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EXCLUSIVE BUS BAY SYSTEM: A CASE OF HYDERABAD CITY

[1] M Vamsi, [2]T Divya Sree
[1]Department of Civil Engineering, CVR College of Engineering, Hyderabad, Telangana
[2]Department of Civil Engineering, Sreyas Institute of Engineering & Technology, Hyderabad, Telangana

Abstract: The primary objective of transit operators is to increase in speed, reliability and capacity of public transportation systems. Exclusive bus-bay systems are the one of the suggestive measure to reduce the congestion due to private vehicles and improving the share of public transport. But the speed and travel time majorly controlled by the location of bus stops, traffic flow conditions across the bus bay and the overtaking zones required for the buses. Normal bus priority measures adopted in different cities in the country are limited in their scope. In this context, this paper primarily focuses on the developing an improved version of exclusive bus-bay system. For this study, Hyderabad city in Telangana state is selected as a study area. Various traffic studies conducted as a part of data collection. A new methodology for the design of bus bay was proposed in the study. This proposal can help in reduction of private vehicles and encourages the use of public transportation.

***Keywords*: -** Reliability, overtaking zones, bus bay.

I. Introduction

Hyderabad metropolitan area: road network profile Transport problems of fast growing cities often get evident along major road corridors connecting suburbs and central city areas. Historically grown road links often cannot cope with continuously growing travel demand hence congestions and sinking average travel speeds occur. Therefore, neighborhoods of major corridors are exposed to massive noise and air pollution; non-motorized traffic modes are repressed and usually very unattractive. With reference to sustainable development extensions of such corridors mainly focused on increasing capacity for motorized private transport modes – as it often happens - are not desirable. On the contrary: solutions for densely populated areas that are viable for the future require a consistent support for public transport and non-motorized modes.

Main factor for heightening the attractiveness of public transport modes is an increase of their average travel speeds. For congested corridors, which are not suitable for rail based mass transport systems, upgrading of existing bus systems is the only possibility to enlarge the overall transport capacity. And while improving public transport, attractive and safe access of pedestrians to the stations or stops needs to be considered as well, to strengthen the acceptance of the improvement action.

Main objectives of the road corridor study are therefore the identification of measures to improve road based public transport operations in a selected corridor and subsequently the quantification of potentials to mitigate climate change (CC) The city has radial and orbital form of road network. The recent growth trend is more in the west and south directions of Hyderabad. The main arterials of the city are the National Highway 9 (connecting Vijayawada in the eastern side and Mumbai in the west), National Highway 7 (connecting Bangalore in south and Nagpur in north) and National Highway 202 (connecting Hyderabad to Warangal). Five State Highways SH1, SH2, SH4, SH5 and SH6 start from the city center and diverge radially connecting several towns and district head quarters within the State in all directions. The road network of Hyderabad is very dense and congested due to narrow roads, heavy encroachments, and high pedestrian and slow-moving vehicle concentration. As per the existing land use plan, the area under roads is only 9-10% in MCH area which is grossly inadequate and it is estimated that at least 20% road space is necessary for the Metropolitan area.

The road network in the core area of MCH remained static at 250 km over a decade. There are nearly 400 road intersections in the Metropolitan area among which 250 are in the core area. Only 80 intersections are signalized. There are more than 160 unmanned intersections resulting in many accidents. Hyderabad metropolitan area: traffic profile In the past decade, the vehicular growth in the Hyderabad Metropolitan area has been phenomenal and the road network has not kept pace with this alarming growth. The two wheelers have recorded a compounded annual growth rate of 11.9 percent in the past decade where as the corresponding percentage growth rates for four wheelers and three wheelers are 13.9 and 10.4 respectively. The vehicular composition on roads on an average exhibits highly heterogeneous mix with two wheelers comprising 50 percent of the traffic; four wheelers 16 percent; three wheelers 16 percent; human powered bicycles 9 percent; buses 5 percent and the remaining part is that of push carts, animal drawn vehicles and others. The change in the average traffic composition over different years is given in Table 2 and the same is graphically presented in Figure 4. The proliferation of personal modes like cars and two wheelers is clearly indicated by these figures. At the same time the drastic reduction in human powered bicycles

[1]Corresponding Author

indicates the inadequate measures to provide the required infrastructure to sustain and support the bicycle transport.

