Initiative 2: Infrastructure Integration

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Abbreviations and Acronyms

Abbreviations	Full Form
ATM	Automatic Teller Machine
BBMP	Bruhat Bengaluru Mahanagara Palike
BDA	Bengaluru Development Authority
BMRCL	Bangalore Metro Rail Corporation Limited
BMTC	Bengaluru Metropolitan Transport Corporation
Comm.	Commercial
CSTEP	Center for Study of Science, Technology and Policy
GoK	Government of Karnataka
HB	High Boarding
IPT	Intermediate Public Transport
LB	Low Boarding
P./Semi Public	Public/Semi Public
PT	Public Transport
RMP	Revised Master Plan
TTMC	Traffic and Transit Management Centre

Executive Summary

Bengaluru Metropolitan Transport Corporation (BMTC) and Bangalore Metro Rail Corporation Limited (BMRCL) are the primary public transport service providers in Bengaluru, and aim to provide safe, reliable, clean and affordable transportation. To achieve this aim and to make public transport the preferred mode of transport in Bengaluru, it is important to integrate these services.

In this context, Government of Karnataka has engaged Center for Study of Science, Technology and Policy (CSTEP) as a technical research institution to suggest ways for integration of BMRCL and BMTC. This study focuses on infrastructure integration[1], which comprises identification of planning interventions and design elements for each Metro station typology.

This study focussed on best practices and accessibility design case studies to arrive at a list of planning interventions and design elements for infrastructure integration. Metro stations were classified into different typologies based on land use within a radius of 500 metres (around the Metro stations), boarding and alighting of Metro commuters as well as access road width to each Metro station. For each Metro station typology, the planning and design elements were assigned to arrive at the desired elements matrix.

For 40 Metro stations (Phase I), a detailed assessment of land use and access road width data was done based on the Revised Master Plan, 2015. The boarding data for all the Metro stations was considered in the analysis. Detailed site visits were carried out at six Metro stations (one from each typology) to validate Metro Station Typology-Elements Matrix.

From the study, it was observed that infrastructure integration requires planning interventions and design elements. The important planning interventions such as bus stops, bus bays, pick-up and drop-off points and pedestrian crossings required upgradation. These planning interventions will help in smooth transfers of commuters between multiple modes of transport. It was also observed that design elements such as signages, footpaths, lighting, ramps, and railings were incomplete or missing. These design elements are needed for better accessibility in and around the metro stations. The Metro Station Typology-Elements Matrix provides a set of guidelines for future Metro station design for better infrastructure integration.

[1] For this study, the terms infrastructure integration and physical integration will be used interchangeably.

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1. Introduction

Given that BMRCL is a mass rapid transport service provider for Bengaluru, it is essential that there is seamless connectivity at metro station area which would ease of access. Hence, there is a need to provide enabling infrastructure elements at the existing Metro stations as well as plan for future Metro stations. This can be done by preparing a guideline which would allow planners to categorise the Metro stations into different typologies and plan for associated infrastructure elements. This would allow commuters to move seamlessly across multiple modes of transport at the Metro stations and may increase the public transport mode share. This study identifies required physical/infrastructure elements (planning interventions and design elements) according to the Metro station typology, for seamless multimodal connectivity.

Planning interventions in this study indicate the strategies to be implemented at Metro stations for seamless multimodal connectivity. Planning interventions include bus stops, bus bays, interchange points, parking facility, etc. Design elements include way-finding, signage, lighting, bus stop shelters, ramps, lifts, staircase, etc. Both of these are important for BMRCL and BMTC infrastructure integration, which would help BMTC feeder service to improve connectivity to BMRCL. More information on feeder services can be found in the Route Integration section.

2. Log Frame / Theory of Change / Programme Theory

Infrastructure integration comprises planning interventions and design elements at Metro stations for:

- Ease of access between different modes of transport
- Ensuring safety of commuters
- Providing a convenient and comfortable commute
- Saving transfer time

	Intervention Logic	Verifiable Indicators of Achievement	Sources and Means of Verification	Assumptions
Overall Objectives	*What are the overall broader objectives to which the activity will contribute?* To suggest planning interventions and design elements that will provide ease of access for commuters at Metro stations	*What are the key indicators related to the overall objectives?*	*What are the sources of information for these indicators?* • Primary survey/site visit[2] • Secondary data	
Specific Objectives	*What specific objectives is the activity intended to achieve to contribute to the overall objectives?* • To identify the required planning and design elements for infrastructure integration • To analyse feasibility of their implementation for different Metro station typologies	*Which indicators clearly show that the objective of the activity has been achieved?* • List of feasible physical elements (planning interventions and design elements) • Implementation of suggested elements by the local authorities (may extend beyond the study period)	*What are the sources of information that exist or can be collected? What are the methods required to get this information?* • Station accessibility plans • Site visits to obtain list of existing and missing elements	*Which factors and conditions outside the PI's responsibility are necessary to achieve that objective? (external conditions)* *Which risks should be taken into consideration?* • Willingness of competent authority to share the data • Willingness of competent authority to implement the recommendations

[2] For this study, the terms primary survey and site visit may be used interchangeably.

Expected results	*The results are the outputs envisaged to achieve the specific objective.* *What are the expected results? (enumerate them)* • Metro Station Typology – Elements Matrix • Suggested list of elements for select Metro stations	*What are the indicators to measure whether and to what extent the activity achieves the expected results?* Data availability and site visits as per the schedule	*What are the sources of information for these indicators?* • Secondary literature on Metro station typology & physical elements • Validation of elements checklist	*What external conditions must be met to obtain the expected results on schedule?* • Permission from competent authority to carry out site visit • Willingness of competent authority to share the data • Availability of literature
Activities	*What are the key activities to be carried out and in what sequence in order to produce the expected results?* *(group the activities by result)* 1. Secondary literature review for: • Identifying required planning interventions and design elements • Classification of Metro stations into various typologies • Preparing Metro station typologies-elements matrix 2. Conducting primary survey/site visit at select Metro stations for comparing existing elements with required elements 3. Suggesting feasible elements for select Metro stations	**Means:** *What are the means required to implement these activities, e. g. personnel, training, studies, etc.* • Urban planning experts • Transport planning experts • Training for conducting site visits and infrastructure planning • Surveys	*What are the sources of information about action progress?* • Site visits • Interaction with competent authority on implementation	*What pre-conditions are required before the action starts?* • Acceptance by the authority to go ahead with the study • Work plan for carrying out and completing the study

3. Progress Review

The progress review provides a brief overview of the existing infrastructure provided by different agencies in and around Metro stations.

