FUNCTIONALITY OF SKYWALKS IN BENGALURU CITY – A CASE STUDY

KALYAN RAO[A], CHETHANA RAMACHANDRA[B]

[A]FORMER M.TECH STUDENT, DEPARTMENT OF TRANSPORTATION ENGINEERING AND MANAGEMENT, B.M.S. COLLEGE OF ENGINEERING, BENGALURU – 560040, INDIA

[B]ASSISTANT PROFESSOR, DEPARTMENT OF CIVIL ENGINEERING, B.M.S. COLLEGE OF ENGINEERING, BENGALURU – 560040, INDIA

Acknowledgment

- Kalyan Rao

  - Former M.Tech Student – BMSCE, Bangalore
  - Assistant Engineer, Highways, WSP India

- BMSCE

Introduction

- India reported a staggering total of 4,12,432 road accidents, claiming the lives of 1,53,972 individuals and causing injuries to 2,84,448 people, as reported by the **Ministry of Road Transport and Highways - Government of India (2023)**.

- To reduce accidents and promote pedestrian safety, various pedestrian facilities are implemented in urban areas.

Introduction

- Some common pedestrian facilities include Sidewalks and Footpaths, Crosswalks and Zebra Crossings, Pedestrian Overpasses and Underpasses, Pedestrian Signals etc.

- Grade-separated pedestrian systems (GSPS), such as pedestrian bridges, are an appealing choice - as they ensure the complete safety of pedestrians by segregating them from vehicular traffic, costing less compared to underground subways.

