

Light Rail Transit - Today's Need for Developing Cities in India

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Abstract: *Traffic congestion and excessive fuel consumption are major issues in present scenario all over the world. Due to the rapid urbanization, trips in growing urban areas are enormously increased. In fact, providing bus transit system as a public transport facility is not sufficient to fulfill this increased demand. To deal with such demand light rail transit (LRT) will be a good solution. It is relatively cheap to construct and pollution free mode. It is so flexible mode that it can be operated on all types of Right of way (ROW) as per traffic condition. The aim of this paper is to provide a literature review and to discuss about the previous and existing light rail transit projects, comparison with other transit modes in terms of fuel consumption and also covers a different case study on LRT in various cities of the world. This study also states the problems in present mass transit system of India and possibility of implementation of LRT to overcome these problems.*

Keywords: Traffic congestion, Fuel consumption, Rapid urbanization, Bus Transit System, Light Rail Transit System (LRT), Pollution free mode, Right of way (ROW)

1. Introduction

The movement of people, freight and information, has always been an essential component of all human societies. Mobility can be provided by modes of transportation like walking, cycling, public transit, private vehicles or ridesharing and other modes. Access is the ultimate goal of any transportation mode. Accessibility indicates the ease of reaching any land use activity from a particular location, using a particular transport system.

Urban transportation is one of the fundamental infrastructure for systematic growth of any urban settlement. With the growing business trade and urbanization all over the globe, there is a growth in demand for transportation. Individual mode of transportation causes problems due to this immense growing demand and the inadequacy of the supply of transport facilities. This imbalance between capacity or supply of transport facilities and the increasing demand from people causes an unmanageable condition. Traffic congestion, travel delays and dissatisfaction amongst the travellers are all the result of this imbalance. By some estimate at least 153 cities in Asia will have population exceeding 1 million people. Urban Transport in Asia and India has to be a united and miscellaneous system with multiple modes of transport – buses, metro, light rail, monorail, private transport system. Generally buses running in mixed traffic cannot maintain their schedule due to traffic congestion and other related problems. In the most of the cities of India there are no exclusive and dedicated bus lanes. Buses and other mass transit systems are also supplemented by environmental problems like air and noise pollution with high vehicular emission and excessive fuel consumption. Rapid urbanization in India has created the migration of people from rural area to metropolitan cities. Rapid urbanization is accompanied by an alarming rate of increase in the number of vehicles. This has resulted in more trips of passenger and goods vehicles in urban areas, often over the

long distances. In fact the inventory of vehicles has been rising at faster rate in terms of percentage as compared to the population. Road networks in cities are clogged by the explosion of personalized vehicles and public transit vehicle has resulted in acute traffic congestion, steeply increasing number of accident, increasing fuel consumption and level of pollution.

Most Indian cities are low rise urban trails and require medium capacity modes only. As per the recommendations of the working group on urban transport for the 12th FYP (Five Years Planning), LRT should be provided in all cities with a population of million plus. There are 53 cities in this category as per the 2012 census. Thus all these cities are couriers for introduction of LRT. In large cities, LRT will be a part of the citywide multimodal MRT (Mass Rapid Transit) network. In other cities, LRT may be the main mode of MRT. In the existing city corridors, if necessary, LRT can be elevated. In new townships and urban extensions however, space should be left in the middle of the road for introduction of at grade LRT at appropriate stage. LRT has been used at some special locations also to protect them against pollution and to promote tourism.

Transportation, where mobility and accessibility itself are one of the major objectives, so constructive new approach system has to be introduced, like LRT system which would incorporate the solution of traffic congestion, passenger convenient, safety, comfort and reduce pollution and fuel consumption of vehicles. Worldwide data (2013) shows that LRT has been adopted in 436 cities (includes 39 under construction and 30 under planning). International experience of 436 LRT systems worldwide confirms that LRT is the most successful medium capacity mode, with over 100 years of development behind it, yet integrating the latest technology for the future.

2. Literature Review

Lam et.al (1998) have studied about important attributes relating to the crowding effects at the Hong Kong light rail transit stations. Data collected at two selected LRT stations during morning peak periods, regression models were established to estimate the dwelling delays of trains due to congestion. The operating conditions on LRT platforms were studied by using the Level of Service concept. In addition, stated preference surveys were used to assess the two discomfort measures in crowded vehicles and at congested platforms respectively. Binary logit model developed to measure the discomfort level of passenger on platform and train and measured that passengers were less sensitive to the crowding condition in a vehicle for a journey with shorter travel time.