The peak hour traffic flows on major roads are in the range of 16000 vehicles per hour in the junctions and about 9000 vehicles per hour on the links. The average traffic speed in the peak hour is estimated as 12 kmph which is an indicator of dismal state of congestion and a very low Level of Service.

On the road safety front, nearly 1000 fatalities occur every year in about 350 fatal road accidents. The total number of road accidents which include non-fatal accidents also is about 1800. Many minor accidents go unreported everyday and the accident recording mechanism needs to be strengthened. More than 60 percent of the victims of the accidents are vulnerable road users like pedestrians, cyclists and two-wheeler riders.

Objectives Of The Study

The main objectives of the transport concept for the city of Hyderabad are as follows:

- To keep the operational functionality of the overall transport system
- To increase safety and efficiency.
- To improve the quality of life and environment.
- To maintain urbanization.
- To achieve the above objectives, the following principles of transport planning is given due importance in this study:
- To promote public transport with the objective of encouraging as many private vehicle users as possible to switch to public transport means.
- To channel motorized traffic into the main road network to bypass residential areas.
- To calm and reduce traffic in residential and restricted areas.
- To set up park and ride facilities in the periphery of the city accompanied by strict parking rules within the CBD and core areas of the city.

II. Scope of the Study

- To have strategic planning and policy, to achieve the vision of Hyderabad as asmart city. The scope of work is to
- Prepare a concept plan report and a transportations structure plan.
- Broad uses and intensity of land-use keeping the overall Master Plan exercise in view.
- Transportation system and traffic management plan.
- Structural road network.
- To carry out traffic surveys and other reconnaissance surveys to analyze the existing traffic situation and travel characteristics.
- Traffic Characteristics
- Midblock Volume Counts for 12 hours (8.00 AM to 8.00 PM)
- Turning Movement Counts for 12 hours (8.00 AM to 8.00 PM)
- Pedestrian Counts for 4 hours (during peak)
- Speed and Delay Studies
- Parking demand and supply
- Roadway inventory comprising of
- Right of Way information and its component by topographic survey
- Junction inventories
- Hawkers zone
- Land use Characteristics
- Topographic Surveys for preparing to the scale base map
- Apart from the above information, field reviews to assess traffic circulation patterns, access management issues, traffic operations/safety issues, roadway connectivity etc and data on major traffic generators (residential, recreational and commercial) within the study area has been collected.

III. Focus and Approach

- This report presents the general approach, methodology and plans for identified corridors within the core area on the pilot basis to evaluate traffic operations in the corridors and develop improvements such as:
- Re-organization of the available space in the corridor for efficient use.
- Minor widening, provision of bus/IPT stops, pedestrian facilities.
- Pavement markings, signing improvements, relocation of overhead utilities.
- Landscaping improvements.
- Channelizing traffic movements, provision for exclusive NMT (Cycle) lanes.

- Bus priority schemes and junction improvements.

IV. Analytical Framework - A Brief Description

The primary role of the corridors is that of movement channel, but reflection of above listed points in the analysis and development plan would result in a more holistic output. Consideration of above points would make an integrated plan on one hand and would also result in a model for other places of HMA region. With the need of understanding the multiple issues and concerns of corridors, a comprehensive analytical framework is being devised and briefly discussed in next section. The framework comprises of five components, as shown in Figure 2-9. Choice of these five components is guided by the following aspects.

- The road connectivity of each corridor as discussed above, are considering the issues for analysis.
- Corridors are placed in a strong urban context, its location in HMA. This context is neither addressed in the present structure nor in the visual quality/experience of driving on these stretches. At present, these corridors are selected to be very important Corridors and connectivity between various important places. Further, pace and character of urban development happening on other arterial roads of HMA points towards a different way of perceiving city highways. Present assignment provides a good opportunity on one hand to address city/region visual quality issues and second to devise strategies towards road space/ROW for future urban development.
- Increase in the accessibility of a place triggers not only growth but also increases land value. Present stretches are already showing signs of these phenomena. Further increase in the accessibility and volume of road users through development plan has implications on the surrounding Land Market and uses.
- There is no transit line along the corridors. At present public transport is only in form of the Buses run by APSRTC. The MRTS work is started in the city. After that these corridors might start functioning as feeder routes to those metro corridors.
- Small but specific activities/structures dot the road surroundings. A component of Local Space has been incorporated to address special needs of these activities/users.