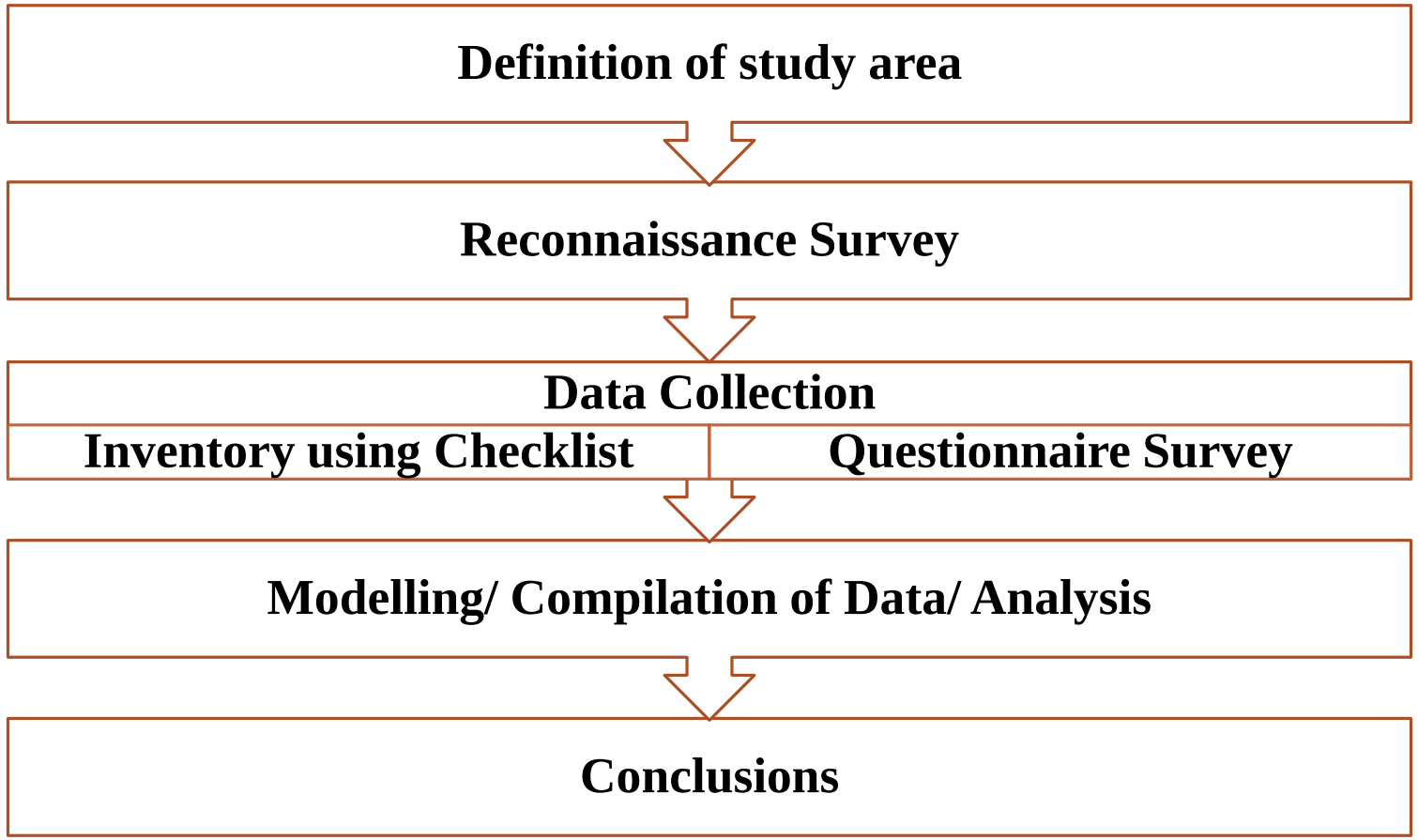
Gaps in literature

- Lack of suitability in the planning and construction of foot-over bridges.
- Weak management and limited awareness of the Skywalk facility.
- Inventory survey was given less importance.
- Level of service (LOS) for Skywalks was not extensively studied.
- To understand strategic locations for Skywalks.

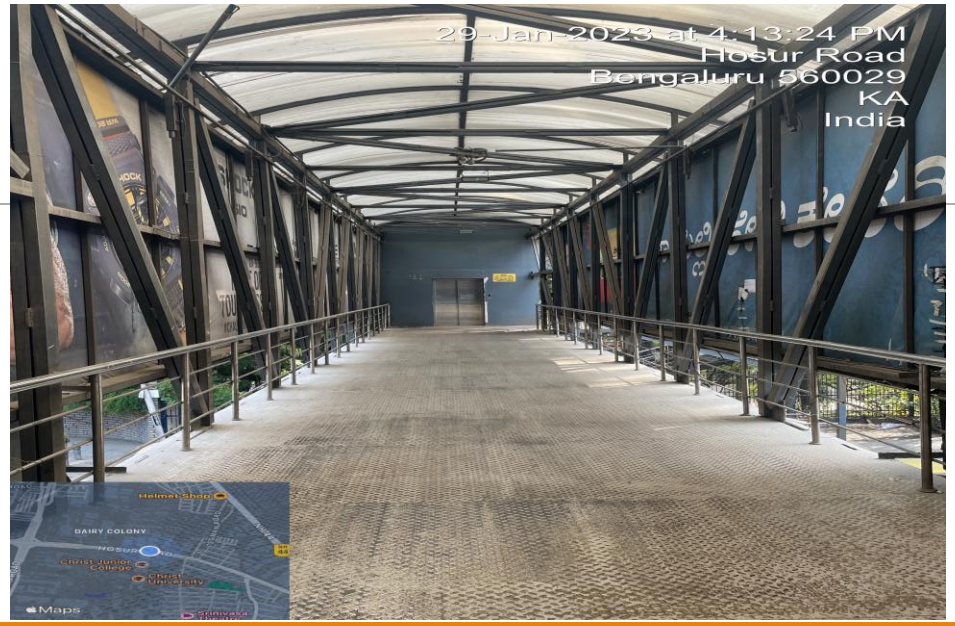
Objectives

1. To evaluate the performance of the Skywalks in terms of usage in Bengaluru city.
2. To analyze the people's perception on the Skywalk utilization.
3. To find the Level of service (LOS) of the Skywalks as per Indian Highway Capacity Manual 2017.
4. Model a Linear regression model for understanding the Skywalk utilization by various categories of people.

Methodology



Reconnaissance survey



(LOCATION – CHRIST UNIVERSITY HOSUR ROAD BENGALURU-560029)