3.1. Overview of Existing Infrastructure

BMTC provides the bus service, while Bruhat Bengaluru Mahanagara Palike (BBMP) is responsible for providing required infrastructure such as bus stops, bus bays, etc. Similarly, while BMRCL runs the Metro service, different agencies are responsible for construction and maintenance of planning interventions and design elements. One key understanding from secondary literature and site visits is that there are multiple agencies that function independently and don't necessarily coordinate with each other on infrastructure integration. For example, the following issues were observed in and around Metro stations:

- Lack of pedestrian facilities
- Lack of seamless multimodal transfer facilities
- Lack of passenger information systems

4. Problem Statement

To examine the existing infrastructure at Metro stations and to develop a station accessibility matrix for providing seamless connectivity.

As mentioned in the earlier section, there is lack of proper infrastructure integration between BMRCL and BMTC. For example, even though there is a bus stop in the close vicinity of M. G. Road Metro station (towards Trinity Circle), it is difficult to locate it from the Metro station exit gate. Also lack of display indicating the destination routes of BMTC buses may deter commuters from using the available bus service. Yet another Metro station, Majestic, which is a multimodal transport hub, has good physical connectivity to all the modes but lacks in signage that would lead the commuters to their intended destinations (way-finding). In addition to this, some entrances and exits have been kept closed for security reasons, which presents challenges from an accessibility point of view.

Evaluation Question

What are the physical elements required for infrastructure integration in and around Metro stations?

This study identifies the physical elements required to overcome the above-mentioned challenges and identify the feasible elements at select Metro stations. It provides a guideline for the required physical elements according to the typology of the Metro station (as defined in Metro Station Typologies).

5. Objectives and Issues for Evaluation

Objectives

- To develop a Metro Station Typology-Elements Matrix
- To assess accessibility measures at select Metro stations

Scope

Target population: The target population are current Metro users as well as non-users of Metro who stay within a radius of five km (from Metro stations). They are the potential commuters[3] who might shift to Metro with improvement in infrastructure integration at Metro stations.

Geographical coverage: This section covers an area within a 500 metre radius from all the existing 40 Metro stations. Figure 1 illustrates the geographical coverage of the study around Yeshwanthpur Metro station.

Figure 1: Geographical coverage around Yeshwanthpur Metro station – 500 m radius

Source: (BDA 2016)

[3] Metro passenger opinion survey as part of route integration study revealed that major access and egress trips are within a radius of 5 km.

6. Evaluation Design

6.1. Information Sources

Secondary Literature:

Global best practices of infrastructure integration were identified as sources of information.

1. Towards a Walkable and Sustainable Bengaluru EMBARQ India (Embarq 2014)
2. Guidelines for station site and access planning – Washington (WMATA 2008)
3. Urban Street Design Guidelines, Pune (PMC and ITDP 2016)
4. NMT Policy and Strategy - Volume 2: Policy Framework, City of Cape Town (Directorate Transport 2005)
5. Universal Access Policy for the City of Cape Town (Tukushe 2014)
6. Portland Pedestrian Design Guide (Office of Transportation 1998)

Primary Site Visits:

Primary site visits at 6 Metro stations (refer Table 2) were carried out in order to:

1) Validate the Metro station typology
2) Compare the existing set of elements with the requisite set of elements

6.2. Research Methods

Secondary Data Literature:

As this study intends to understand the physical elements required for multimodal integration, it is necessary to understand the best accessibility practices in and around Metro stations. Global best practices helps to understand various physical elements that are necessary for infrastructure integration. This review also helps to understand the function of each identified element and contextualise it for Bengaluru Metro stations.

Primary Data Collection: Site Visits

After studying the global best practices and preparing the list of required physical elements for infrastructure integration, there is a need to contextualise this information to the study area. Site visits help validate Metro station typologies and examine the feasibility of introducing the identified elements for select stations. This study identifies the gaps between the best practices and the ground reality.

6.3. Evaluation Criteria or Indicators

This study focuses on the physical elements for infrastructure integration. Thus the compliance of existing elements with the desired elements for respective Metro station typologies forms the basis of evaluation.

7. Evaluation Methodology

7.1. Procedure Adopted for Infrastructure Integration

A systematic methodology was followed to achieve the expected results. Figure 2 shows the methodology flowchart adopted for this study.

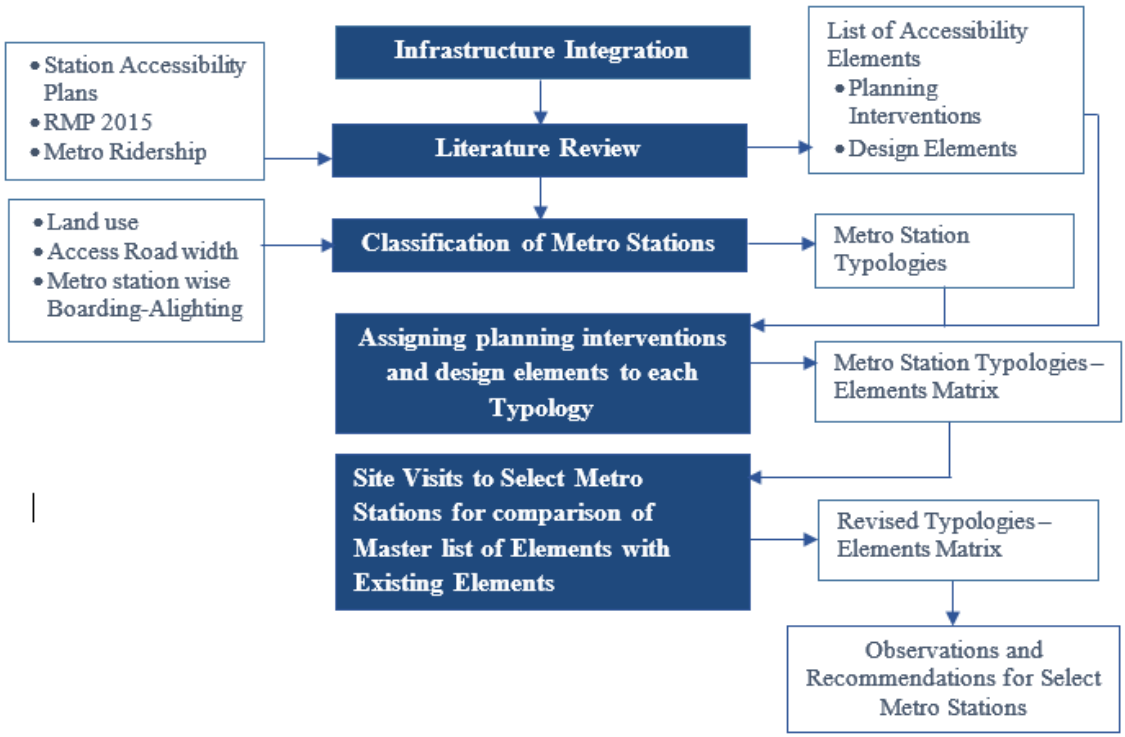

Figure 2: Methodology for infrastructure integration

7.2. Sample and Sampling Technique

In this study, the 40 Metro stations were classified based on existing land use, access road width and Metro station boarding and alighting data. One representative Metro station for each typology was surveyed through primary site visits.