The train dwelling time model, Binary logit model, the application of the level of service concept to evaluate the operating conditions on the station platforms, and the perceived in-vehicle and on-platform penalty due to congestion form an empirical background for the platform design and planning for LRT stations in Hong Kong.

Puchalsky (2005) has presented a paper on comparison of emissions from Light Rail Transit and Bus Rapid Transit system. In this study he created fuel cycle analysis of different modes of both best and average alternatives and also concluded that BRT system utilizing advance propulsion technology outperform electric rail system in the area of particulate matter. NO_x and CO₂ emission per passenger mile LRT has a clear advantage over BRT in both the standard (average versus average) and superior (best versus best) comparisons. The best performing bus (CNG) has emissions slightly below that of the average LRT and BRT vehicle.

In VOC (volatile organic compound) again the electric rail modes outperform the BRT vehicles in both the average and best categories. The CNG vehicle with comparatively low NO_x emissions had particularly bad VOC emissions. CO emissions using the high bus occupancy figure similar to the VOC chart, LRT outperforms BRT in both standard and superior comparisons with the CNG bus performing especially poorly.

The results show that, although advances in diesel technology have radically improved bus emissions, LRT systems still produce less regional or urban emissions in the three categories considered than BRT systems. This is true whenever equal technology levels are compared and even when superior BRT technology is compared with standard LRT systems for some pollutants.

Rathod (2007) has studied on Feasibility of Light Rail Transit System: A case study of section from APMC to RTO in Ahmedabad. In this study, a methodology was developed for checking feasibility of LRT system on isolated corridor. Also, it was attempted to re-design the existing roads to provide safe & convenient environment with a new public transportation system. This presents efficient public transport

option which has been carried out to move large number of people in cities, specifically in low-income countries having unique set of problem and requirements.

The Feasibility check of LRT system has been done based on some parameters required for the ridership level along the corridor which ensure its sustainability over a longer period of time. The parameters including traffic volume, occupancy rate of each category of vehicles etc. The methodology developed in this study was developed only for an isolated corridor, which included data collection regarding travel demand analysis, forecasting travel demand and checking feasibility along a corridor. Travel demand estimated and trip forecasted for a future year to check the feasibility of LRT system, for corridor under study. It was observed from the study that line capacity increased considerably with the introduction of the exclusive lane along the corridor under study. LRT considered most efficient, faster, safe, reliable, cost effective, environment friendly and by the figures which were achieved from the study can make it feasible in year 2020.

Gunduz, et.al (2010) have studied of Parametric cost estimation system for light rail transit and metro track works. Public transportation and transit become one of the most important infrastructural investments. The most efficient solutions to public transportation are light rail train (LRT) and metro systems. Considerable gap in terms of the availability of the length of LRT or metro line per citizen between developed and developing countries. Government make a huge investment in abovementioned public transportation system to compensate this gap. At this point, a precise early cost estimation of this system while taking investment decision become more critical for many parties including owner. The accuracy of estimation of construction cost as a critical factor for determining the success of project. So in this research study contrasts from other in literature by its introduction in to early cost estimation on track work.

The sample data employed for cost prediction came from intensive survey managed on the contractors and municipalities in Turkey. The main objective of this work was to develop the early cost estimation models for LRT and METRO track work, using the multivariable regression and artificial neural network (ANN) approach. Both regression techniques and ANN are frequently used in cost estimation. All results suggested that ANN have great potential for estimating non deterministic costing system, if a petite knowledge of dependent and independent variable present.

ANN outperformed more than classical regression techniques. A target project list was formed by conducting small scaled investigation in to the completed and under construction project, which had track work in their scope. The data for this study were collected from 16 urban rail project (7metro and 9 LRT) physically within a period of one year. So the data set of 16 project by using 17 parameters were available at early decision phase.

The regression analysis estimated the cost of testing sample with an error 2.3%. On other hand ANN estimated the cost 5.76% error, which was slightly higher than the regression

error. As a result two successful cost estimation models have been developed depending on the finding of this paper. These models can effectively be utilized in tender decision making phase of projects with track works.