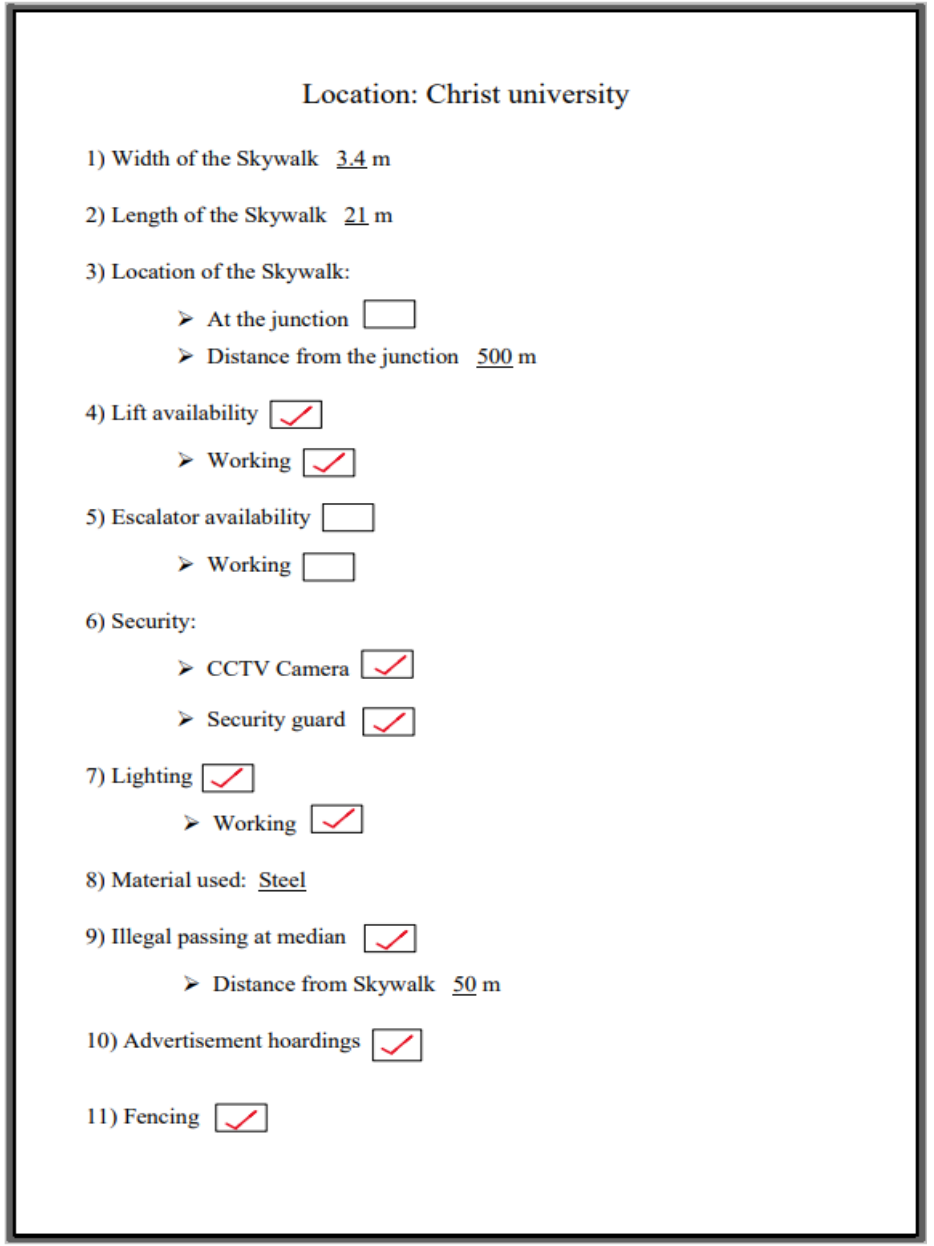
Data collection

- Site selection – selected based on Land use

Hospital	Nimhans
	St. Johns
Educational	Christ university
	Koramangala Prestige RMZ
Commercial	Jayanagar 3rd block
	Nexus Koramangala
Business	Madiwala
	Hudson circle

❑ Inventory survey -

- An inventory survey was conducted to gather information about the existing facilities and conditions.
- The key elements included are information about the width and length, lift and escalator availability, security measures, lighting, and fencing.
- This information can then be used to identify areas for improvement.



Location: Christ university

1) Width of the Skywalk 3.4 m

2) Length of the Skywalk 21 m

3) Location of the Skywalk:

- ➢ At the junction ☐
- ➢ Distance from the junction 500 m

4) Lift availability ☑

- ➢ Working ☑

5) Escalator availability ☐

- ➢ Working ☐

6) Security:

- ➢ CCTV Camera ☑
- ➢ Security guard ☑

7) Lighting ☑

- ➢ Working ☑

8) Material used: Steel

9) Illegal passing at median ☑

- ➢ Distance from Skywalk 50 m

10) Advertisement hoardings ☑

11) Fencing ☑

Questionnaire Survey




❑ Questionnaire survey -

➢Two questionnaires, Questionnaire A and Questionnaire B, were designed to target users and non-users respectively.