7.3. Metro Station Typologies

The Metro stations were divided into different typologies based on parameters such as land use in the influence area (500m radius), access road width and boarding type – high boarding (HB) and low boarding (LB). The 6 station typologies are described below:

Type 1 – Transport hubs that are connected with other public transport modes in the vicinity

Type 2 – Metro stations that are located in predominantly residential areas, with high boarding and access road width of 30 to 80 metres

Type 3 – Metro stations that are located in predominantly non-residential areas, with high boarding and access road width of 30 to 50 metres

Type 4 – Metro stations that are located in predominantly residential areas, with high boarding and access road width of 12 to 30 metres

Type 5A – Metro stations that are located in predominantly residential areas, with low boarding and access road width of 30 to 80 metres

Type 5B – Metro stations that are located in mixed land use, with low boarding and access road width of 30 to 80 metres

Type 6 – Metro stations that are located in predominantly residential areas, with low boarding and access road width of 12 to 30 metres

Table 1 shows the six different typologies of Metro stations.

Table 1: Metro station typologies

Station Name	Predominant Land Use				Access Road Width			Boarding Data		Type	
	Residential	Comm/ P-Semi-public	Industrial	Transport	50m - 80m	30m - 50m	12m - 30m	HB	LB		
Majestic										1	Transport Hubs
Yeshwanthpur											
Baiyappanahalli											
City Railway Station											
Nagasandra										2	High Residential, 30-80m road, HB
Dasarahalli											
Yelachenahalli											
Rajajinagar											
Banashankari											
J. P. Nagar											
Vijayanagar											
Trinity											
Sandal Soap Factory										3	Non-Residential, 30-50m road, HB
M. G. Road		ü									
Mysore Road											
National College										4	Residential, 12-30m road, HB
South End Circle											
R. V. Road											
Indiranagar											
Sampige Road											
Vidhana Soudha		ü									
Sir M. Visveshwaraya		ü									

Station Name	Predominant Land Use				Access Road Width			Boarding Data		Type	
	Residential	Comm/ P-Semi-public	Industrial	Transport	50m - 80m	30m - 50m	12m - 30m	HB	LB		
Hosahalli										5 A & 5 B	Residential, 30-80m road, LB
Deepanjali Nagar											
Mahalakshmi											
Halasuru											
Attiguppe											
Jalahalli											Mixed Land Use, 30-80m road, LB
Peenya Industry											
Peenya											
Goraguntepalya											
Cubbon Park		ü									
S. V. Road											
Chickpet		ü								6	Residential/ Mixed, 12-30m road, LB
K. R. Market		ü									
Kuvempu Road											
Srirampura											
Jayanagar											
Lalbagh											
Magadi Road											

Legend:

- Residential
- Public/Semi Public
- Commercial
- Green
- Industrial
- Transport
- 50-80 m Wide Road
- 30-50 m Wide Road
- 12-30 m Wide Road
- High Boarding
- Low Boarding
- ü Other Additional Land Use (Defined by Colour)

After deriving the Metro station typologies shown in the above table, one Metro station from each type was selected for detailed study and site visits. The list of the Metro stations selected for further study is given in Table 2.

Table 2: Typology-wise Metro stations selected for the study

Station Name	Type
Yeshwanthpur	Type 1
Banashankari	Type 2
Sandal Soap Factory	Type 3
South End Circle	Type 4
S. V. Road	Type 5
K. R. Market	Type 6

7.4. Type of Data Collected from Various Sources

Secondary Literature: The secondary literature helped to prepare a list of physical elements required for station accessibility improvement. These elements were categorised as

1. Planning interventions
2. Design elements

Table 3 shows the required planning interventions and design elements for station accessibility.

Primary survey: The primary survey helped validate the Metro station typology and examine the feasibility of introducing the identified elements for select stations.

7.5. Instruments for Data Collection

Primary Survey: For the primary survey, a data collection template was prepared. This template is given in Annexure II. The template helped identify the existing physical elements at select Metro stations and compare them with the global list of elements prepared from the secondary survey.

7.6. Protocols for Data Collection and Ethics Followed

For the secondary data collection, references in the form of published data and literature were used to arrive at Metro station typologies as well as the list of required physical elements. For the primary survey, permission letters from BMRCL, BMTC and the Commissioner of Police, Bengaluru, were obtained to conduct the site visits. Care was taken so that the regular movement of passengers as well as the duties of workers were not hampered.

8. Data Collection and Analysis

8.1. Procedure of Data Collection and Cleaning

Secondary Data Collection: Published reports were studied to identify the list of physical elements in and around Metro stations. Based on these studies, a list of physical elements recommended for infrastructure integration was prepared (Annexure I). This list was revised to arrive at a finite list of elements to suit the Bengaluru context (Table 3).

Primary Data Collection: Primary data was collected by conducting site visits at 6 select Metro stations which represent six different Metro typologies. A template was prepared based on the secondary literature, to record the site visit observations (Annexure I).

8.2. Procedure Adopted for Data Cleaning

The list of physical elements derived from the secondary literature was finalised to arrive at a finite list of elements to suit the Bengaluru context.

8.3. Data Analysis

Secondary Data Analysis:

Table 3: List of physical elements at Metro stations from global best practices

Intervention Criteria	Best Practice	References
Pedestrians and Cyclists		(PMC and ITDP 2016)
Right of way (ROW) including the pedestrian zone	Arterial Road – 30-80m Distributor Road – 12-30m Local Roads – 6-15m	
Pause points at regular intervals	500m	(Embarq 2014)
Multimodal shift points	500m	
Cycle parking spaces	At Metro station	
Public Transport Users		(PMC and ITDP 2016)
Bus stops		
Intermediate public transport (IPT) stands		
Private transport users		
Drop-off and pick-up points		
Public Amenities		(Embarq 2014)
Retail stores/ Eateries /ATMs	400m	
Street Network Modification		(WMATA 2008)
Tactile paving	400m	
Curb ramps	At Metro stations	
Way-finding	400m	
Walkways, elevators, escalators	At Metro stations	
Refuge islands and medians	400m	

Information kiosks	50m	
Garbage bins	50-200m	
Drinking water fountains	50-200m	

Primary Data Analysis:

A detailed analysis of six select Metro stations, one from each typology, is given below.