Fig 1: The Analytical Framework

Table 1 Types of Buses Operated in Hyderabad city

Types of buses operated by united apsrtc	NO.s
Vennela ac sleeper	17
Garuda plus ac	41
Ac garuda	97
Ac city (jnnurm)	91
Ac indra	153
Ac megh. Mala	6
Super luxury	1766
Deluxe	1050
Express	4223
City ordinary (cng)	**252**
Ghat	352
Mini ordinary	**106**
Pallevelugu	9688
Metro express (cng)	**125**
Metro deluxe	**45**
Metro deluxe (l.f. jnnurm)	**134**
Metro express	**1269**
Vestibule	10
City ordinary	**2117**
City suburban	**810**
Moffussil	**203**

V. Methodology

- The general approach and methodology towards development of Corridor improvement plan has been translated into undertaking the following eight tasks as:
- Initial field visits and consultation with stake holders.
- Scoping of work and identification of primary survey needs.
- Data collection/field surveys.
- Analysis of traffic data.

- Develop alternative solutions/plans.
- Stakeholder consultations on improvement plans and feedback.
- Develop and submit corridor improvement plan.

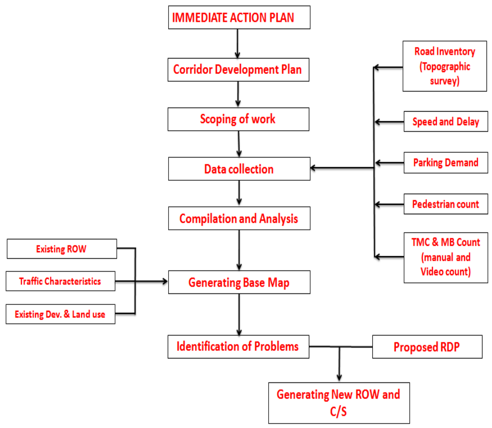

Fig: 2 Methodology adopted in Corridor Improvement Plan Preparation

The general approach to implement the study comprised the following tasks which are described in detail in the following sections:

- Selection of an appropriate study area.
- Data collection and analysis of existing conditions:
- Inventory of existing design (e.g. cross sections, junction designs)
- Private Transport: Traffic volumes, traffic composition, through traffic volumes, peak hour turning volumes at main intersections etc.
- Public Transport: Existing PuT lines, PuT frequency and PuT stops
- Pedestrians: existing facilities for pedestrians
- Travel time measurements for PrT and PuT – vehicles
- Deficiency characterization for existing conditions
- Development of 2 options for optimization of the corridor including a combination of following elements
- New assignment of road space (exclusive bus lanes, sufficient pedestrian paths and crossings, road dividers)
- Improvement of PuT facilities (e.g. exclusive bus lanes, new organization of bus stops)
- Optimization of junction design and traffic signal control
- Impact analysis by microscopic traffic flow simulation
- Setup of a microscopic simulation model for existing conditions
- Calibration of the model based on measurements
- Setup of models for proposed options
- Evaluation of characteristic traffic performance figures (avg. travel times, avg. speeds, no. of stops, waiting times) of all transport modes for existing conditions and proposed options

Proposal of strategies to scale up results to strategic and city-level.

VI. Selection and Description of Corridor

Fig: 3 Location map of study area (Based on Google map)

For selection of the corridor the following boundary conditions had to be considered:

The corridor should be of great importance for public transport as well as for private transport

The corridor should face typical problems of urban traffic in Hyderabad

The corridor should not be directly affected by planning for Hyderabad Metro and should not be focused by currently developed CTS for Hyderabad.