➢The survey considered various parameters, including:

Familiarity with the location and frequency of skywalk use

- Characteristics of the skywalk
- Trip characteristics
- User demographics
- Reason for not using

Questionnaire survey

Questionnaire-1

1.Frequency of use:

- How often do you visit this particular location?

a) Rarely ☐ b) Once or twice a month ☐ c) Once a week ☐
d) Several times a week ☐ e) Every day ☐

2. Characteristics of skywalk:

- Saves time

a) Not at all ☐ b) Not very well ☐ c) somewhat ☐
d) Very well ☐ e) Extremely well ☐

- Ease to use

a) Not at all ☐ b) Not very well ☐ c) somewhat ☐
d) Very well ☐ e) Extremely well ☐

- Maintenance

a) Not at all ☐ b) Not very well ☐ c) somewhat ☐
d) Very well ☐ e) Extremely well ☐

- Security at night

a) Not at all ☐ b) Not very well ☐ c) somewhat ☐
d) Very well ☐ e) Extremely well ☐

- Crowded

a) Not at all ☐ b) Not very well ☐ c) somewhat ☐
d) Very well ☐ e) Extremely well ☐

- Safe

a) Not at all ☐ b) Not very well ☐ c) somewhat ☐
d) Very well ☐ e) Extremely well ☐

- Free from obstruction like hawkers

a) Not at all ☐ b) Not very well ☐ c) somewhat ☐
d) Very well ☐ e) Extremely well ☐

3) User demographics:

i. Gender :-
ii. Age :-
iii. Education :-
iv. Occupation :-

4) Trip characteristics:

i. Trip details, Origin :- Destination :-
ii. Residence location :-
iii. Mode of travel :-
iv. Trip purpose :-

5) User opinion:

Comment on Hoardings :-

Remarks :-

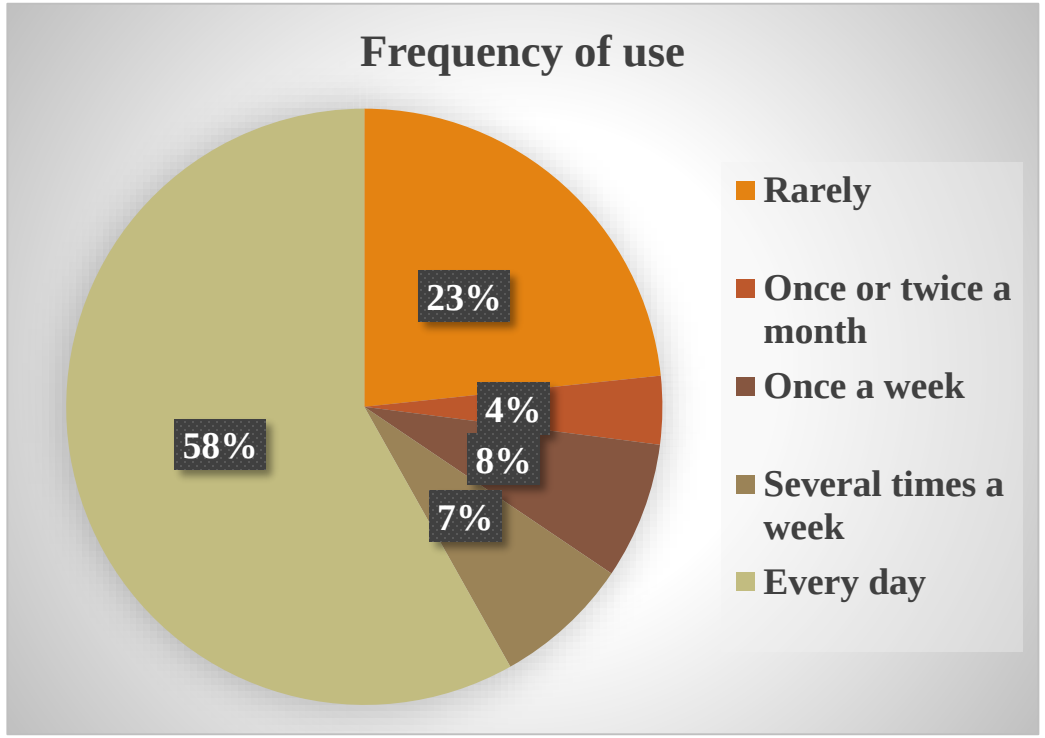
Overall rating (1-5) :-

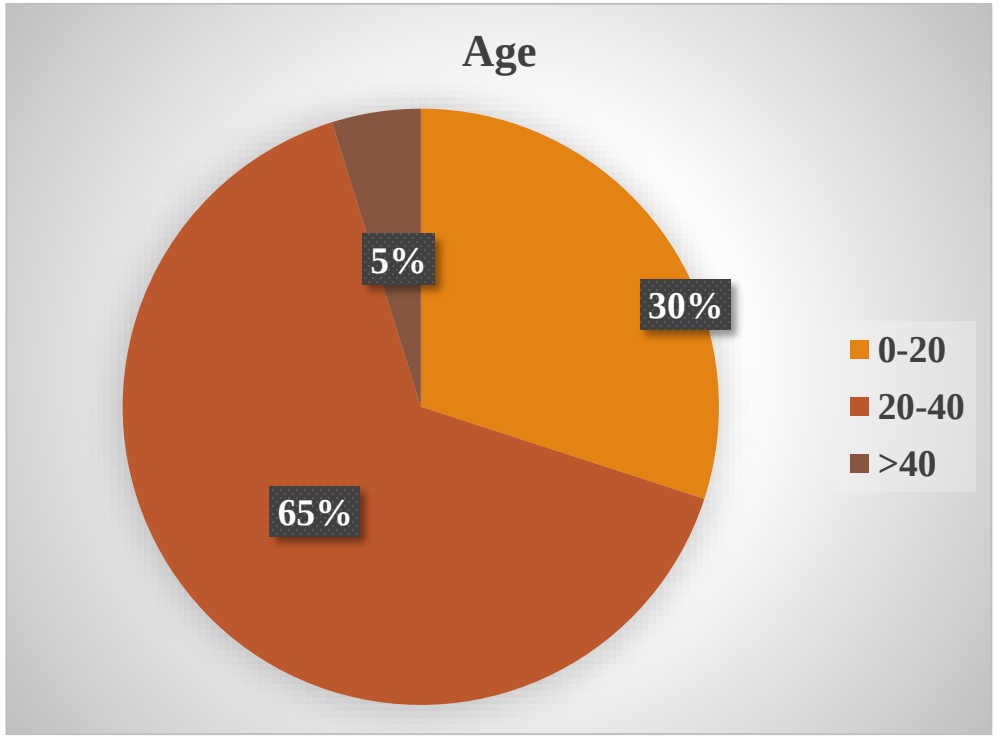
Questionnaire-2

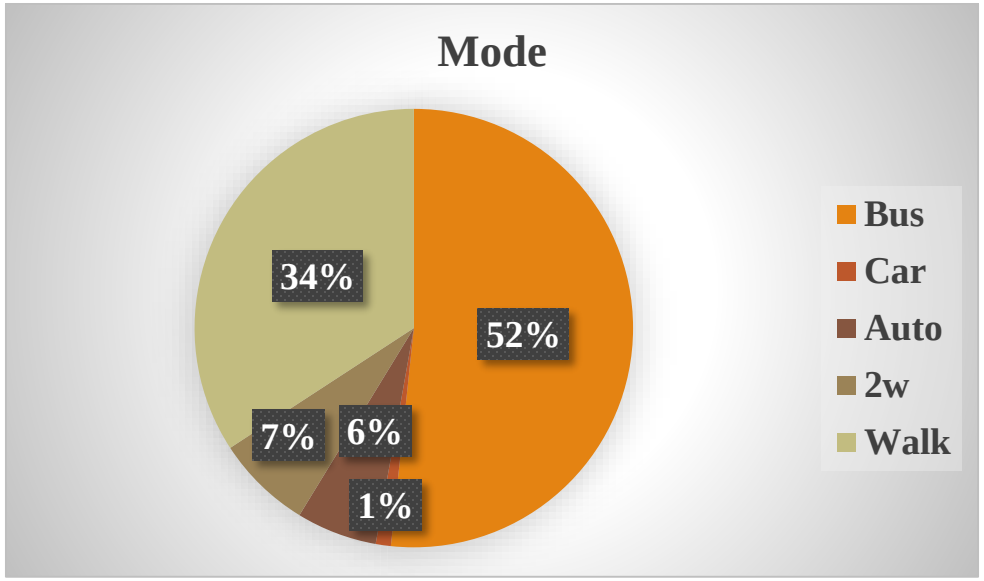
- Reasons for not using:

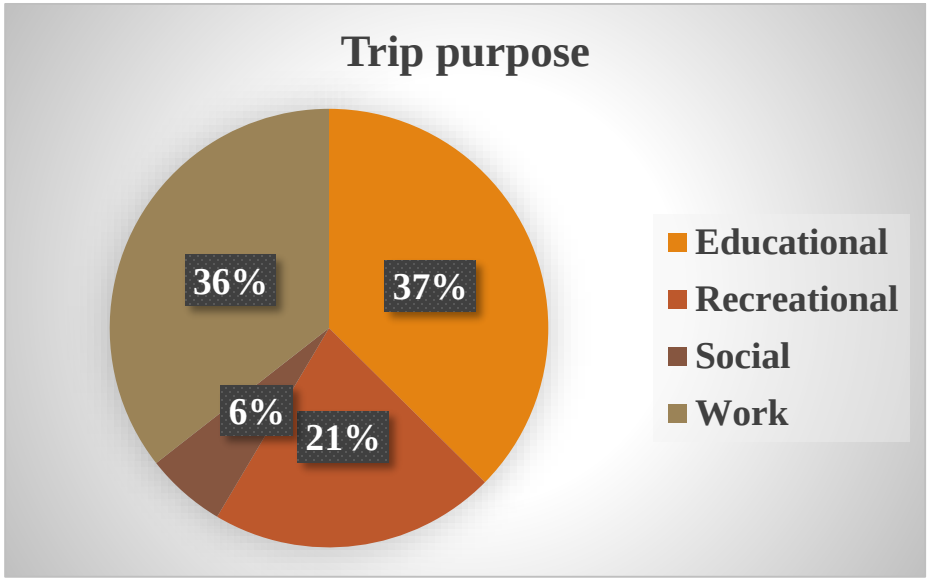
1) Lift ☐
2) Escalator ☐
3) Better lighting ☐
4) Fear of height ☐
5) Due to hawkers and beggars ☐
6) Security ☐
7) Increased travel time ☐

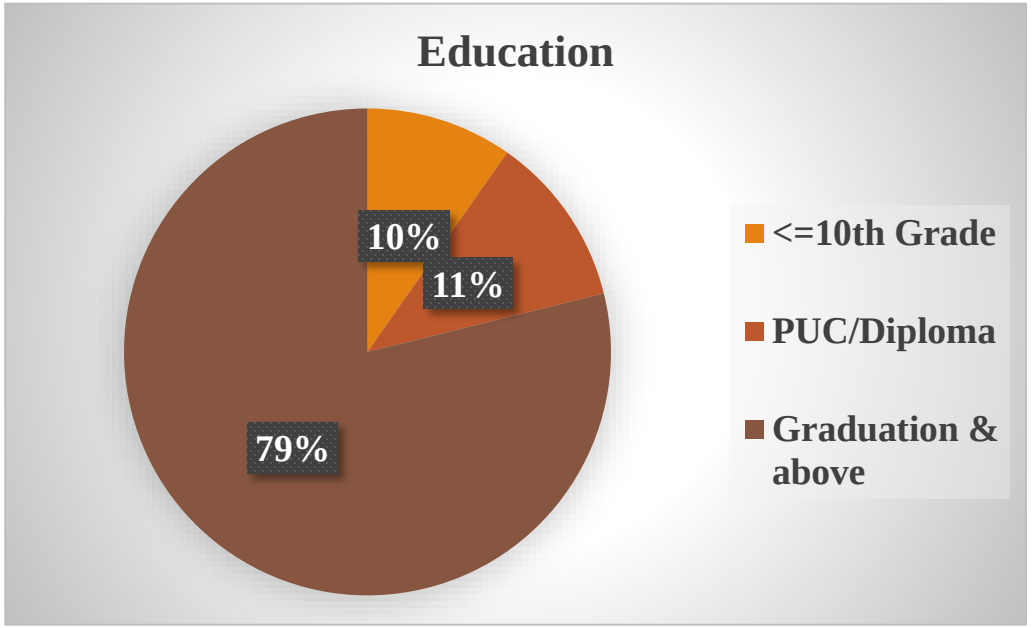
Descriptive analysis






Mode
52%
1%
6%
7%
34%
Bus
Car
Auto
2w
Walk


Trip purpose
37%
21%
6%
36%
Educational
Recreational
Social
Work


Education
10%
11%
79%
<=10th Grade
PUC/Diploma
Graduation & above

- Level of service (LOS) – Table 9.13: PLOS for Foot Over Bridge (Indo-HCM 2017)
- The values from the table are used to define LOS for different Skywalks in the study.