8.3.1. Typology 1 – Yeshwanthpur Metro Station

Figure 3: Study area for Yeshwanthpur Metro station

This typology includes the Metro stations having multiple transport modes in the vicinity of 500 metres. Yeshwanthpur Metro station has a railway station (Yeshwanthpur railway station), inter-city bus service (private and KSRTC), intra-city bus service (BMTC bus stops) within a radius of 500 metres. Figure 3 shows the area with its land use within 500 metres as well as 1 km radius of Yeshwanthpur Metro station.

Table 4: List of typology-wise required elements and existing scenario – Yeshwanthpur

Required Elements	Existing Scenario
Footpaths	Yes
Pedestrian crossings, interchange connections	No
IPT bays, pre-paid IPT counters	No (Only IPT Stops)
Way-finding	No
Pick up, drop off	No

Figure 4: Access points at Yeshwanthpur Metro station

Figure 4 illustrates the different access points at Yeshwanthpur Metro station for analysis. The access points D, E, F and G are adjoining the railway station and A, B and C are on the opposite side. Access B faces the railway yard.

Access point A

- There is a 1.5 metre wide footpath being used for parking (two-wheelers and four wheelers) and commercial activities, causing hindrance to pedestrian movement as well as obstructing the Metro entry signage. These encroachments need to be minimised for better pedestrian movement and improve accessibility to feeder buses.
- The Metro signage at the service road leading to access A is placed parallel to the road, hence it is not noticeable to the drivers coming from Tumkur Road. It should be oriented perpendicular to the road.

Figure 5: Parking on footpath at access point A

Figure 6: Commercial activities at access point A

Access point B

- This entry has only a lift and no staircase or escalators. Hence this entry can be dedicated for use by sick, aged or differently abled people.
- The footpath has a railing on one side that provides a sense of safety, especially for the differently abled and aged people. A vehicle bay has been provided at this entry but is utilised by freight vehicles. This space can be used as an IPT bay for this entry.

Figure 7: Access point B

Figure 8: Footpath at access point B

Access point C

- This access point has a one-way escalator going up as well as staircase.
- It is connected to the road level as well as the adjoining property which is approximately 1-1.5 metres below the road level.
- The footpath along this access point is not in a good condition and needs to be repaired. To avoid accidents, a railing is required on the off-road side of the footpath where there is a level difference.
- Since this access is on a service road, feeder and IPT services can be provided.

Figure 9: Access point C

Figure 10: Footpath at access point C

Access point D

- This entry has only a lift and no staircase or escalators. Hence this entry can be dedicated for use by sick, aged or differently abled people.
- There is a narrow footpath with a garbage dump on one side and untreated road space on the other. This untreated space can be used to widen the footpath and provide bus stops and IPT stops.

Figure 11: Access point D

Figure 12: Footpath at access point D

Access point E

- This access only has one lift and is meant to serve the railway travellers coming to the Metro station.
- This entry is not visible from the railway station side and hence railway travellers were seen using access F which opens right in front of the railway station.

Figure 13: Access point E

- Proper signage needs to be provided for people coming from the railway station, to identify this access point.

Access point F

- This access connects the Yeshwanthpur railway station to the Yeshwanthpur Metro station. Hence this access is majorly used by the public coming from or going to the railway station, that is, mostly by outstation travellers.
- Even then this access only has a stairway leading to the concourse, making people climb the whole staircase with their luggage.
- A signage to identify access point E will help the railway travellers.

Figure 14: Access point F

Figure 15: Staircase at access point F

Access point G

- This access point has a one-way escalator going up and a stairway to reach the concourse.
- This access also has a connection to the Yeshwanthpur Metro station.
- The regular Metro users coming from railway station use this access point.
- There is a narrow but well-maintained footpath outside this access.
- Currently the feeder buses tend to stop right in front of the entry, which hampers the vehicular movement on that road. But there is scope for provision of feeder bus stop without any physical intervention at this access (Figure 17).

Figure 16: Access point G

Figure 17: Footpath at access point G

8.3.2. Typology 2: Banashankari Metro Station

This typology includes the Metro stations having predominantly residential land use with access road width of 30 – 50 metres or 50 – 80 metres and high boarding. Figure 18 shows the area and land use in 500 metres radius of Banashankari Metro station.

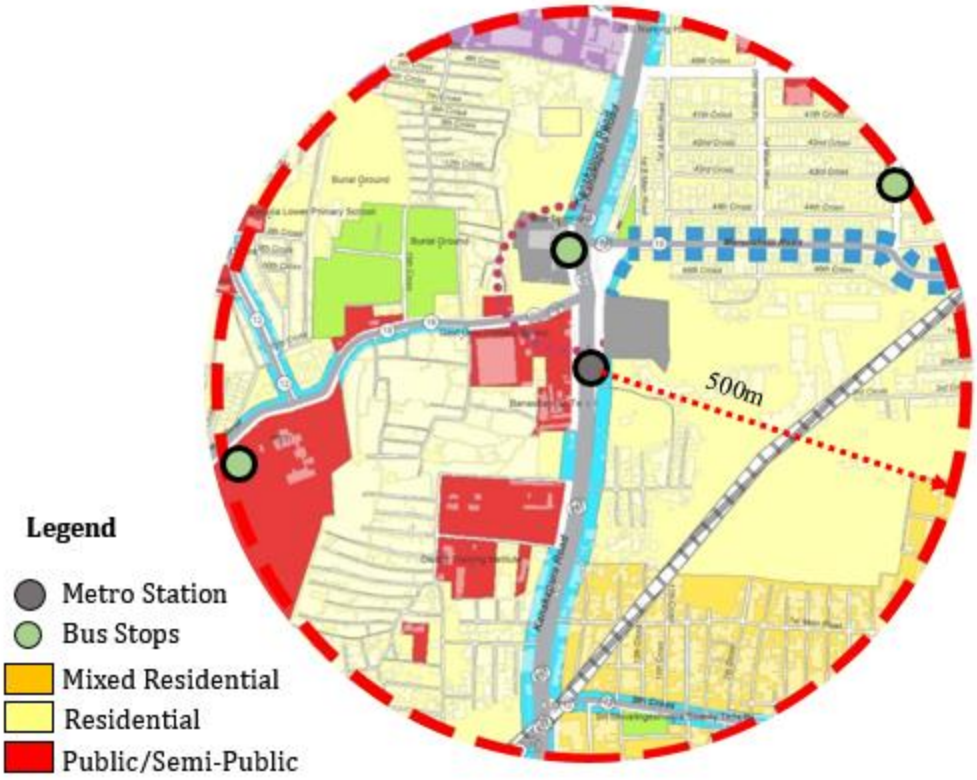

Figure 18: Study area for Banashankari Metro station

There are two BMTC bus stops and Banashankari TTMC within a walkable distance (<500 m) from Banashankari Metro station.