Bhattacharjee and Goetz (2012) have carried out the study of impact of light rail on traffic congestion in Denver. In Denver LRT is operated by the regional transportation district (RTD). It includes 6 LRT rail lines with 46 stations and 76 Km of track. In this research, they carried out both temporal and spatial analysis of vehicle miles travelled data from 1992 to 2008. In temporal analysis, changes in the level of highway traffic before and after opening of three segments (central, southwest and southeast corridors) of the light rail system is included. Spatial analysis examines whether the changes have taken place uniformly throughout all the highways or whether they have been concentrated on particular highway. Finally they proved that the existing light rail system in Denver have contributed to reduce traffic.

Zhang and Wang (2012) have studied the Impact of mass transit on land development in Beijing of China. This paper attempts to fill the gap by presenting evidence from China, with a detailed case study of Beijing. Selecting three newly built suburban transit lines in Beijing, the study scrutinized land development situation and estimated hedonic housing price models to measure the proximity premiums associated with these three lines. The empirical evidence in Beijing, one of the first tier mass transit cities in China, shows that investments in mass transit can have significant and positive impacts on land development. Properties with transit proximity enjoy sizable price or value premiums. In closing, the empirical evidence reported from selected Chinese cities in general and from Beijing in specific shows that Investments in transit systems could help shape urban spatial outcome in the process of rapid urbanization.

Boral (2013) has studied the topic of tramway an eco-friendly mode of mass transportation: a case of Kolkata city. The principal function of any transit system is to carry passengers efficiently and in large numbers. Trams stand out in comparison to other vehicular modes within the transport system of Kolkata for its distinctiveness. This cheap, electrically operated pollution-free mode, having a high carrying capacity is the most viable option for crowded cities like Kolkata. Slow though it may be, it ensures a safe journey through the madding crowd. Populated cities of the world are revitalising the Tramways system since it runs on electricity and has a high carrying capacity. However the situation in Kolkata is quite different. There is a constant rise in passenger demand but the proportion met by tramways system has been decreasing over the years. There is a need for rethinking. Reorientation of the undertaking, efficiency in management, justification of routes and modernization of the system would help the tramways to provide valuable service to the city. It is the one of the best modes of transport in global parameter which will have a better prospect. The present paper is an attempt to look into the position of tramways as a means of mass transportation within the transport scenario of Kolkata and to assess the issues and concerns of retaining tramcars in the city instead of removing them.

3. Review of different Case studies

In Nantes (France), where the first of the LRT was built (opened 1985, extended 1989 - 14.2 km with 30 stops), the use of public transport has accelerated, the increase in use of private motor vehicles has moderated and the decrease in cycling has stopped. Between 1984 (before the tram) and 1995 the rider-ship of LRT + bus increased by 65.1%. 43% of the total public transport journeys are now made on the LRT (33m journeys per year). 16% of LRT users had never used the bus network before the LRT was built and 39% of LRT users had a private vehicle which they could have used - they prefer the LRT to the car for certain journeys. The main reasons for choosing the LRT are its rapidity and accessibility to go to work or to go shopping. They showed that LRT is a more reliable than bus and other transit mode.

In Strasbourg (Germany) total public transport rider-ship increased by 45% (1990 to 1997) since the opening of the LRT, car use in the city centre reduced by 17%. The evidence is that LRT not only attracts passengers to itself but also, where there is good integration between modes, increases rider-ship of the public transport system as a whole.

In Zurich, a city of around 300,000 population - a similar size to Coventry in UK - only 29% of journeys are made by private car, whereas in Coventry the figure is more than 75%. Car ownership rates are actually higher in Zurich than in Coventry, but people do not use them for many of their urban journeys. Zurich has an incorporated public transport system that utilizes buses, trolley-buses, trams, light rail, commuter trains, funiculars and passenger ferries in a dense and highly utilized network. Coventry has buses and one lightly used commuter railway line with just two suburban stations and the city's main railway station within the city boundaries. To all intents and purposes LRT are the only mode of public transport within the city boundaries.



