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"Exploring Pedestrian Dynamics at Metro Station for Effective Transportation Planning: Jaipur case study"

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Introduction

- Metro stations serve as major transportation hubs in urban areas, catering to a significant influx of pedestrians during peak hours
- By studying pedestrian movement, researchers can gain insights into crowd behavior, flow patterns, congestion levels
- These insights are invaluable for metro station planners in designing efficient and pedestrian-friendly stations
- Effective station design is essential for ensuring smooth pedestrian flow and minimizing congestion

Figure 1. (Source: Google)

Objectives

- To identify the most effected areas of metro station with increase in pedestrian flow
- To study the pedestrian dynamics and Level of Service (LOS) at metro Station
- To gain valuable insights into user perceptions related to comfort at metro station
- To identify the scope of inclusion of shops at different areas of metro station for economical activities

Literature Review

Authors	***Title***	***Outcomes***
Hagos et al. (2020)	Effect of sidewalk vendors on pedestrian movement characteristics: A microscopic simulation study of Addis Ababa, Ethiopia	• Average pedestrian density varied with the location and width of the vending stall, width of the walkway, pedestrian flow
Alam et al. (2022)	Pedestrian movement simulation for an airport considering social distancing strategy	• Need for potential infrastructural modifications • Emphasize the implications of social distancing regulations on pedestrian traffic flow
Basbas et al. (2019)	Pedestrian level of service assessment in an area close to an under-construction metro line in Thessaloniki, Greece	• Pedestrian street had a high level of service and could accommodate increased pedestrian flows
Shi et al. (2021)	Verifying the applicability of a pedestrian simulation model to reproduce the effect of exit design on egress flow under normal and emergency conditions	• Application of the VISWALK model in simulating emergency situations needs scrutiny and further investigations in the future with empirical data
Liu et al. (2021)	Microscopic Simulation-based Pedestrian Distribution Service Network in Urban Rail Station	• Model can better reflect the pedestrian decision-making model of the real scene and the station's distribution process

Study Area

- The study area includes Choti Choupar Metro station which is in Pink City, Jaipur.
- Choti Choupar and Badi Choupar areas are famous bazaars known for artisans, jewelers, and craftsmen.
- This metro line was started in 2020. After the extension of this metro line, signification growth in metro ridership was observed which was around 38,000 per day.