LOS	Flow(ped/min/m)	Speed(m/min)	Space(m^2/ped)
A	≤12	≥56.78	≥4.89
B	>12-17	>55.03-56.78	>3.3-4.9
C	>17-27	>51.08-55.03	>1.9-3.3
D	>27-38	>45.65-51.08	>1.2-1.9
E	>38-52	>30.91-45.65	>0.6-1.2
F	Variable	<30.91	<0.6

Application of LOS to the collected data

Location: Christ University

Flow(ped/min/m)

8	12	13	11	12	6
6	15	9	9	10	8
7	10	12	15	8	7
8	14	9	12	10	6
11	13	14	10	11	10
10	12	13	8	7	6
9	12	9	7	5	10
13	10	8	8	8	8
15	14	6	9	11	7
13	16	12	7	7	5
				Avg	10

Speed(m/min)

76.62	58.82	72.87	73.47	65.93	78.26	78.60	73.77	78.26	74.38
71.43	61.64	59.02	64.52	70.31	67.67	66.17	77.58	77.25	68.44
								Avg	70.75

Space(m^2/ped)

2.55

LOS of the locations

- The table shows the LOS of all the Skywalks based on flow, space and speed.
- The LOS is varying across the parameters for individual Skywalk.

Place	Parameters	Avg value	LOS
Christ University	Flow	10	A
	Speed	70.75	A
	Space	2.55	A
RMZ Star tech park	Flow	13	B
	Speed	71.52	A
	Space	1.88	A
St. John's	Flow	17	B
	Speed	68.82	A
	Space	1.7	B
Madiwala	Flow	12	A
	Speed	70.1	A
	Space	2.1	A
Nimhans	Flow	8	A
	Speed	67.3	A
	Space	2.32	A
Nexus Koramangala	Flow	6	A
	Speed	72.65	A
	Space	3.2	A
Hudson circle	Flow	2	A
	Speed	70.79	A
	Space	3.5	A
Jayanagar	Flow	-	A
	Speed	-	A
	Space	-	A

Modelling

- A simple linear regression modelling is adopted using valid questionnaires to determine skywalk utilization factors.

- Pedestrian frequency of use is the dependent variable, and the explanatory variables are the characteristics of participants and walking trips of the pedestrians.

- The variables considered are *age*, *trip purpose*, *education*, *gender and mode of travel*.

Regression analysis

Multiple R	0.507431
R Square	0.257487
Adjusted R Sq	0.284822
Standard Erro	2.98819
Observations	267

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	10	792.6962514	79.2696	8.8774942	1.64058E-12
Residual	256	2285.895509	8.92928		
Total	266	3078.59176			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	7.196902	0.54845256	13.1222	1.985E-30	6.116849001	8.276956	6.116849	8.27695561
Age(0-20)	0.603743	0.48920189	1.23414	0.2182826	-0.35962908	1.567116	-0.3596291	1.56711594
>40	0.583302	0.905293227	0.64432	0.5199421	-1.19946798	2.366073	-1.199468	2.36607265
Recreational	-3.066975	0.549468405	-5.5817	6.061E-08	-4.14902923	-1.984922	-4.1490292	-1.9849217
Social	-3.83954	0.982007763	-3.9099	0.0001183	-5.77338224	-1.905698	-5.7733822	-1.9056978
Work	0.713832	0.518508232	2.3767	0.0498067	-0.3072526	1.734917	-0.3072526	1.73491685
<=10th Grade	0.504318	0.695989085	0.72461	0.469355	-0.86627473	1.874912	-0.8662747	1.87491154
PUC/Diploma	-0.431049	0.600880304	-0.7174	0.4738046	-1.61434677	0.752249	-1.6143468	0.75224901
Female	0.209785	0.402165484	0.52164	0.6023736	-0.58218931	1.001759	-0.5821893	1.00175866
Bus	0.380011	0.395968688	2.9597	0.0381116	-0.39975956	1.159782	-0.3997596	1.15978203
2w	0.174653	0.809063339	0.21587	0.8292607	-1.41861452	1.76792	-1.4186145	1.7679201

Conclusions

- A significant majority of 60%, utilize Skywalks "Every day."
- The prominence of participants within the "20-40" age range seems to constitute the majority within the surveyed group.
- The prevalence of "Educational" and "Work" trip purposes suggests that functional and utilitarian activities strongly influence Skywalk utilization.
- Based on the evidence gathered, it is recommended to reconsider the installation of Skywalks at market junction places.
- It is evident that the LOS grades reflect the performance of each Skywalk in handling pedestrian traffic based on flow, speed, and space attributes.
- The ANOVA analysis reveals that several explanatory variables, such as "Recreational," "Social," and "Work," are statistically significant in explaining the variance in pedestrian frequency of Skywalk usage.

