>
<td></td>
</tr>
<tr>
<td>Pedestrians, other non-motorists, and slow vehicles on highways</td>
<td>Special facilities for slow and local traffic all along highways</td>
<td>Pedestrian detection technology</td>
<td>Pedestrian-friendly front ends of vehicles</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Forward collision warning systems</td>
<td>Crashworthiness of slow vehicles</td>
</tr>
<tr>
<td>Motorcycles and small cars in urban areas</td>
<td>Daytime running lights</td>
<td>Enforcement of helmet-use and seatbelt laws</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Improved lighting and signaling</td>
<td>Introduction of passive measures like airbags</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pedestrian/motorcycle impact standards for small cars</td>
<td></td>
</tr>
</tbody>
</table>

Source: Mohan et al (2009)
Best practices (UTTIPEC, 2009)
Best practices (UTTIPEC, 2009)
Best practices (UTTIPEC, 2009)

01B - Walking Zone Width

1.5 M
Not enough
1.8 M or More
Minimum width for two people to cross each other comfortably

01C - Maximum Kerb* Height

- Maximum height of a pavement (kerb, walking surface, paving) shall not exceed 150 MM (6").
- Foot path and bus stop surfaces should be matt-finish/ anti-skid.

Since the pedestrian flow is determined by land use, the following sidewalk widths can be applied:

- Residential Areas: 2.00 M
- Commercial/ Mixed Uses: 2.50 M
- Commercial Nodes: 4.00 M

In addition to the above, a requisite “dead width” is to be added to all pedestrian zones, as per IRC Standards in Section 02.
Some observations

- Effective width of footpath is reduced due to poles, trees and other objects
- Bad condition of footpaths – geometry, surface and space
- Level difference between footpath and road carriageway is too high and varying (~ 300 mm)
- At some places no footpath (because of obstructions - work zones, hawkers etc.) forcing pedestrian to walk on the carriageway
- Poor pedestrian facilities at work zones
- No pavement markings to guide the pedestrians for crossing the road
- Two wheeler parking and driving on footpaths
- Auto rickshaws and cars occupying the pedestrian spaces at bus stops and at the entry/exit points of metro stations
Way forward

• A strong legislation mandating the provision of footpaths on all the roads in urban environment
• Coherence and uniformity of design specs (across various agencies)
  Inclusive – Universal design concepts
• Active policing to penalize the violators of pedestrian spaces
• Retrofit – identify problems – Toolkits
• Once these basic needs are achieved - access routes to these facilities increases multifold!
  • Work/shopping – Public transport access – bus stops/ metro stations
  • Education and
  • Recreation!
Guidelines/Books/Reports

- ITDP (2013) *Footpath design: A guide to creating footpaths that are safe, comfortable, and easy to use*, ITDP
Papers

Thank you