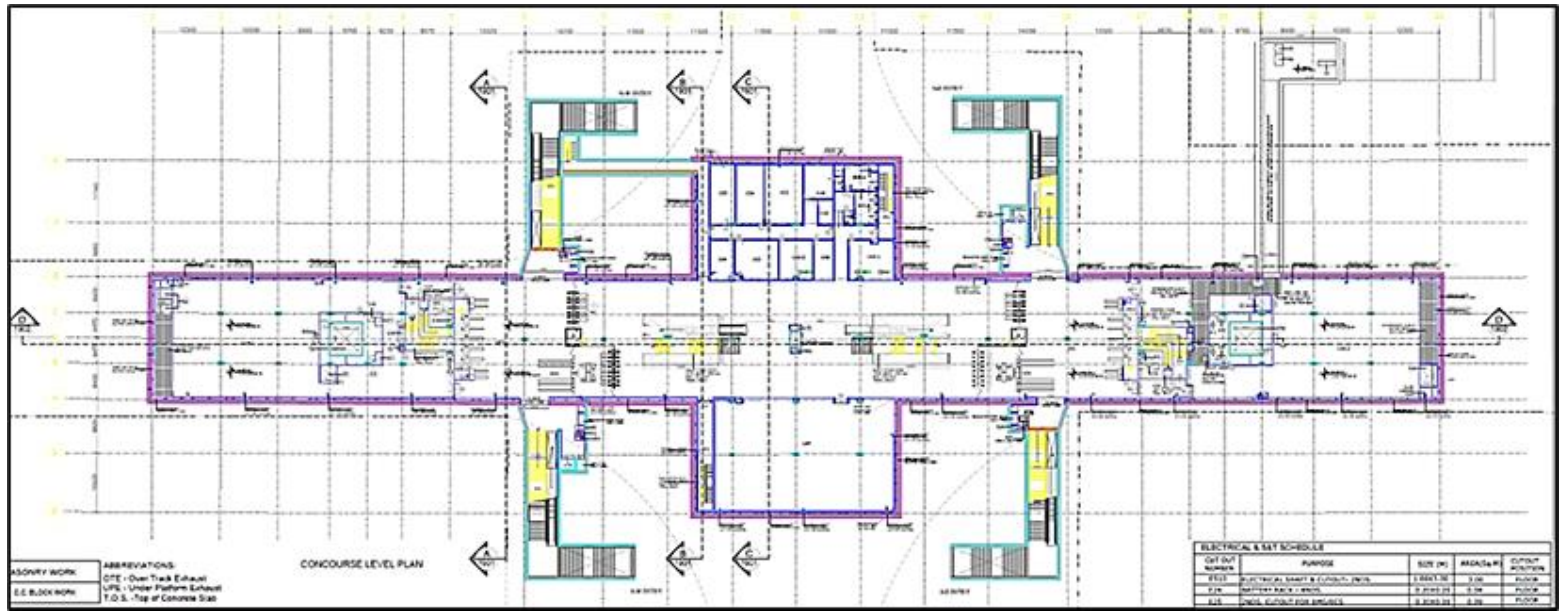
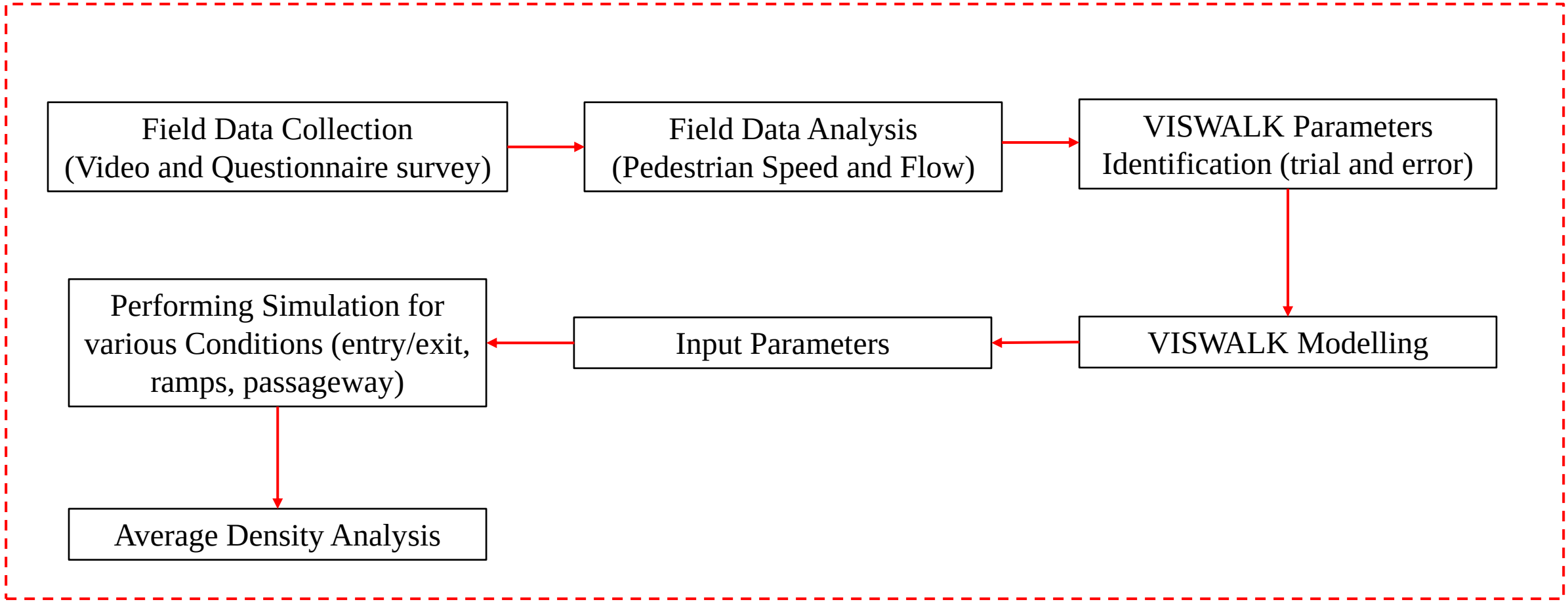