References

Banerjee, A., R. Raoniar, and A. K. Maurya. 2020. “Pedestrian overpass utilization modeling based on mobility friction, safety and security, and connectivity using machine learning techniques.” *Soft Comput.*, 24 (22): 17467–17493. Springer Berlin Heidelberg. https://doi.org/10.1007/s00500-020-05277-w.

Bhatia, S. Y., G. R. Patil, A. D. Chopadekar, and S. Sharma. 2022. “Skywalk facility utilization and factors influencing its use: A case study of Mumbai Metropolitan Region, India.” *Case Stud. Transp. Policy*, 10 (1): 396–405. Elsevier Ltd. https://doi.org/10.1016/j.cstp.2021.12.019.

Cui, J., A. Allan, and D. Lin. 2013. “The development of grade separation pedestrian system: A review.” *Tunn. Undergr. Sp. Technol.*, 38: 151–160. Elsevier Ltd. https://doi.org/10.1016/j.tust.2013.06.004.

Gupta, S., R. Jain, and V. Tare. 2017. “Feasibility of Providing a Skywalk for Pedestrian ‘ A Case Study .’” 4 (5): 224–228.

Hasan, R., and M. Napiah. 2018. “The perception of Malaysian pedestrians toward the use of footbridges.” *Traffic Inj. Prev.*, 19 (3): 292–297. Taylor & Francis. https://doi.org/10.1080/15389588.2017.1373768.

Landa-Blanco, M., and J. Ávila. 2020. “Factors related to the use of pedestrian bridges in university students of Honduras.” *Transp. Res. Part F Traffic Psychol. Behav.*, 71: 220–228. Elsevier Ltd. https://doi.org/10.1016/j.trf.2020.04.016.

Mayur, L., S. Dharmendra, P. Darshan, P. Neel, P. Hiren, C. Dixit, B. E. Civil, and M. College. 2019. “Appraisal and Design of Foot Over Bridge.” 2134–2137.

Hasan, R., and M. Napiah. 2018. “The perception of Malaysian pedestrians toward the use of footbridges.” *Traffic Inj. Prev.*, 19 (3): 292–297. Taylor & Francis. https://doi.org/10.1080/15389588.2017.1373768.

Landa-Blanco, M., and J. Ávila. 2020. “Factors related to the use of pedestrian bridges in university students of Honduras.” *Transp. Res. Part F Traffic Psychol. Behav.*, 71: 220–228. Elsevier Ltd. https://doi.org/10.1016/j.trf.2020.04.016.

Mayur, L., S. Dharmendra, P. Darshan, P. Neel, P. Hiren, C. Dixit, B. E. Civil, and M. College. 2019. “Appraisal and Design of Foot Over Bridge.” 2134–2137.

Minh, N. N. 2019. “Advanced solutions to increase the efficiency in the use of pedestrian bridge systems in Hanoi.” (August).

Oviedo-Trespalacios, O., and B. Scott-Parker. 2017. “Footbridge usage in high-traffic flow highways: The intersection of safety and security in pedestrian decision-making.” *Transp. Res. Part F Traffic Psychol. Behav.*, 49: 177–187. Elsevier Ltd. https://doi.org/10.1016/j.trf.2017.06.010.

Rajeshirke, U., and N. Bhadane. 2013. “Design and construction of pedestrian bridge at Kharghar, Navi Mumbai, India.” *Long Span Bridg. Roofs - Dev. Des. Implement.*, (September 2013). https://doi.org/10.2749/222137813808627415.

Rankavat, S., and G. Tiwari. 2016. “Pedestrians perceptions for utilization of pedestrian facilities – Delhi, India.” *Transp. Res. Part F Traffic Psychol. Behav.*, 42: 495–499. Elsevier Ltd. https://doi.org/10.1016/j.trf.2016.02.005.

Räsänen, M., T. Lajunen, F. Alticafarbay, and C. Aydin. 2007. “Pedestrian self-reports of factors influencing the use of pedestrian bridges.” *Accid. Anal. Prev.*, 39 (5): 969–973. https://doi.org/10.1016/j.aap.2007.01.004.

Rizati, H., S. Z. Ishak, and I. R. Endut. 2013. “The utilization rates of pedestrian bridges in.” *BEIAC 2013 - 2013 IEEE Bus. Eng. Ind. Appl. Colloq.*, 646–650. IEEE. https://doi.org/10.1109/BEIAC.2013.6560210.

Indo-HCM 2017. "Indian highway capacity manual (Indo-HCM). CSIR-Central Road Research Institute, New Delhi.

Thank you