Table 5: List of typology-wise required elements and existing scenario – Banashankari

Required Elements	Existing Scenario
Bus bays/stops	Yes (Bus stops)
IPT bays	Yes (IPT stops)
Private vehicle parking	Yes (Two wheeler)
Footpaths	Yes

Figure 19 shows the access points at Banashankari Metro station. The access points C and D are on the Banashankari temple side, while A and B are on the opposite side of the temple.

Figure 19: Access points at Banashankari Metro station

Access point A

- This access point has a one-way escalator going up and a staircase to reach the concourse. Hence this is not preferred by differently abled or aged people.
- There is an unorganised two wheeler parking space, which extends to access B causing hindrance to pedestrian movement. This parking needs to be organised for ease of access.
- This access opens towards the Banashankari TTMC on the opposite side of the road. It is very difficult for pedestrians to reach the Banashankari TTMC from this access point.
- The Banashankari TTMC junction needs to be redesigned to ensure safe pedestrian crossing and easy access from the Metro station.
- A feeder bus stop can be designed at this access by utilising the service lane.

Figure 20: Access point A

Figure 21: Two-wheeler parking at access point A

Access point B

- This access point has an escalator, a lift as well as a staircase to reach the concourse.
- This point provides access to all the major activity centres around Banashankari Metro station – Banashankari Temple, Banashankari TTMC and Sarakki Market.
- A safe pedestrian pathway from this access to the TTMC needs to be designed.

Figure 22: Access point B

Figure 23: Parking at access point B

Access point C

This access was yet to be opened for public when the site visit was carried out.

Figure 24: Access point C

Access point D

- This access point has an escalator and a staircase to reach the concourse.
- The signage for this access gets blocked due to the commercial activities along the street.
- The footpaths are wide enough and provide a good scope for IPT transfer points.
- There is little scope for private parking and feeder bus stop at this access point.

Figure 25: Access point D

Figure 26: Footpath and IPT stop at access point D

8.3.3. Typology 3 – Sandal Soap Factory Metro Station

This typology includes the Metro stations situated in the non-residential areas with access road width of 30-50 metres and high boarding. This Metro station has only one bus stop within a radius of 500 metres (Figure 27).

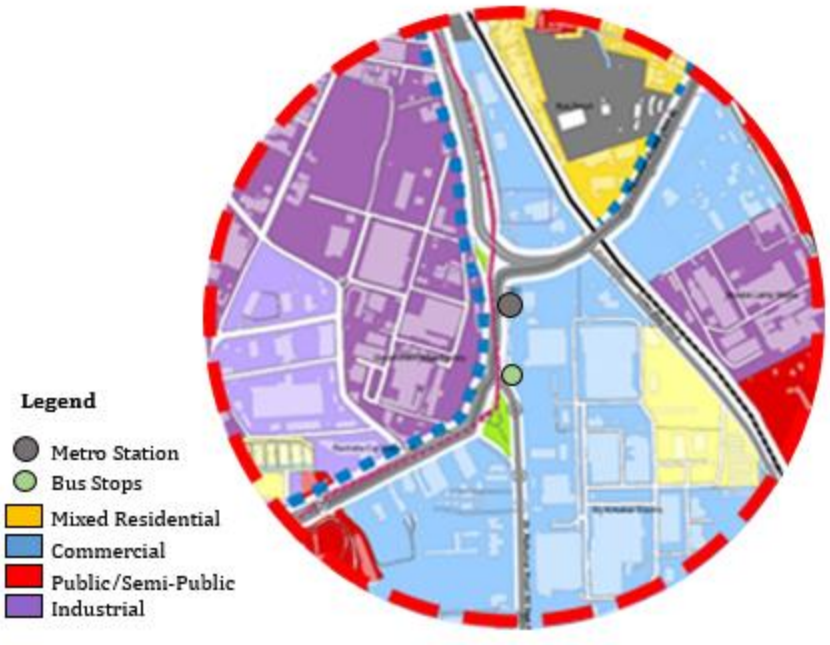

Figure 27: Study area for Sandal Soap Factory Metro station

Table 6: List of typology-wise required elements and existing scenario – Sandal Soap Factory

Required Elements	Existing Scenario
IPT bays, pre-paid IPT counter	No
Bus bays/stops	Yes
Footpaths	Yes
Way-finding	No

There are three access points to this Metro station - Access point A towards Dr Rajkumar Road, B on West of Chord Road and C on the East of Chord Road.

Access point A

- This access has a staircase and escalator to reach the concourse. This is an access for the general public.
- There is a bus stop right next to this access point, which is the only bus stop in 500 metres radius of this Metro station.
- Signage for this access is blocked due to trees. Another signage needs to be put near the bus stop.
- Footpath is narrow and encroached by commercial activities.
- There is no dedicated space for IPT stops, but there is a scope to provide this facility beside the bus stop.

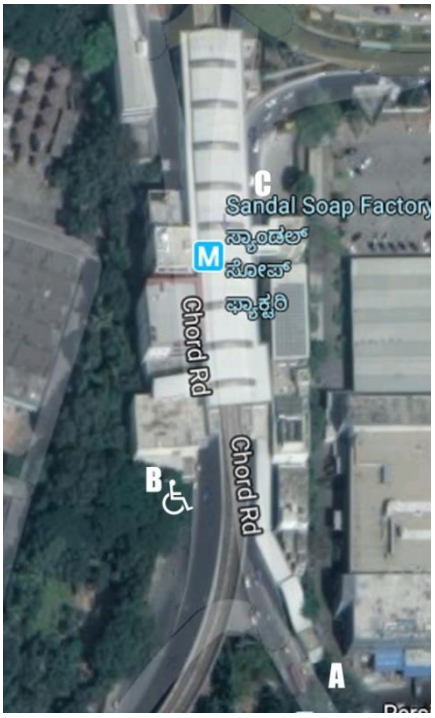

Figure 28: Access points at Sandal Soap Factory Metro station

Figure 29: Access point A

Figure 30: Bus stop at access point A

Access point B

- This access caters to the differently abled passengers and hence has a lift with staircase. There is a ramp to reach the lift lobby.
- There is a well-maintained 1.2 metre wide footpath at this access. This space has been bifurcated to provide space for hawkers and pedestrians (Figure 32).
- There is a paid two and four wheeler parking space at this access point.