Figure 2. Choti Choupar, Jaipur Metro station concourse area plan (Source: Google)

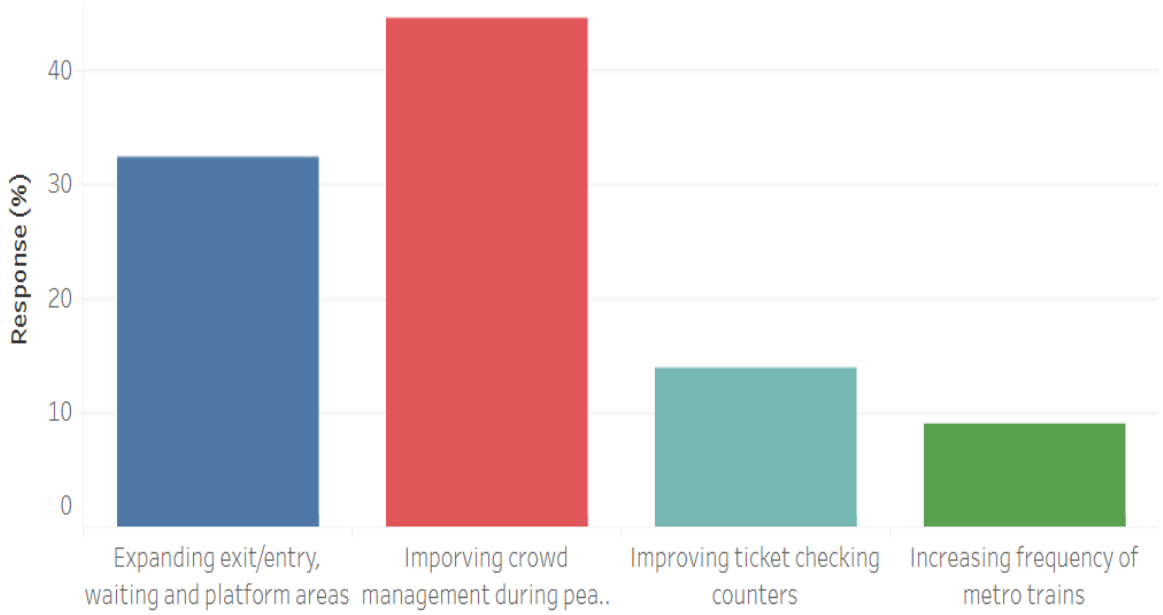
Methodology



Data Collection

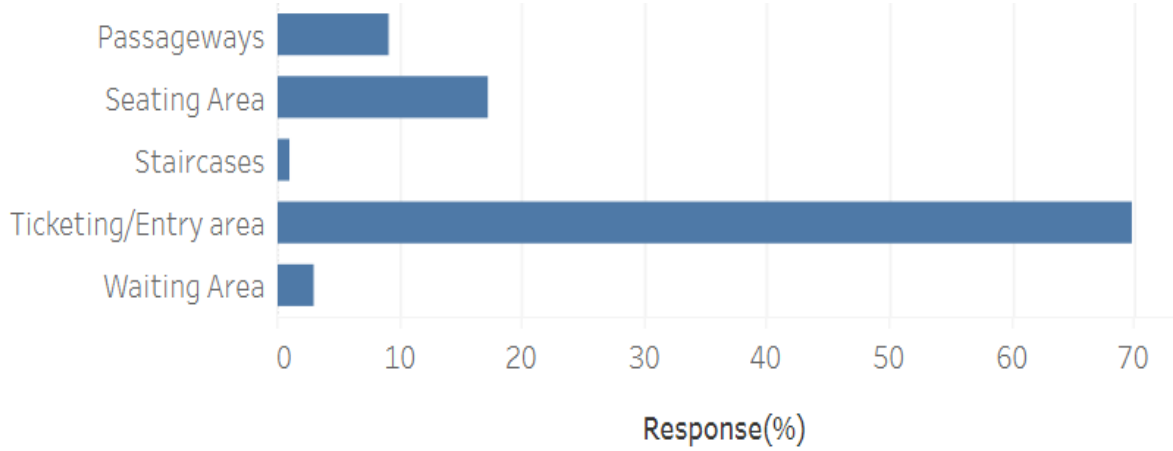
- Video survey was conducted at Choti Choupar Metro Station, Jaipur
- On-site surveys were conducted during morning peak hours (8AM-10AM) and evening peak hours (6PM - 8PM) data on pedestrian behavior
- This included recording walking speeds, counting the number of pedestrians in various areas of the station, and noting their movement patterns
