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Utilization and Effectiveness of Grade-Separated Pedestrian Crossings: A Case Study of Kathmandu

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Abstract

This study examines the utilization and effectiveness of grade-separated pedestrian crossings in underdeveloped urban settings, focusing on Kathmandu. Observations of 47,783 pedestrian crossings across five sites (four overhead bridges and one underpass) were conducted over 15 days, collecting data on age, gender, and crossing functionality using manual and video methods. The analysis revealed a high overall utilization rate of 83.20%. The underpass had the highest usage at 97.92%, compared to 93.67% for overhead bridges. Age and gender significantly influenced usage patterns, with individuals under 25 and males utilizing crossings more frequently. Site selection considered factors such as lane count, median barriers, and facility type, highlighting their impact on utilization. Median barriers and the ergonomic design of facilities, particularly the number of steps, emerged as key determinants of utility. The findings underscore the importance of strategic planning and design in enhancing pedestrian safety and usability in underdeveloped urban areas. Median barriers and ergonomic considerations, such as minimizing physical effort, play a pivotal role in encouraging usage. This research provides valuable insights for urban planners and policymakers to develop pedestrian-friendly infrastructure, addressing safety concerns and demographic needs in similar urban contexts.

Keywords*—Pedestrian, Overhead Bridges, Underpass, Utility, Effectiveness*

1. INTRODUCTION:

A. Challenges In Pedestrian Safety:

As per Nepal Road Safety Plan (2013-2020), road traffic accidents are mainly caused by reckless driving and pedestrian recklessly crossing the streets. A total of 2,485 individuals lost their lives in road traffic crashes during FY 17/18 in Nepal. Out of this, 28% were pedestrian, while 44% of pedestrian fatalities involved buses or trucks. It highlights the need for pedestrian facilities, as well as stricter vehicle fitness tests and control of cruising speed for buses and trucks [1]. The trend of road traffic injuries and deaths in Kathmandu over five years showed that the number of accidents in FY 2019/20 was 1.5 times higher than in FY 2018/19. The fatality rate increased to 0.4 per 100,000 population, with higher fatalities among males, particularly in the 16-35 age group. The death and injury ratio were higher in FY 2019/20, indicating more mild injuries and 2 severe ones. The main causes of accidents were road user negligence, speeding, and overtaking. In conclusion, the young population is most at risk, but these accidents are preventable [2]. According to UN estimates, nearly 1.3 million people die globally each year from road traffic accidents (RTAs), or more than 3,000 daily. Additionally, 20–50 million people are injured, with many facing disabilities. Despite having less than half of the world's registered vehicles, 90% of RTA fatalities occur in low and middle-income countries. Road traffic injuries are a leading cause of death for people aged 5 to 44 and result in significant economic losses worldwide [3]. The Ministry of Physical Infrastructure and Transport and JICA study shows that walking accounts for 40.7% of travel mode share. However, vehicle-friendly policies and infrastructure discourage walking and cycling, leading to increased congestion, air pollution, dependency on imported fossil fuels, and higher road fatalities, particularly among pedestrians and cyclists [4]. In Kathmandu, pedestrians represented 49% of all road fatalities in 2015, and pedestrian deaths accounted for over 39% of road crash fatalities on average from 2012/13 to 2017/18 [5]. In urban planning, pedestrian safety is crucial, and separated crossings like overpasses or underpasses are necessary to ensure safe, efficient movement. Guidelines recommend a minimum width of 8 feet for pedestrian overpasses, and more for those accommodating cyclists [6], [7]. However, usage of these structures remains low due to time constraints, poor design, and inadequate accessibility [8], [9]. In other cities, adding escalators or improving traffic control measures has been found to increase footbridge usage, particularly for elderly pedestrians [10], [11]. The goal of this research is to analyze the functionality of pedestrian bridges and underpasses in Kathmandu and identify factors affecting their use [12].

B. Problem Statement:

Pedestrian overpasses and underpasses separate pedestrian movement from vehicular traffic, crucial for pedestrian safety, especially in high-traffic areas where pedestrians are vulnerable to accidents [13], [14], [15]. Despite their importance, studies have focused more on driver behavior than on vulnerable road users like pedestrians [16]. Pedestrians face higher risks when crossing busy roads, with challenges varying by age and gender [17], [18], [19], [20]. Developing countries, where pedestrians are heavily involved in road accidents, face a more significant challenge [21].