Figure 1: Zurich modern LRT and Coventry modern LRT
Source: (www.google.com)

A modal choice survey by UITP in 1997 showed that an average 11% car drivers had transferred to using LRT in 93% of the cities since the opening of the LRT. Another survey by UITP showed that in 100% of the cities responding, customers rated LRT as being more accessible than buses, 73% rated LRT as more reliable than buses. Figure 1 and 2 show photographs of typical modern LRT. This case studies of LRT in different developing country proved that LRT is more effective option as compared to other transit system, it gives encouragement of constructing and implementing LRT in developing cities like India. (Source: UITP Light Rail Commission and Town Planning Agency of Nantes area, 1998)

4. Present need of Mass Transit in India

Mass rapid transit in cities in India in the past has been limited to suburban services and buses. Indian Railway's suburban rail services started in 1928 in Mumbai and followed by a similar rail system in Chennai and Kolkata. There has not been much investment in the upgrade of these services. Recently, however, considerable progress has been made in the upgrade of the Mumbai suburban rail services.

The first underground Metro rail of length 18 km started operating in Kolkata in 1984 and later an 11 km elevated rapid transport system was commissioned in Chennai, as an extension to its existing suburban rail system. Work on the third Metro rail project started in Delhi in 1998. First phase of 65 km was completed in 2007. A small length of Metro rail in Bangaluru started operating in 2012. Construction of Metro rail systems has started in 6 more cities i.e. Kolkata, Chennai, Bangaluru, Kochi, Jaipur, Gurgaon and Mumbai. Many other cities such as Lucknow, Nagpur, Pune, Ludhiana, Ahmedabad Metro, Bhopal Metro, Indore Metro and Chandigarh are planning rail transit. Standard bus services which are low capacity MRT modes (Up to 5000 phpdt-peak hour peak direction trips) till recently were limited to about 15 cities. After 2009 the number of cities operating bus services has increased to 65Jawaharlal Nehru National Urban Renewal Mission (JNNURM) cities when nearly 16000 buses were sanctioned. The enormous gap between demand and supply of mass rapid transit is presently met by para-transit in the form of three wheeler motorized tempo and manually driven cycle rickshaw which have much lower capacity.

Metro rail can serve corridors with demand level more than 30000 phpdt and buses are good for corridors with demand level up to 5000 phpdt. For demand below the range of 30000 phpdt, it would be uneconomic and insufficient to introduce Metro rail. Metro rail requires flat curves (necessitating property acquisition) and long ramps taking up much road space. In Indian cities, road space and traffic congestion are major issues. So implementation of metro in all Indian condition is quite difficult. Demand level between 5000 to 30000 phpdt needs medium capacity modes. Three modes of MRT are in use around the world in this category; BRT, LRT and Monorail. Bus rapid transit can serve up to 10000 phpdt essentially at-grade modes. Monorail is an elevated mode suited in congested areas with limited ROW and where at grade service cannot be introduced.

According to Indian condition, where most mega cities are having population around 2.0 to 8.0million and around 20000 to 30000 phpdt. As per static, there are 4378 urban agglomerations and towns identified by the census of India. Distribution of cities in various population sizes are given in Table 1. Nearly 50% of the urban population lives in small cities (<.5 million), whereas 15% of the urban population lives in mega cities (>8 million population).

Table 1: Population distribution in different cities in India

Category	Population in millions	Total no. of census cities	(%) total population in different cities
1	<0.5	4304	53
2	0.5-1.0	39	10
3	1.0-2.0	22	10
4	2.0-4.0	6	6
5	4.0-8.0	4	8
6	>8.0	3	15
Total		4378	

Source: (Wilbur Smith Associates, 2008)

In India, for medium size cities like Ahmedabad, Rajkot, Kochi, Jaipur, Bhopal, Indore etc. having the population around 2.0 to 8.0 million. So, metro rail is not feasible and BRTS cannot prove efficient because of less passenger carrying capacity. According to the 2011 census the population of Ahmedabad metropolitan was 6,352,254. Ahmedabad as the fastest-growing city in India, and listed it as third fastest-growing in the world. The Greater Ahmedabad Urban agglomeration is an amalgam covering an area of about 4200 sq. Km. Greater Ahmedabad covers AMC area, Auda area, peripheral area and also cover Gandhinagar and surrounding villages. So in medium size cities LRT seems to be solution of all transport problems.

Following schematic representations shows the proposed LRTS routes in existing route of the different cities in India. But because of less passenger carrying capacity (5000-10000 phpdt), more fuel consumption, vulnerable to pollution, BRT system is not prove to be effective but Light Rail Transit can implemented on pre-existing BRTS route will prove more feasible, efficient and economical due to its more passenger carrying capacity (20000-30000phpdt), less fuel consumption and other following beneficial features.