- Pedestrian flow metrics such as flow rate, density, and speed were manually extracted from the recorded video footage
- Additionally, to gain valuable insights into user perceptions, an online questionnaire survey was conducted having 219 respondents

Questionnaire Analysis

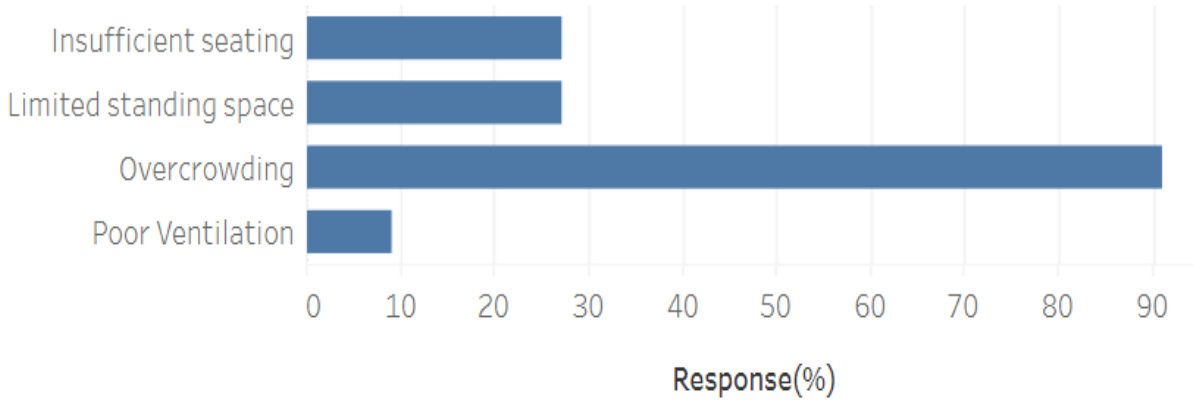


How do you think the metro station could be improved to address the discomfort caused by limited space?

Which area of the metro station do you find the most uncomfortable?



What specific aspects contribute to discomfort in the selected area(s)?