Subject to these conditions one corridor north of Hyderabad was selected. This corridor is part of the important connection between the sub-centers of Lingampally and L B nagar in the east of Hyderabad city area and has a local concentration of plenty of APSRTC & TSRTC bus lines. Furthermore, the Whole section of the corridor is the National Highway 9 (NH9), which is a main line for regional and interurban traffic from Hyderabad center towards north.

Total length of the selected corridor is 36 km and many intersections are in the corridor, of which traffic signals control some intersections.

VII. Inventory of Existing Road Designs

As there was no availability of cadaster or as-built plans for the selected corridor and conventional cadastral survey for a corridor of this length would be very costly, for physical inventory a Instrument (ELITE ROADO METER) was used. After software based pre- and post-processing of recorded data, the information is converted into AutoCAD drawings. These AutoCAD drawings show complete corridor profiles including details as Right of way (ROW), carriage width and median width, dimensions of pedestrian facilities and position of road equipment or obstacles.

Main results of the physical inventory are:

Existing road in the corridor has two carriageways divided by a median. Carriageway width is not uniform – it ranges between 15 – 20 m in the western and the central part of the corridor and 13 to 8 m in the eastern sections. Bottlenecks with carriageway widths around 5 - 6 m are located in Lingampally.

At intersections, usually there are no systematic extensions of carriage width for approaches. At intersection (chadherghat) there is a huge enlargement – but utilization of the area is not controlled.

Only few sections of the corridor are equipped with facilities for pedestrians. The total length of regular footpaths sums to approx. 1.8 km, which means that only 15 % of carriageways are equipped.

VIII. Travel Time Measurements and Queue Length Survey

Peak hour travel times for buses and cars were collected by GPS-based travel time measurement (floating car data method). Based on two trips per direction, vehicle class and observation interval (morning and evening peak) average travel times were calculated as follows. Average travel speed for buses for both directions and both observation intervals range between 20 km/h and 25 km/h. Compared to this car have significantly higher average travel speeds. They range between 30 km/h and 35 km/h.

Maximum vehicle queue length was observed at all approaches of intersections during peak hours. For main directions, maximum queues reach up to length between 150 and 250 m. Highest values were observed for driving direction at Chaderghat intersection during morning peak. For minor road approaches queue length is mainly below 100 m.