Figure 31: Access point B

Figure 32: Footpath at access point B

Figure 33: Parking at access point B

Access point C

- This access is not open to the public.
- It has two and four wheeler parking space.
- The footpath is very narrow and not pedestrian friendly. The parking space could be redesigned to accommodate a new, wider footpath (for proper pedestrian movement) as well as the required parking.

Figure 34: Access point C

Figure 35: Parking at access point C

8.3.4. Typology 4 – South End Circle Metro Station

This typology includes Metro stations located in a predominantly residential area with access road width of 12-30 metres and high boarding. This Metro station has 10 bus stops and institutions such as Vijaya College within a radius of 500 metres. Figure 36 shows the area covered within a 500 metre radius from the South End Circle Metro station (with land use and bus stops).

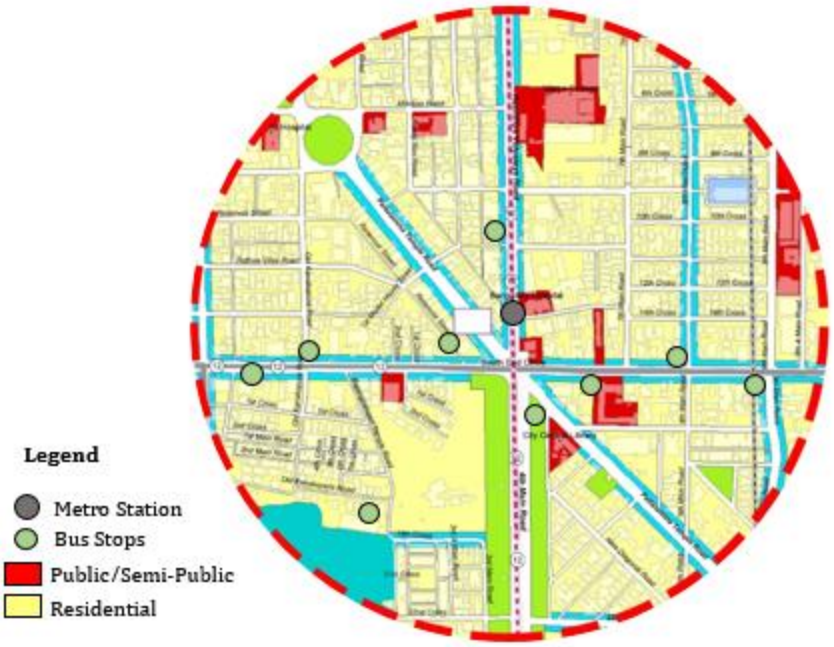

Figure 36: Study area for South End Circle Metro station

Table 7: List of typology-wise required elements and existing scenario – South End Circle

Required Elements	Existing Scenario
IPT bays/stops	Yes
PV parking	Yes
Footpaths	Yes

There are three access points to this Metro station. Figure 37 illustrates the three access points for further analysis. Access point A is located towards Banashankari, access point B is a central entry on the Eastern side of the Metro station and the access point C is located on the North of the Metro station.

A is accessible for people driving towards the South, whereas B and C are accessible for people driving to the North.

Figure 37: Access points at South End Circle Metro station

Access point A

- This access point has an escalator and a staircase to reach the concourse. There are no ramps and lifts, hence this access is not accessible for differently abled and aged people.
- There is a Metro signage at this access, but is blocked due to the IPT stop.
- There is a wide footpath which narrows down at this access point.

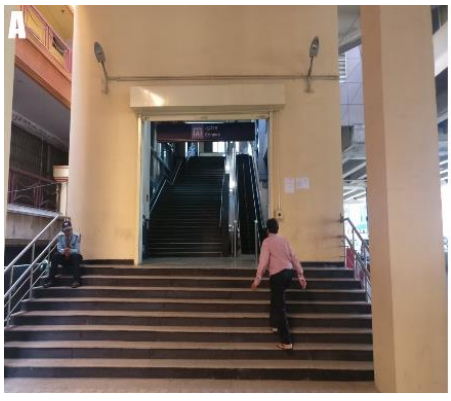

Figure 38: Access point A

Figure 39: Autos at access point A

Access point B

- This access has an escalator and stairs, hence it is not accessible for the differently abled and aged people.
- Two wheelers are usually parked on the footpath and four wheelers on the road along the footpath. This area can be segregated to accommodate IPT and feeder bus pick-up/ drop-off.

Figure 40: Access point B

Figure 41: Four-wheelers parked at B

Access point C

- This is a barrier-free access point with a ramp and a lift. This access does not have stairs and escalators.
- There is a signage stating lift entry on the doorway of this access, but there is no signage elsewhere to lead to this access point.
- The footpath leading to this entry is not in a walkable condition (Figure 43).
- There is an ad hoc private parking besides this access. This can be converted to a pick-up/drop-off point.

Figure 42: Access point C

Figure 43: Footpath at access point C

8.3.5. Typology 5 – S. V. Road Metro Station

This typology includes Metro stations with residential or mixed-use areas within a 500 metre radius (of the Metro station), access road width of 30-80 metres and low boarding. There are three BMTC bus stops in this area (Figure 44).

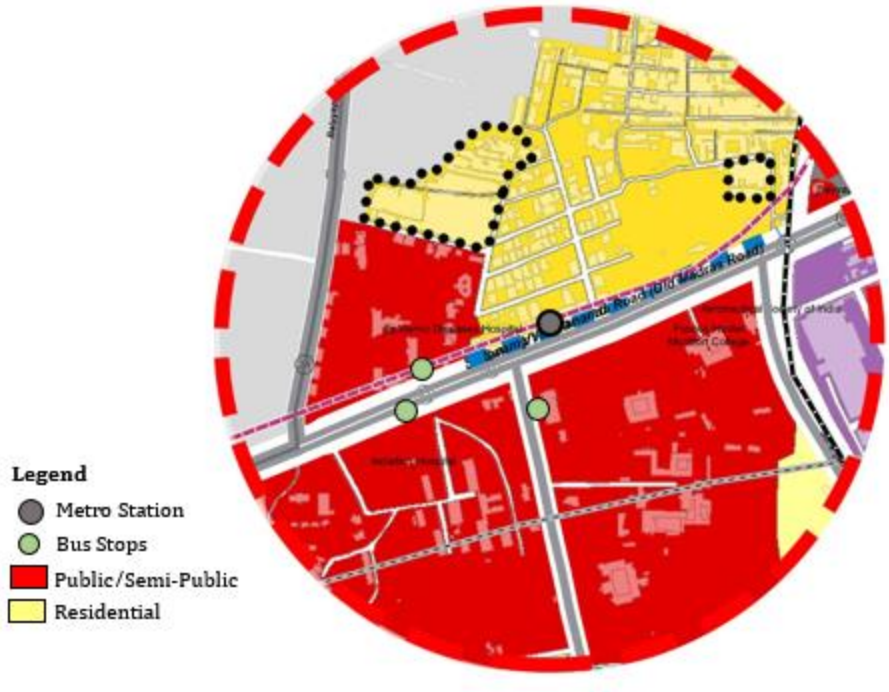

Figure 44: Study area for S. V. Road Metro station

Table 8: List of typology-wise required elements and existing scenario – S. V. Road

Required Elements	Existing Elements
Footpaths	Yes
Bus bays	Yes
IPT bays	No
Commercial activities	Yes
Way-finding	Partially (explained in text)

This Metro station has five access points. Access points A and B are accessible for the people coming from the West (Indiranagar), and C, E and D are accessible to the people coming from the East (ITPL, Baiyappanahalli). Figure 45 shows the locations of all the access points for S. V. Road Metro station.