Grade-separated structures, such as overpasses and underpasses, prevent collisions and reduce congestion in areas lacking pedestrian facilities [30]. These are especially essential for multi-lane roads or highways with fast traffic [22]. While walking is sustainable and beneficial for public health [23], [24], studies show pedestrians often prefer crossing busy roads directly rather than using overpasses [25], [26]. The cost of building underpasses and overpasses varies, with underpasses costing between $1.6

million and $10.7 million, and overpasses ranging from $1.1 million to $5.3 million, depending on location [22].

Well-designed pedestrian systems reduce traffic accidents and improve public transportation quality [27], [28]. Pedestrian bridges and underpasses help overcome obstacles like highways, improving connectivity [29]. However, their effectiveness depends on usage, and many cities report low utilization rates, with studies from Bogotá, Colombia (25%), Tanzania (26%), India (26%), Mexico City (49.5%), and Malaysia (19–74%) showing that pedestrians often avoid using overpasses [30], [31], [32], [21], [33]. The goal of this research is to investigate the utility of pedestrian crossings in Kathmandu and compare it with similar studies in developing countries.

2. LITERATURE REVIEW

Pedestrians, unprotected road users, rely on facilities like overpasses for safe movement. However, many opt to cross directly, bypassing these structures and increasing risk. Factors such as safety, comfort, and accessibility influence bridge usage, and strategic placement is key to ensuring their effectiveness [34], [35].

Advancements in transportation have created barriers between pedestrians and vehicles in urban areas [36]. Pedestrians account for 22% of road traffic fatalities, with younger individuals in low-income countries being particularly vulnerable. In these regions, many roads lack proper infrastructure, increasing pedestrian risk [37].

Pedestrian fatalities and injuries are a major concern in urban areas, with many incidents involving pedestrians being at fault. Around 15% of fatalities and 8% of hospitalized casualties are pedestrian-related [38]. Illegal pedestrian behaviors, such as jaywalking, contribute to higher accident rates when drivers interact with jaywalkers [39]. In Nepal, road traffic accidents result in over 1,600 fatalities and thousands of injuries annually, with pedestrians, motorcyclists, and cyclists being the most vulnerable road users. Pedestrian fatalities account for a significant proportion of these accidents, with young people under 26 being particularly affected.

Nepal's road safety situation is worsened by under-reporting of accidents, with minor incidents often settled privately [40].In Nepal, road accidents result in an average of seven deaths and 31 injuries daily. In 2016-17, 2,385 fatalities occurred from 10,178 accidents, with 2,006 deaths in 2015-16. The rise in accidents is linked to the increasing vehicle count and higher speeds. Minor incidents are often resolved privately, bypassing official reports. The table extracted from the Traffic Directorate of Nepal Police's traffic accident records reveals that most accidents (60.89%) result from driver negligence, followed by speeding at 12.51%. Other factors like overtaking, high speed, overloading, and driving under the influence also fall under driver negligence, reflecting a lack of enforcement and driver awareness. Pedestrian negligence contributes to 6.08% of accidents. The absence of a lead agency for road safety and limitations in the accident database system make comprehensive analysis difficult. Although the Department of Roads (DoR) has collected accident data since 1995, the system lacks detailed information for effective road safety engineering.

Table 1: Causes of Accidents
*[**Source:** Kathmandu Valley Traffic Police Office [41]]*

SN	Year	Driver's Negligence	Pedestrian's Negligence	Overtaking	High Speed	Drinking and driving	Technical fault of vehicle	Over Load	Cattles on the road	Miscellaneous	Total
1	2007-08	1491	492	546	962	461	310	339	17	19	4637
2	2008-09	1896	629	569	1066	434	440	434	24	27	5519
3	2009-10	2315	1011	939	1451	504	523	484	39	11	7277
4	2010-11	5795	361	528	1453	240	325	104	34	52	8892
5	2011-12	4056	18	126	154	156	118	21	22	7	4678
6	2013-14	4542	13	73	81	151	114	5	19	6	5004
7	2014-15	5281	11	46	48	183	77	0	15	5	5666
8	2015-16	5205	4	33	41	167	50	2	20	7	5529
	Average	3625	362	403	745	304	272	198	24	18	5953
		60.89%	**6.08%**	**6.77%**	**12.51%**	**5.11%**	**4.57%**	**3.33%**	**0.40%**	**0.30%**	