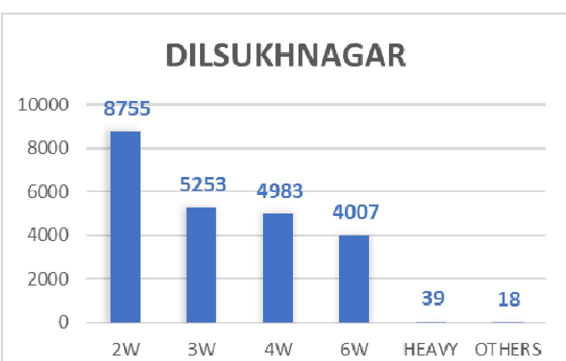

Fig: 4 Trafic flow at Dilsukhnagar

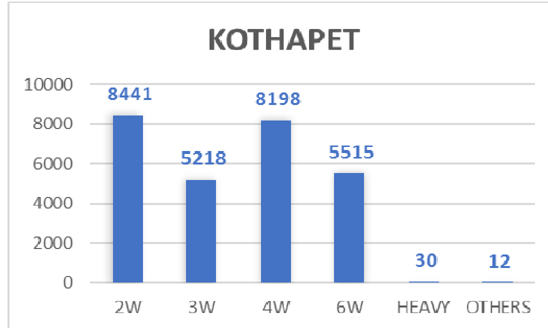

Fig: 5 Trafic flow at Kothapet

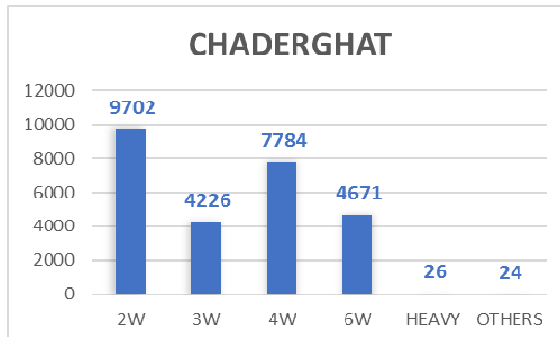

Fig: 6 Trafic flow at Chaderghat

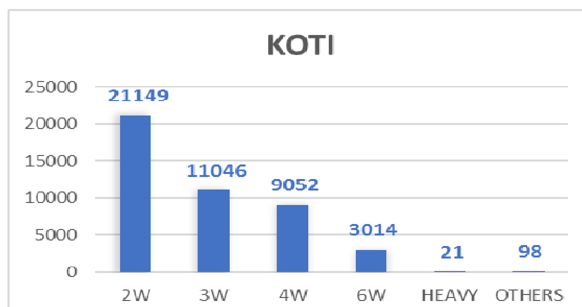

Fig: 7 Trafic flow at Koti Circle

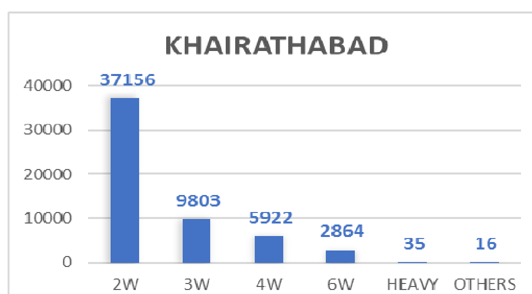

Fig: 8 Trafic flow at Khairathabad

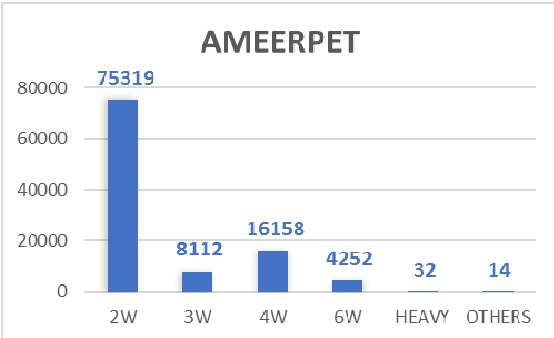

Fig: 9 Trafic flow at Ameerpet

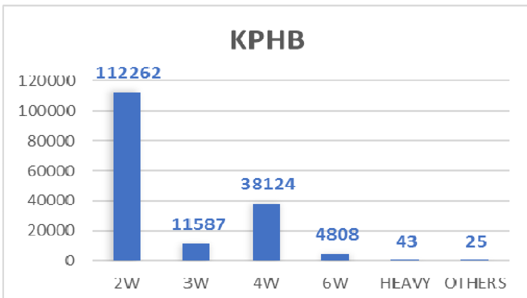

Fig: 10 Trafic flow at KPHB

IX. Deficiency Characterization For Existing Conditions

Based on the results of the data collection deficiencies of existing traffic conditions in observed corridor can be summarized as follows:

Although the corridor has high travel demand and vital functions for the connection of important sub centers of Hyderabad, current state of road infrastructure does not comply with this important network functions. Coming from Khairathabad to KPHB there is no clear alignment of the corridor: main direction traffic must wind through sharp curves.

Pedestrian facilities in the corridor are very poor: only short passages of the corridor are equipped with footpaths. Crossing facilities for pedestrians are completely missing. Moving in existing road space for pedestrians is neither attractive nor safe.

Even though there is already a considerable supply of bus transport along the corridor, the usage of public transport modes is not attractive at all. Bus stop locations are not visible and not easy accessible for bus passengers. Bus stops are not adequately equipped with shelters and passenger information.

Furthermore, average travel speeds for buses are significantly lower compared to private traffic. A comparison with international bench marks for operational bus speeds shows on the on one hand that current bus speeds in the corridor are not at an alarming level. But on the other hand, parts of the surveyed corridor are outside of built up area, meaning that speeds above overall city average can be expected. Hence it can be concluded that there is room and necessity for improvements.