Figure 45: Access points at S. V. Road Metro station

Access point A

- This access point has a lift, an escalator and a staircase to reach the concourse, which can be accessed by a ramp. Hence this entry is accessible to all commuters.
- As this access point is covered, it needs both proper lighting and signage, which it currently lacks. The signage is not visible due to street hawkers and other commercial activities.
- This access is at the bus bay and needs a proper pedestrian movement plan.

Figure 46: Access point A

Figure 47: Commercial activities at A

Access point B

- This access point has an escalator and stairs to reach the concourse. Hence it is not convenient for differently abled passengers.
- This access does not have a signage and the way leading to this access is not well lit.
- The footpath is wide enough and in a good condition.

Figure 48: Access point B

Access point C

- This access point has a staircase and an escalator to reach the concourse.
- This access is perpendicular to the passenger movement; it can be easily noticed and requires no special signage.
- The footpath is wide enough and in a good condition.
- It has a signage pointing to the access point for differently abled commuters (Figure 50).

Figure 49: Access point C

Figure 50: Signage at access point C

Access point D

- This access is dedicated for differently abled passengers and hence only has a lift.
- This access has ramps on both sides running parallel to the footpath and hence can be accessed from both directions.
- There is clear signage at the all the nearby access points, pointing the differently abled passengers to this access (Figure 52).
- The footpath is wide and in a good condition.

Figure 51: Access point D

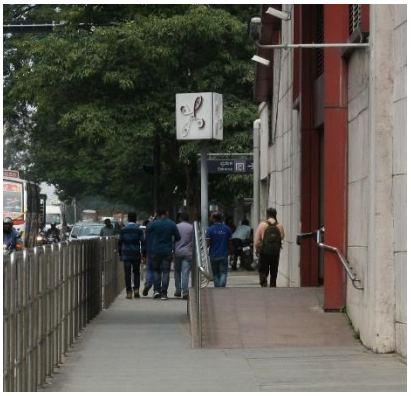

Figure 52: Signage at access point D

Access point E

- This access is at the other end of access C.
- It has a staircase and an escalator to reach the concourse.
- Even though the footpath is in a good condition, it is occupied by street hawkers and has a garbage dump adjacent to the road.

Figure 53: Access point E

Figure 54: Footpath at access point E

8.3.6. Typology 6 – K. R. Market Metro Station

This typology includes Metro stations having mixed land use, access road width of 12-30 metres and low boarding. There are nine BMTC bus stops in the study area (Figure 55).

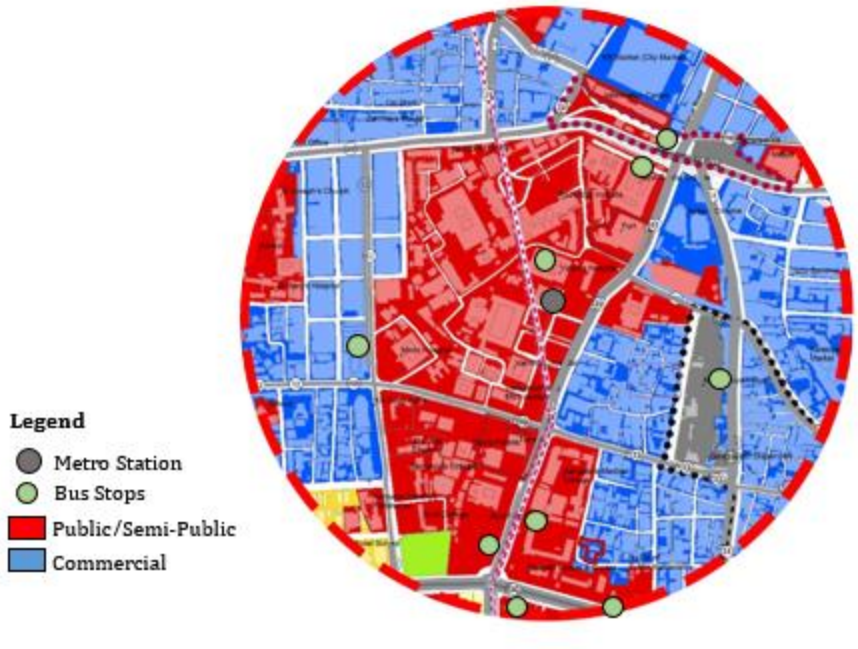

Figure 55: Study area for K. R. Market Metro station

Table 9: List of typology-wise required elements and existing scenario – K. R. Market:

Required Elements	Existing Scenario
IPT transfers	No
Footpaths	Yes
PV parking (two wheeler)	No

This Metro station has five access points (Figure 56). The point A is towards K. R. Market. The access point B is centrally located on the East side of the road. Access point C is located opposite Tipu Sultan's Summer Palace. Access D is adjacent to C, and E is near the Ganapathi Temple.

Figure 56: Access points at K. R. Market Metro station

Access point A

- This access is for the general public and has a staircase and an escalator leading to the concourse.
- The footpath is almost 1.5 metres wide and in a good condition.
- There is a two wheeler parking space at this access, which is not properly distinguished from the walking area. Clear segregation of vehicular and pedestrian movement is required (Figure 58).

Figure 57: Access point A

Figure 58: Parking space at A

Access point B

- This access has a staircase and an escalator.
- Pedestrian bollards are placed only on the other side of the Metro station after the ramp. Thus, vehicles are able to easily enter the pedestrian zone and reach the Metro station gate (Figure 60).
- Encroached two wheeler parking right at the gate of this access point causes hindrance to pedestrian movement.

Figure 59: Access point B

Figure 60: Bollards at access point B

Access points C and D: Not open to the public

Figure 61: Access point C

Figure 62: Access point D

Access point E

- This access point has a lift to reach the concourse and a ramp as well as stairs to reach the lift lobby.
- This access has a 1.5 metre wide footpath which is in a good condition.
- As this access stands alone on a wide footpath, no special signage is required.