Microsimulation

- The pedestrian behavior in microsimulation is governed by the social force model
- The model was customized to replicate Indian pedestrian scenarios, considering the behavior patterns unique to the region
- The calibration process involved minimizing the Root Mean Square (RMS) error, a metric used to measure the difference between simulation outputs and observed data

Table 1 . VISWALK Pedestrian walking behavior parameters and their values

Parameter	Default Values	Adopted Values
Tau (τ)	0.4	0.4
React to N	8	7
$A_{Social\_Isotropic}$	2.72	1.50
$B_{Social\_Isotropic}$	0.2	0.2
Lambda	0.176	0.10
A_{Soc_mean}	0.4	0.550
B_{Soc_mean}	2.8	1.50
VD	3	9
Noise	1.2	0.90
Side. Pref.	None	None

Figure 3**.** Simulation Models of Concourse area (left) and platform area (right) depicting the field conditions with pedestrian routing and entry/exit routes

Result and Discussion

Table 2. Chance in Level of Service with an increase in pedestrian flow for different conditions on metro station

Pedestrian flow (Ped/hr)	*Average Density (ped/m²)*							
	Entry/Exit Area (Concourse level)							
	No Shop	*LOS*	*1m Shop*	*LOS*	*2m Shop*	*LOS*	*3m Shop*	*LOS*
500	0.01	A	0.01	A	0.02	A	0.05	A
1000	0.02	A	0.02	A	0.04	A	0.07	A
1500	0.02	A	0.02	A	0.10	A	0.15	A
2000	0.04	A	0.05	A	0.12	A	0.23	B
2500	0.09	A	0.11	A	0.19	B	0.28	C
3000	0.10	A	0.12	A	0.26	B	0.36	C
3500	0.12	A	0.17	A	0.30	C	0.48	D
4000	0.16	A	0.25	B	0.43	C	0.59	D
4500	0.35	C	0.33	C	0.52	D	0.63	D
5000	0.43	C	0.42	C	0.64	D	0.77	E
5500	0.51	D	0.53	D	0.69	D	0.81	E
6000	0.60	D	0.62	D	0.74	E	0.95	E
	Passageway Area (Concourse level)							
500	0.01	A	0.02	A	0.04	A	0.05	A
1000	0.01	A	0.03	A	0.07	A	0.09	A
1500	0.02	A	0.06	A	0.09	A	0.11	A
2000	0.04	A	0.09	A	0.13	A	0.15	A
2500	0.08	A	0.11	A	0.17	A	0.19	B
3000	0.09	A	0.16	A	0.21	B	0.23	B
3500	0.12	A	0.19	B	0.27	C	0.27	C
4000	0.15	A	0.25	B	0.31	C	0.32	C
4500	0.21	B	0.31	C	0.36	C	0.38	C
5000	0.27	C	0.35	C	0.41	C	0.43	C
5500	0.34	C	0.38	C	0.45	C	0.48	D
6000	0.39	C	0.41	C	0.49	D	0.60	D

Table 3. Change in level of service of access ramp based on average density for different pedestrian flow

Pedestrian flow (ped/hr)	***Average Density (Q/2) Entry Access Ramp (2.85m)***	***LOS***	***Average Density (ped/) Platform area***	***LOS***
500	0.02	A	0.03	A
1000	0.05	A	0.07	A
1500	0.08	A	0.13	A
2000	0.11	A	0.19	B
2500	0.13	A	0.23	B
3000	0.17	A	0.31	C
3500	0.21	B	0.37	C
4000	0.25	B	0.42	C
4500	0.29	C	0.45	C
5000	0.33	C	0.53	D
5500	0.37	C	0.60	D
6000	0.45	C	0.68	D

Conclusion

- In the entry/exit area, it was evident that as pedestrian flow increased, average density also increased, resulting in higher congestion levels.
- The absence of commercial shops seemed to contribute to smoother pedestrian movement, emphasizing the need for careful planning when integrating commercial activities.
- Larger shop sizes showed higher average densities, indicating a significant impact on pedestrian flow during peak hours.
- In case of ramps, as flow increased, congestion levels rose, leading to slower pedestrian movement and reduced comfort.
- In conclusion, the analysis of average density and the assigned Level of Service (LOS) provides crucial insights for transit planning and designing to create pedestrian-friendly spaces.

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Thank you