5. Features of LRT

LRT is a low cost, low axle load, eco-friendly, electrically propelled system with no local pollution and low noise and vibrations. Light rail vehicles (LRV) generally have a top speed of around 80kmph though mostly operating at much lower speeds. LRT features include:

- Steel wheel vehicles operating on steel rails and are almost universally operated by electricity delivered through overhead lines. Electric power provides greater acceleration, making it suitable for operation with closely-spaced stations.
- Grooved steel rails laid flush with road surface or ballasted like normal railway track, making light rail the only system

which can operate on both city roads and jointly with conventional rail services.

- Sharp road bends up to 25m radius, minimizing need for property acquisition and hence ideal for urban environment.
- Steeper inclines than heavy rail
- Shares its operational space with other road vehicles (e.g. automobiles) and often runs on, across or down the center of city roads.
- Grade separation only in exceptional circumstances.

(Source: www.ficci.com)

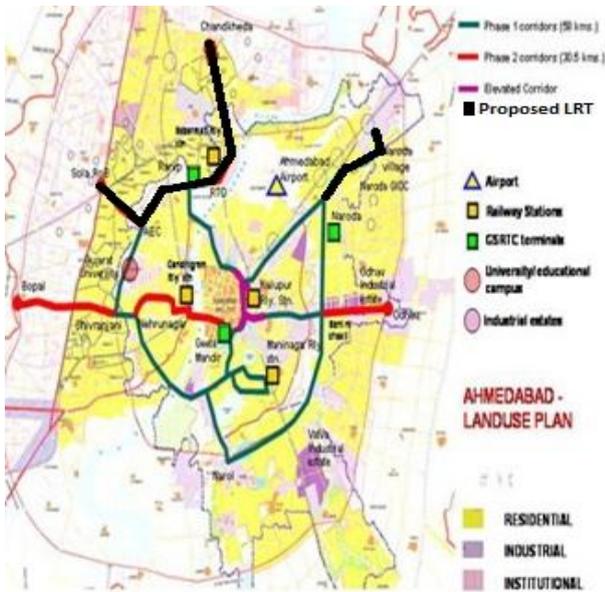


Figure 2: Available route for implementation of LRT in Ahmedabad city

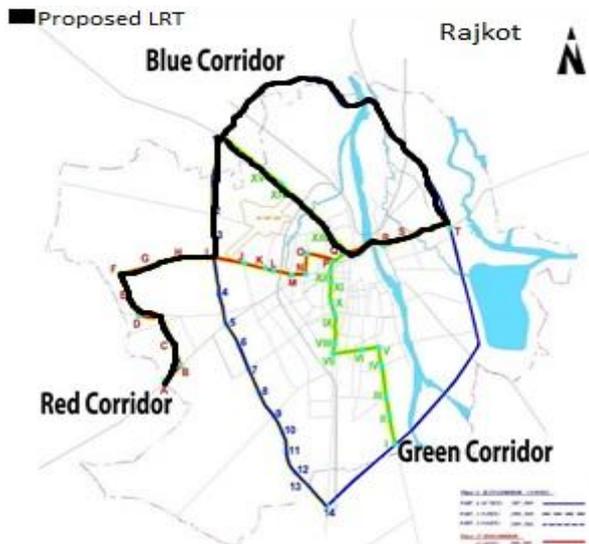


Figure 3: Available route for implementation of LRT In Rajkot city

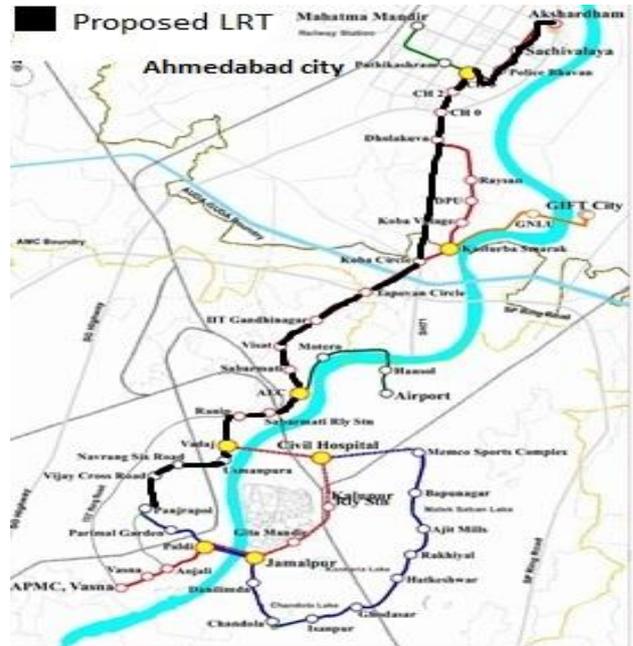


Figure 4: Available route for implementation of LRT in Ahmedabad metro Route

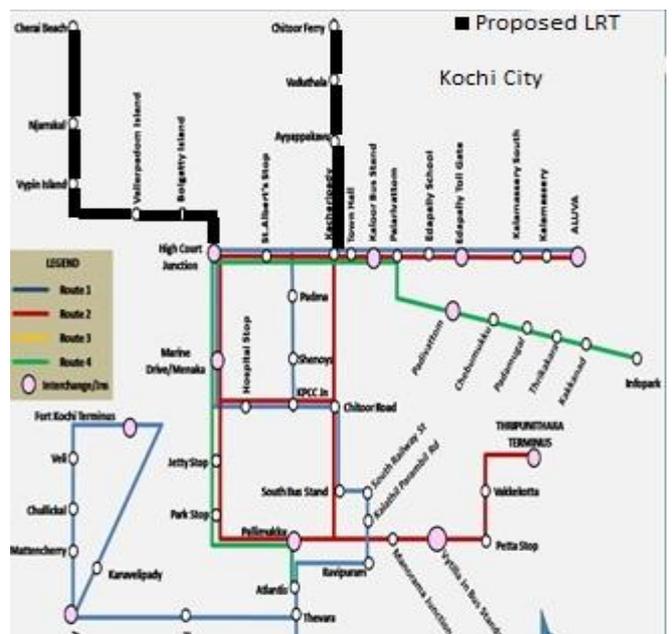


Figure 5: Available route for implementation of LRT In Kochi

6. Advantage of LRT over other Mass Transit System

The choice between the three medium capacity modes; LRT, Monorail and Bus rapid transit depends on several factors. From consideration of commuter convenience at grade modes should be preferred as climbing up and down, particularly for short trips is eliminated. At grade modes offer the best aesthetics as they do not interfere with the skyline or the privacy of roadside premises. Thus at-grade BRT and LRT is the first choice for Commuter Convenience, low initial cost, low operating cost and hence financial sustainability.