Figure 63: Access point E

9. Findings and Discussion

After the site visits were carried out, the revised infrastructure element matrix according to the Metro station typologies was prepared. The revised matrix is given in Table 10.

Table 10: Metro station typology-infrastructure elements matrix

Metro Station Typology	Required Infrastructure Elements
1	• Footpaths, pedestrian crossings, interchange connections (Jani and Kost 2013), • IPT bays, pre-paid IPT counters • Way-finding • Pick-up, drop-off
2	• Bus bays/stops (Gandhi et al. 2015) • IPT bays • Private vehicle parking • Footpaths
3	• IPT bays, pre-paid IPT counter • Bus bays/stops • Footpaths • Way-finding
4	• IPT bays ('Complementary Paratransit Plan User Guide' 2016) • PV parking (Govt. of NCT of Delhi 2017) • Footpaths
5A	• Footpaths • Bus bays • IPT bays • Commercial activity space
5B	• Bus bays • IPT bays • Footpaths • Way-finding
6	• IPT transfers • Footpaths • PV parking (two wheeler)

A few elements such as footpaths, pedestrian crossings, ATMs and retail outlets are common passenger amenities that have to be provided in and around Metro stations. But, some elements

have to be prioritised based on the Metro station typologies defined in this report. For the Metro stations located in the transport hubs of the city, elements such as interchange connections, way-findings, pre-paid IPT counters and pick-up/drop-off points are essential. For the Metro stations in areas with predominant residential land use and wide roads, elements such as bus bays and private parking are essential. For commercial areas with wide roads, elements such as bus bays and IPT bays are more suitable; for residential/mixed land-use areas with narrow roads (< 30 m), elements such as IPT stops and private vehicle parking are preferred.

10. Conclusion and Recommendations

Conclusion

Most of the Metro stations have the required infrastructure such as footpaths and IPT stops; however, in many cases these are not well maintained. Some of the issues with the footpaths are:

- Narrow width
- Encroachment
- Poor condition of pavers and stone slabs
- Garbage along the footpath

There are buses and autos that stop at the Metro stations, but most of the Metro stations do not have a dedicated feeder or IPT stop/bay. Hence these vehicles (bus and autos), stopping at the Metro station access points, not only cause hindrance to the vehicular movement along the road, but also to the pedestrian movement along the footpath.

Apart from this, signage is another concern. Even though there are sign boards at Metro stations, they are often visually blocked.

Recommendations

In the infrastructure integration study, design elements and planning interventions at Metro stations were examined through primary and secondary analysis. Metro station typologies were developed considering land use, access road width and Metro station ridership. Select Metro stations (one from each typology) were considered for primary site visits and analysis. Based on the analysis, infrastructure element matrix was developed and required design and planning interventions were suggested.

Following are the set of recommendations for infrastructure integration:

- For better accessibility in and around Metro stations, physical design should be an integral part of the Metro planning process.
- For seamless multimodal transfers, encroachments on footpaths or service roads need to be removed.
- Adequate crossings (foot overbridges/underpass) need to be provided for safe movement of pedestrians.
- Dedicated transfer facilities for buses and IPT can be provided at Metro stations.
- The way-finding to and from Metro stations needs to be re-designed to make it more user friendly.
- Proper signages for public amenities within Metro stations are required.
- Transfer signages at interchange stations need to be improved for smoother transfers between the green and purple lines.
- The Metro Station Typology – Elements Matrix provides a guideline for effective physical integration for future Metro station design.

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Annexure I

Literature Review – Global Best Practices and Guidelines

Intervention Criteria	Ideal Situation
Planning Interventions	
For pedestrians and cyclists	
ROW including the pedestrian zone	Arterial: 30-80 metres Distributor: 12-30 metres Local: 6-15 metres
Land use along the influential zone	
Pause points in regular intervals	500 metres
Multimodal shift points	500 metres
Cycle parking spaces/points	At the Metro stations
For public transport users	
Bus stops	400 metre radius
Auto/Other IPT stands	400 metre radius
Non-encroached/Dedicated IPT Stands	
For private transport users	
Non-encroached/Dedicated parking spaces	
Fuel stations	300 metres
Drop-off/Pick-up points	At the Metro stations
For private transport users: Share cabs (Ola, Uber, etc.)	
Non-encroached/dedicated parking spaces	
Drop-off/Pick-up points.	At the Metro stations
Pooling strategies based on specific results from O-D survey	
Design Elements	
Street network modification	
Pavement type - permeable pavers	
Tactile paving	
Kerb ramps	
Tactile paving	
Refuge islands and medians	
Lighting pole	Height – 12 metres; Distance between poles – 35 metres
Seating - inbuilt/externally added	50-200 metres
Drinking water fountains	50-200 metres
Information kiosks	At Metro stations
Frame boards (advertisements)	50-200 metres
Smartphone charging points	50-200 metres

Plantations	
Garbage bins	
Retail stores	400 metres
Pedestrian/Cycle access plan	
Way-findings	At Metro stations
Signage (showing direction, time and distance)	50-200 metres
Lost spaces – below Metro pillars	Can be used for advertisement

Annexure II

Primary Data Collection Template

Metro station name: _____

Sl. No.	Required Elements	Existing Elements	Remarks

Annexure III

Comprehensive table showing status of planning interventions/elements at select Metro stations

Intervention Criteria	Metro Stations					
Planning Interventions	**1**	**2**	**3**	**4**	**5**	**6**
Footpaths	Y	Y	Y	Y	Y	Y
Cycle track	N	N	N	N	N	N
Pause points in regular intervals	N	N	N	N	N	N
Multimodal shift points	P	Y	N	N	Y	N
Cycle parking spaces/points	N	N	N	N	N	N
Bus stops	Y	Y	Y	Y	Y	Y
Auto/Other IPT stands	Y	Y	N	Y	Y	P
Non-encroached/Dedicated IPT Stands	N	N	N	N	Y	N
Non-encroached/Dedicated parking spaces	P	Y	Y	Y	Y	P
Fuel stations	Y	N	N	Y	N	N
Drop-off/Pick-up points	N	N	P	P	Y	N
Non-encroached/dedicated cab parking spaces	N	N	N	N	N	N

1 – Yeshwanthpur Metro station

2 – Banashankari Metro station

3 – Sandal Soap Factory Metro station

4 – South End Circle

5 – SV Road Metro station

6 – KR Market

Y – Yes (Element exists)

N – No (Element does not exist)

P – Partially (Partially exists or not is a good condition)