3. DATA COLLECTION AND ANALYSIS

A. Study Area

In this study, five sites were chosen within a densely populated region, selected for their diverse geometric attributes, including median type Prior to data collection, a preliminary survey was conducted to identify pedestrian observation sites. The study focused on five pedestrian facilities in the central area of Kathmandu, including four overhead bridges and one underpass, all located in key business and institutional areas, serving significant pedestrian movements.

The observed pedestrian facilities were:

- Station 1: Bishnumati Overhead Bridge, Dallu (Institutional area)
- Station 2: Bhotahity Overhead Bridge (Business and Institutional area)
- Station 3: Bhotahity-Ratnapark Underpass/Subway (Business and Institutional area)
- Station 4: Sundhara Overhead Bridge (Core business area)
- Station 5: Koteshwor Overhead Bridge (Business and Institutional area)

Station	Type of facility	Type of median barrier	Lanes
Station 1	Overhead Bridge	Undivided	4
Station 2	Overhead Bridge	Undivided	4
Station 3	Underpass (Subway)	Undivided	4
Station 4	Overhead Bridge	Plastic jersey barriers	4
Station 5	Overhead Bridge	Outer separators	6*

**Main Road: 4 lanes of dual carriageway, Service Road: 2 lanes of single carriageway both sides*

B. Data Collection:

The research employs an observational approach with a non-probability sampling method, similar to the methodology used in 2023 [7]. Data were collected from five selective pedestrian facilities between mid-November and the end of the month, during fair weather conditions and within regular working hours across three consecutive days at each site. Pedestrian volume counts, both grade-separated and at-grade, were recorded during peak hours, which were identified using a pilot survey: morning peak hour (9:30 to 10:30) for work-school traffic, afternoon peak hour (13:00 to 14:00) for work-school break, and evening peak hour (17:00 to 18:00) for the work-home commute.

Three independent observers gathered the data using a specific format designed for the purpose. Data for grade-separated crossings, such as overhead bridges and underpasses, were collected manually through direct observation and recording of relevant parameters. At-grade crossings were observed using video photography, enabling a more comprehensive capture of pedestrian movement patterns. This combination of methods allowed for a detailed analysis of the utility of different types of pedestrian crossings.

The pedestrian data were categorized into four groups based on gender (Male/Female) and age (>25 and <25), with age and gender estimated visually. During a preliminary survey of the area, the type of facility, the number of lanes, and the presence of a median barrier were assessed. Facility dimensions, including height, length, and width, were measured using tape measures and observational techniques, and the number of steps within each facility was recorded.

C. Data Entry and Data Analysis:

All analyses were conducted using SPSS (IBM Statistics 25), with an alpha level of 0.05 maintained for all statistical tests. The results were then compared with existing literature on the utility of pedestrian facilities, particularly in developing countries.

Utility refers to the ability of pedestrian facilities to meet user needs efficiently, safely, and comfortably. The utility of overpasses and underpasses can be measured by comparing the number of pedestrians using these facilities with those crossing the road at grade level [42]. The formula for calculating the utility percentage is:

$$Utility\ (\%) = \frac{A}{B} x100$$

A = Number of pedestrians using the overpass/underpass,

B = Total number of pedestrians crossing at grade or using the overpass/underpass

The level of service (LOS) standard and actual capacity was determined in accordance with the Highway Capacity Manual: A Guide for Multimodal Mobility Analysis [43]. The capacity of an overpass or underpass is defined by the maximum volume it can accommodate at a given level of service, which depends on the width of the section and pedestrian speed. The formula for computing actual capacity and LOS is:

$$Capacity/hour = \frac{Width(ft)xSpeed\left(\frac{ft}{min}\right)*60}{Pedestrian\ Module\ (ft^2 per\ pedestrian)}$$