X. Development of Two Options for Optimization of Traffic Conditions

Based on the results of the data collection and deficiency analysis two options for optimization of traffic conditions were developed. The focus here was on improvements for public transport services, but other transport modes and possibilities for urban development are considered as well. For the development of the options different limiting conditions concerning the availability of additional land were considered: Option 1 assumes, that acquisition of additional land for road widening is not possible generally. Whereas for option 2 it is assumed, that land acquisition for required extensions of ROW is possible.

Table 2 : Overview of options

Option 1 Exclusive bus bay system	Option 2 Exclusive bus lane system
➢ Bus priority measures mainly on existing road space, land acquisition only in exceptions ➢ Reorganization of bus stops and bus passenger accessibility ➢ Reduction of paratransit parallel to bus corridor ➢ Acceptance of capacity reductions for private transport	➢ Implementation of an efficient bus corridor, extension and built up of road sections ➢ Reorganization of bus stops and bus passenger accessibility ➢ Dimensioning of bus infrastructure for bigger vehicle types (Articulated buses) ➢ Reduction of paratransit parallel to bus corridor ➢ Ensuring of sufficient capacity for private transport ➢ Improvement of public space supporting commercial and residential uses

XI. Option 1 (Exclusive Bus Bay System)

The concept for bus priority in option 1 is based on an access control for private transport in advance to the densely populated and congested sections of the corridors from Lingampally to LB nagar. Private transport flows will be metered by new traffic signals. Traffic inflow is supposed to be limited at a level, which does not exceed general capacity of the corridor. By this queues and congestion will be relocated from populated areas to areas outside of the built-up area. For buses, there will be "queue jumping lanes" at the pre-signals, which allows them to get prioritized access into the controlled area.

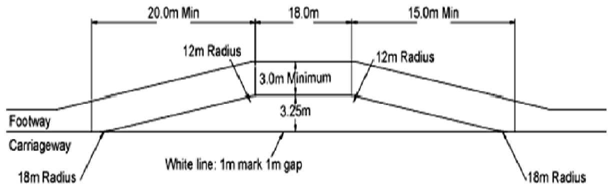

Fig 11 Typical Cross section of Exclusive bus bay

XII. Option 2 (Exclusive Bus Lane System)

Exclusive bus lanes remove buses from mixed flow traffic and allow buses to move unimpeded by traffic throughout a corridor. Bus lanes are typically marked with special striping and are signed to indicate that only transit vehicles are allowed. Bus lanes are in certain transit rich areas of the region.

Grade-separated transit ways also provide the advantages of bus ways and increase the overall performance of the transit system. Transit ways are physically separated from roadways or freeways and are dedicated exclusively for bus use. Along a given corridor, passengers board and alight transit vehicles at transfer centers like boarding vehicles at rail stations.

In contrast to option 1 & option 2 is based on extensive infrastructural measures, which require extension of the ROW and additional land acquisition. Basically option 2 is characterized by two main infrastructural elements:

In the eastern part of the corridor a new bypass link will be introduced. By this bypass link transit traffic can be kept out of the narrow and curvy corridor segments in Lb nagar. The new link will start at the southeastern corner of the area and will than head west parallel to the border strip of that area. After crossing the market road, it will head towards easternwest and connect to the existing corridor. Additionally, the bypass will be connected towards direction north NH9 using the alignment of the Lb nagar road. All new bypass roads will have a dual carriageway with 2x2 lanes. Removing the transit traffic from the town roads of L b nagar will create the opportunity for upgrading the road space there. This will be used for improvement of the pedestrian facilities, parking facilities and enhancements to adjacent public spaces. The routing of bus lines will remain on the old corridor, as for the local population nearby access to public transport services must be secured.

For the western part of the corridor no favorable possibility for new bypass links exist. Here the corridor must be upgraded in the existing alignment. It is suggested to implement a corridor cross section with 2x2 lanes for private traffic and exclusive bus lanes in the median. Required width for the carriageway including pedestrian paths is 26 – 28 m. An additional width of 6 to 10 m is required at the positions of the bus stops and as widening for turning movement lanes at the intersection.