Between LRT and BRT, the choice depends on demand level and availability of road right of way on a corridor. As stated earlier, the capacity of BRT is unlikely to exceed 10000 pphpd (passengers per hour per direction) as a rule. This compares with the capacity of LRT which may go up to 30000 pphpd without requiring additional road lanes. Secondly as stated earlier LRT requires less road space (2-3 lanes) than BRT (3-4 lanes) because overtaking facility is not needed and one island platform will suffice against two platforms for BRT, one in each direction.

In selecting from amongst the 4 more commonly used medium capacity modes i.e. LRT, Monorail, Electric Trolley Bus (ETB-Similar to bus in capacity) and BRT, five factors have to be kept in mind; safety, environment, energy and land conservation and flexibility. LRT helps in all five features and offer the best safety, minimum pollution, conservation of fossil fuel and minimum land requirement; ETB helps with two features i.e. pollution and energy saving; bus is the least favoured in respect of these five elements. Table 2 shows this comparison. (Source: www.ficci.com)

Table 2: Comparison between medium capacity modes

Mode	Pollution control	Fuel Saving	Safety	Land Conservation	Flexibility
LRT	Yes	Yes	Yes	Yes	Yes
Mono Rail	Yes	Yes	Yes	Yes	-----
ETB	Yes	Yes	-----	-----	-----
BRTS	-----	-----	Yes	-----	Yes

7. Conclusion

This review consists the study of implementation and adoption of Light rail as an alternative mass transit system. Light rail is suitable well for the developed country and also for developing country like India. Latest upgraded technology in LRT, more passenger's carrying capacity, Eco friendly mode and economical features proves it mandatory option in transportation of Indian era today. Furthermore, it can reduce the problem of accidents, congestion and fuel consumption. So, Light Rail Transit System seems to be solution of most of the transport and traffic related problem in India.

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