To calculate travel time across the overpass/underpass at different LOS levels, the following formula is used:

$$Travel\ Tim(min) = \frac{Length\ of\ Overpass/Underpass(ft)}{Speed(\frac{ft}{min})}$$

Table 3: Pedestrian Level of Service (LOS) on walkways:

*[**Source**: Highway Capacity Manual: A Guide for Multimodal Mobility Analysis [44]]*

Level of Service	Space (Ft.^{2}/Ped)	Expected Flows and Speeds		
		Ave. Speed, s (Ft./Min)	**Flow Rate, v (Ped. /Min./Ft.)**	**Vol./Cap. Ratio v/c**
A	≥ 130	≥ 260	≤ 2	≤ 0.08
B	≥ 40	≥ 250	≤ 7	≤ 0.28
C	≥ 24	≥ 240	≤ 10	≤ 0.40
D	≥ 15	≥ 225	≤ 15	≤ 0.60
E	≥ 6	≥ 150	≤ 25	≤ 1.00
F	< 6	< 150	Variable	

4. RESULTS AND DISCUSSION

A. Descriptive Results:

Table 3 showcases the descriptive statistics for the variables investigated in this research. It outlines the findings regarding utility concerning demographics (age and gender), observation sites, station types, and the infrastructure attributes of these sites (such as lane count, median type, and facility height).

Table 3: Descriptive results of all stations

Variable	Total Pedestrians observed (A)	Pedestrians using the facility (B)	Utilization % ($\frac{B}{A} \times 100$)
Demographics			
Gender			
Male	29166	27465	94.17
Female	18617	17455	93.76
Age			
Less than 25 years old	19701	18825	95.55
More than 25 years old	28082	26095	92.92
Observation Sites			
Station 1 (Overhead)	1884	550	29.19
Station 2 (Overhead)	24598	23715	96.41
Station 3 (Underpass)	3842	3762	97.92
Station 4 (Overhead)	10121	10065	99.45
Station 5 (Overhead)	7338	6828	93.05
Station Type			
Overhead pedestrian bridge	43941	41158	93.67
Underpass for pedestrians	3842	3762	97.92

Observation Sites' properties			
Number of Lanes			
6	7338	6828	93.05
4	40445	38092	94.18
Median Barriers			
Undivided	30324	28027	92.43
Plastic jersey barriers	10121	10065	99.45
Outer separators	7338	6828	93.05
Height of Facility			
5.20 m	1884	550	29.19
4.75 m	34719	33780	97.30
3.50 m	3842	3762	97.92
5.00 m	7338	6828	93.05
Time of the Day			
9:30 – 10:30	17677	16358	92.54
13:00 -14:00	14334	13597	94.86
17:00 -18:00	15772	14965	94.88

Differences due to gender, age and type of pedestrian facility

The study analyzed the relationship between pedestrian facility usage and factors such as gender, age group, and facility type. While both males and females showed high utility (94.17% and 93.76%, respectively), the chi-square tests indicated only a marginally significant association between gender and facility usage ($p \approx 0.066$). Conversely, age group showed a highly significant relationship with facility usage ($p < 0.001$), with younger pedestrians (<25 years) demonstrating higher utility compared to older ones (>25 years). Similarly, facility type significantly influenced usage, with underpasses (mean utility = 0.979) being strongly preferred over overhead bridges (mean = 0.937; $p < 0.001$). Overall, age group and facility type are strong determinants of facility usage, while gender shows only a marginal tendency toward association.

Effect of time on utility of pedestrian facility

The analysis of pedestrian facility utility by time of day revealed that usage is lowest in the morning hours (92.54%) and highest in the evening hours (94.88%), with no significant differences between the afternoon and evening. Chi-square tests indicated a highly significant relationship between facility usage and time of day ($p < 0.001$ across all tests). These results demonstrate a strong association, suggesting that pedestrian facility usage varies notably depending on the time of day, with the highest utility observed during evening hours.