XIII. Impacts and Issues

Besides the direct results of the study described in the chapter above, the following general results and impacts can be stated briefly:

Set-up and application of tool (VISSIM) helped to identify options to improve travel speed of public transport within the corridor while also improving the accessibility of the bus stops (allocation of appropriate road space for PuT and non-motorized modes etc.).

Conceptualization and implementation process of measure has created capacities regarding different options to improve an existing corridor for public transport services and non-motorized transport, but it has also helped to stress again the also importance and potentials of PuT and non-motorized modes for an energy-efficient transport system.

Research activity has given another proof that VISSIM software allows for realistic modeling, forecast and assessment of different measures in the Indian context of non-lane based travel behaviour, due to substantial software improvement, implemented earlier during the research project. Hence methodology and software can be transferred to other parts of the city, other cities in India and to other emerging or developing countries.

3D-visualisations of new concepts or measures, provided by VISSIM, shows high potential for participatory planning approach in Indian context.

More general: application of improved microscopic simulation allows the planners to forecast and compare ex ante: ecological impacts (e.g. GHG-emissions, air-pollution), economic impacts (average speeds, Level-of-service, travel times, bus operating hours) and social impacts (e.g. accessibility) for different esp. small-scale measures.

In the long-term it is generally expected that the results of the measure (methodologies, knowledge) will enable the planning bodies to develop by themselves small-scale improvement plans (e.g. traffic circulation plans, bus priority schemes) that support and encourage the use of energy-efficient modes.

As the knowledge on appropriate cross-section or junction designs, can be fed into the strategic planning process, it is expected that the measure will also support the development of long-term transport master plans that take issues of energy-efficiency, air pollution and climate change but also economic and social issues into account, which is not the case so far.

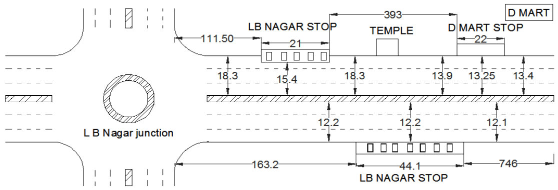

Fig 12 Typical Cross section of LB Nagar Junction

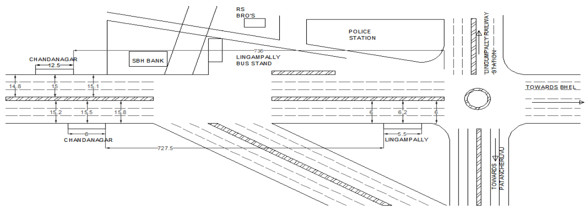

Fig 13 Typical Cross section of Lingampally Junction

Fig 14 Typical Plan of proposed Corridor showing Bus-bay

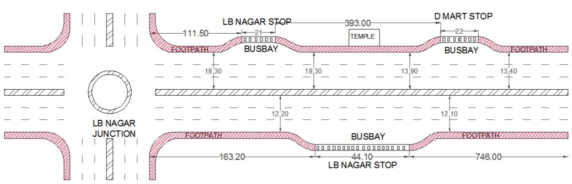

Fig 15 Typical Plan of proposed Corridor showing Bus-bay at LB Nagar Junction

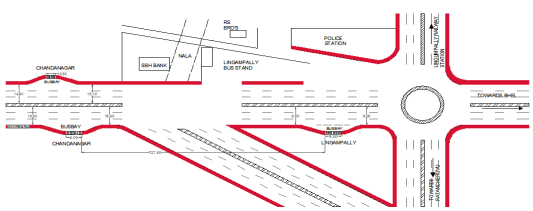

Fig 16 Typical Plan of proposed Corridor showing Bus-bay at Lingampally Junction

XIV. Conclusion

- Execution of exclusive bus bay system (EBBS) provides a free flow of traffic on roads.
- Traffic congestion is reduced to maximum.
- Travel time has decreased to 40 % compared to on street bus bays.
- Safe pickup and drop of passenger.
- Decreased the fuel consumption.
- Execution of exclusive bus bay system (EBBS) is economic than going for a separate lane which costs high.
- The cost and maintenance for construction is very less.

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