Station 1: Bishnumati overhead bridge, dallu

Station 1 had a utility rate of 29.19%, with younger pedestrians (<25 years) more likely to use the facility (mean = 0.34) compared to older ones (>25 years, mean = 0.26). Chi-square tests confirmed a highly significant association between age group and facility usage ($p < 0.001$). Similarly, males (mean = 0.34) were more likely to use the facility than females (mean = 0.26), with chi-square tests again indicating a strong and significant relationship between gender and facility usage ($p < 0.001$). Despite 1,884 pedestrians being observed over three days, females over 25 constituted the majority of non-users. The lack of a median barrier at this site likely contributed to the low usage, as pedestrians opted to cross the road directly. The highest utility was observed among males under 25, with 38.76% using the facility.

Table 4: Pedestrian count against gender at station 1

Total observed		Not using facility	Using facility	Utility
Gender & Age	**Number (A)**	**Number (B)**	**Number (C)**	$(C/A \times 100)$
M>25	576	404	172	29.86
M<25	356	218	138	38.76
F>25	562	438	124	22.06
F<25	390	274	116	29.74
Total	**1884**	**1334**	**550**	**29.19**

Station 2: Bhotahity overhead bridge

Located in a bustling area with business zones and institutions, this site recorded high pedestrian activity, with 96.41% of pedestrians using the overhead bridge. Younger pedestrians (<25 years) were more likely to use the facility (mean = 0.98) compared to older ones (>25 years, mean = 0.95), with chi-square tests indicating a highly significant association between age group and facility usage ($p < 0.001$). Female pedestrians (mean = 0.97) were slightly more likely to use the facility than males (mean = 0.96), with a similarly strong and significant relationship between gender and facility usage ($p < 0.001$). Over three days, 24,598 pedestrians were observed, with males over 25 constituting the majority of non-users. Younger males and females (<25 years) showed the highest utility, with rates of 97.15% and 99.51%, respectively.

Table 5: Pedestrian count against gender at station 2

Total observed		**Not using facility**	**Using facility**	**Utility**
Gender & Age	**Number (A)**	**Number (B)**	**Number (C)**	$(C/A\times100)$
M>25	7734	427	7307	94.48
M<25	6693	191	6502	97.15
F>25	4834	239	4595	95.06
F<25	5337	26	5311	99.51
Total	**24598**	**883**	**23715**	**96.41**

Station3: Bhotahity ratnapark underpass

This site exhibited one of the highest utility rates in the study, with 97.92% of pedestrians utilizing the facility. Younger pedestrians (<25 years) were marginally more likely to use the underpass (mean = 0.982) compared to older pedestrians (>25 years, mean = 0.977). However, chi-square tests indicated no statistically significant relationship between age group and facility usage ($p > 0.05$). Similarly, female pedestrians (mean = 0.980) were slightly more likely to use the facility than males (mean = 0.979), but the association between gender and facility usage was also not statistically significant ($p > 0.05$). Over three days, 3,842 pedestrians were observed, with the highest utility recorded among younger males and females (<25 years), at 98.17% .

Table 6: Pedestrian count against gender at station 3

Total observed		**Not using facility**	**Using facility**	**Utility**
Gender & Age	**Number (A)**	**Number (B)**	**Number (C)**	$(C/A\times100)$
M>25	1632	32	1600	98.04
M<25	604	14	590	97.68
F>25	938	25	913	97.33
F<25	668	9	659	98.65
Total	**3842**	**80**	**3762**	**97.92**

Station 4: Sundhara overhead bridge

This site recorded the highest utility in the study, with 99.45% of pedestrians utilizing the facility. Younger pedestrians (<25 years, mean = 0.996) were slightly more likely to use the facility than older pedestrians (>25 years, mean = 0.993), but chi-square tests showed no statistically significant relationship between age group and facility usage ($p > 0.05$). Similarly, gender differences were minimal, with males (mean = 0.995) marginally more likely to use the facility than females (mean = 0.994), and no statistically significant relationship was found between gender and facility usage ($p > 0.05$). Over three days, 10,121 pedestrians were observed, with jersey barriers and ropes effectively deterring jaywalking despite gaps in the barrier. The highest utility was noted among females aged less than 25 years.

Table 7: Pedestrian count against gender at station 4

Total observed		Not using facility	Using facility	Utility
Gender & Age	**Number (A)**	**Number (B)**	**Number (C)**	$(C/A \times 100)$
M>25	4523	26	4497	99.43
M<25	1884	8	1876	99.58
F>25	2184	17	2167	99.22
F<25	1530	5	1525	99.67
Total	**10121**	**56**	**10065**	**99.45**

Station 5: Koteshwor overhead bridge

This overhead pedestrian bridge, located on the ring road section at Koteshwor, Kathmandu, saw 93.05% of pedestrians using the facility. Pedestrians under 25 years (mean = 0.9423) were more likely to use the bridge compared to those over 25 years (mean = 0.9295). Chi-square tests showed a statistically significant association between age group and facility usage ($p < 0.05$), indicating that younger pedestrians were more inclined to use the facility. Additionally, gender had an effect on utility, with females (mean = 0.9416) being more likely to use the facility than males (mean = 0.9302). Chi-square tests also indicated a statistically significant relationship between gender and facility usage ($p < 0.05$). Over three days, 7,338 pedestrians were observed. Despite the high usage rate, the presence of outer separators allowed easier road crossing, leading many males (age >25) to prefer crossing the road rather than using the bridge. The highest utility was noted among females aged under 25.

Table 8: Pedestrian count against gender at station 5

Total observed		Not using facility	Using facility	Utility
Gender & Age	**Number (A)**	**Number (B)**	**Number (C)**	$(C/A\times100)$
M>25	3794	297	3497	92.17
M<25	1370	84	1286	93.87
F>25	1305	82	1223	93.72
F<25	869	47	822	94.59
Total	**7338**	**510**	**6828**	**93.05**

Comparison between bridges and underpass

The total number of pedestrians recorded on overhead bridges and underpasses is 43,941 and 3,842, respectively, with overhead bridges showing a lower utility (93.67%) compared to underpasses (97.92%). The construction cost of pedestrian facilities depends on factors such as location, length, materials, and the construction process. Generally, pedestrian overhead bridges are more expensive than underpasses. The cost of a steel truss bridge ranges from $500 to $2,000 per linear foot, while a steel stringer/beam bridge costs between $400 and $1,600 per linear foot. In contrast, pedestrian underpasses cost less, with total expenses ranging from $1.6 million to $10.7 million, averaging $120 per square foot. Overpasses cost between $150 and $250 per square foot, totaling $1.07 million to $5.37 million, depending on site conditions [22], [45]. Height has a psychological impact on the utility of pedestrian crossings. For instance, a higher overpass at Station 1 (5.20 m) has a utility of 29.19%, while a lower underpass at Station 3 (3.50 m) has a utility of 97.92%. This suggests that increased height leads to decreased utility. A key difference between overpasses and underpasses is the vertical space required for construction. Overpasses need sufficient clearance for vehicles, which requires more vertical height, while underpasses, being below ground level, need less clearance. This makes underpasses a viable alternative when vertical space is limited. The minimum clearance for pedestrian underpasses is typically 8 feet (2.44 meters) and 10 feet (3.05 meters) desirable, while for overpasses, it is 17.5 feet (5.33 meters) for state highways [46], [47]. The utility of underpasses is superior to overpasses, with a higher usage rate of 62.5% compared to 11.62% for overpasses. Underpasses are more suited for commercial areas, while overpasses are typically found in educational areas [7], [5]. Additionally, median barriers and the number of lanes impact utility, with plastic jersey barriers at Station 4 contributing to a utility of 99.45%.

Comparison between station 2 and station 3 in terms of LOS, capacity and travel time:

The comparison between the overpass and underpass highlights the underpass's superior efficiency in terms of both Level of Service (LOS) and travel time. The overpass currently accommodates a peak hour volume of 2790 pedestrians, maintaining LOS B, and can handle up to 2904 pedestrians if all violators use it, nearing the LOS B capacity of 3375. In contrast, the underpass experiences significantly lower peak hour volumes, with 503 pedestrians under current conditions and 512 if all violators comply, both well below its LOS A capacity of 1080. LOS B on the overpass allows pedestrians to select walking paths and bypass others but requires them to adjust to the presence of other pedestrians, whereas LOS A on the underpass offers smoother pedestrian flow and higher capacity. Additionally, the underpass has a shorter travel time of 22.7 seconds, compared to 31.5 seconds for the overpass. This is attributed to its 35-meter length and higher walking speed associated with LOS A, as opposed to the overpass's 40-meter length and LOS B conditions. Overall, the underpass proves to be more efficient, providing a better Level of Service and faster travel time for pedestrians.

Table 9: Capacity of overpass and underpass at different level of service standard and actual peak hour volume

Width (ft)	Speed (ft/min.)	Level of Service	Pedestrian Module (ft^2/Ped)	Capacity per hour
9	260	A	130	1080
	250	B	40	3375
	240	C	25	5184
	225	D	16	7594
	150	E	8	10125
	<150	F	5	Variable
Actual peak hour volume				
Overpass	Pedestrians not using the facility			Total
2790	114			2904

<table>
<tr><th>Width (ft)</th><th>Speed (ft/min.)</th><th>Level of Service</th><th>Pedestrian Module (ft2/Ped)</th><th>Capacity per hour</th></tr>
<tr><td rowspan="6">9</td><td>260</td><td>A</td><td>130</td><td>1080</td></tr>
<tr><td>250</td><td>B</td><td>40</td><td>3375</td></tr>
<tr><td>240</td><td>C</td><td>25</td><td>5184</td></tr>
<tr><td>225</td><td>D</td><td>16</td><td>7594</td></tr>
<tr><td>150</td><td>E</td><td>8</td><td>10125</td></tr>
<tr><td><150</td><td>F</td><td>5</td><td>Variable</td></tr>
<tr><td colspan="5">Actual peak hour volume</td></tr>
<tr><td>Underpass</td><td colspan="3">Pedestrians not using the facility</td><td>Total</td></tr>
<tr><td>503</td><td colspan="3">9</td><td>512</td></tr>
</table>

Comparison with other studies:

Table 10 highlights the effectiveness of underpasses compared to overhead bridges across various countries, with key factors like stair slope and design features influencing utility. Proper median barriers and ramp facilities significantly enhance usability, as evidenced by a Kenyan study where the absence of ramps reduced utility. Similarly, the Ankara study in Turkey revealed that the number of steps and stair slope are critical to the facility's efficiency. The Kenyan study further emphasized that installing ramps or elevators can greatly improve the accessibility of pedestrian crossings [7].

Table 10: Result comparison with other studies

Country/City	Result (Utility %)	Reasons for less usage	Recommendation	Source
Ankara (Turkey)	6.3% (Overpass)	High stairs and health reasons	Stairs' slope should be rephrased	[8]
Delhi (India)	78% (Underpass)	Distance travel to reach the underpass	Traffic police and proper median barriers	[48]

Malaysia	65% (Overpass)	Time loss from using the overpass	Continuous median barrier over a long distance can reduce violation	[9]
Kenya	30% (Overpass)	No ramp to enable the physically challenged to use the bridge	Installation of ramp/elevator facility	[49]
Turkey	54% (Overpasses)	Time loss from using the overpass	Proper median barrier and presence of law enforcement agency persons	[12]
Pakistan	62.5% (underpass) & 11.62% (overpasses)	The number of lanes, type of median barriers, and type of facility (bridge/underpass)	Proper median barrier can increase the serviceability	[7]
Kathmandu	97.92% (underpass) & 93.67% (overpasses)	Lack of median barriers and ramp facilities for bicycles	Provision of median barriers and dedicated ramp facilities for bicycles	Current study

5. CONCLUSION AND RECOMMENDATION

The study finds that pedestrian facilities in Kathmandu generally show satisfactory utility, with underpasses being significantly more effective than overhead bridges. Demographic factors like age and gender influence usage, with males and younger pedestrians using facilities more. Utility varies by time, peaking in the evening, and locations with proper median barriers have higher utility. Four-lane roads perform better than six-lane roads, likely due to inadequate barriers on the latter. Facility height affects utility, with shorter facilities showing higher effectiveness. The absence of ramps at locations like Bhotahity Overhead Bridge reduces accessibility for cyclists and the elderly. The study recommends adding bicycle ramps, prioritizing underpasses, and minimizing facility height to improve utility. Proper median barriers are also crucial, particularly on six-lane roads. Future research should explore traffic flow, jaywalkers, and compare Kathmandu's pedestrian facilities with those in other developing nations to identify best practices.

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