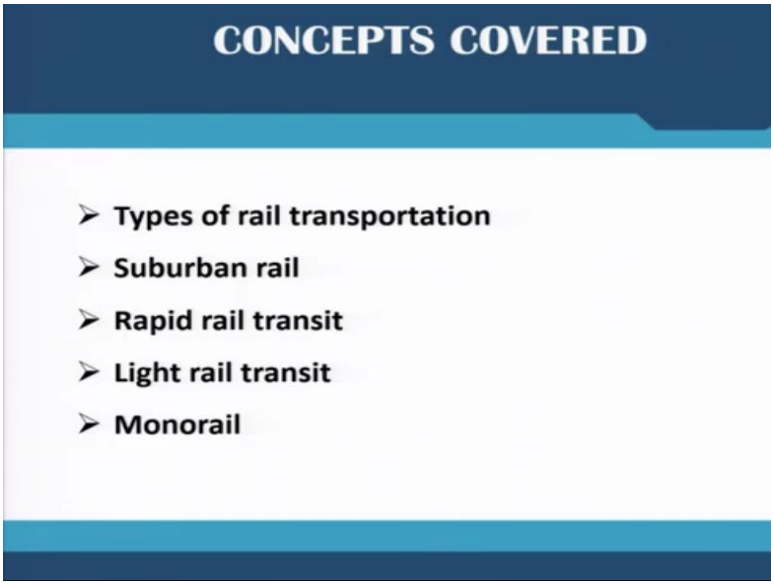
Introduction to Multimodal Urban Transportation Systems (MUTS)
Prof. Arkopal Kishore Goswami
Department of Ranbir and Chitra Gupta School of Infrastructure Design and Management
Indian Institute of Technology – Kharagpur

Module No # 03
Lecture No # 13
Public Transportation: Rail Transportation

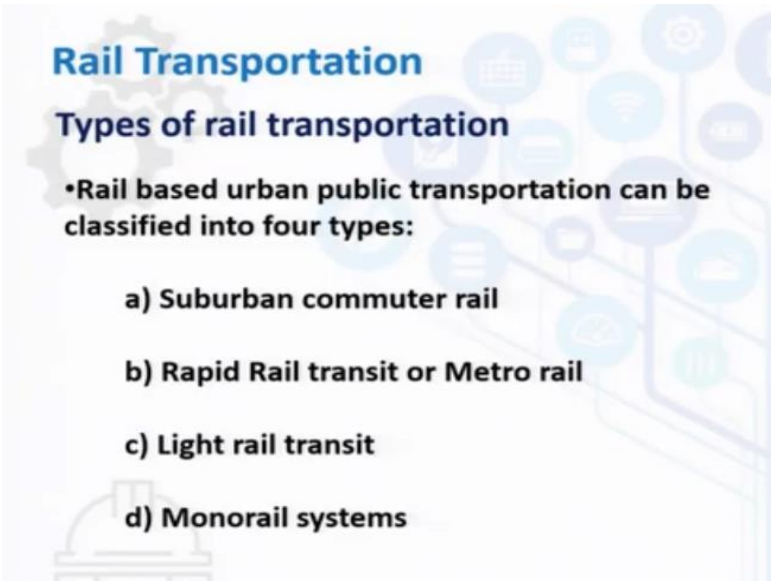
Welcome back friends, now that we have looked at different financing and marketing strategies in public transportations and also in the previous lectures we have covered lot about bus transport, i.e. bus public transportation systems. Now let us introduce you to the topic of urban rail transportation.

(Refer Slide Time: 00:40)



So in this lecture, we will look at the different types of rail transportation and especially we will be focusing on urban rail transportation. We will look at the suburban rails a bit and then start studying about the mass rapid rail transit systems or metros and light rail and also give you an overview about what is monorail, how can they be planned for, what are the capacities and so on and so forth.

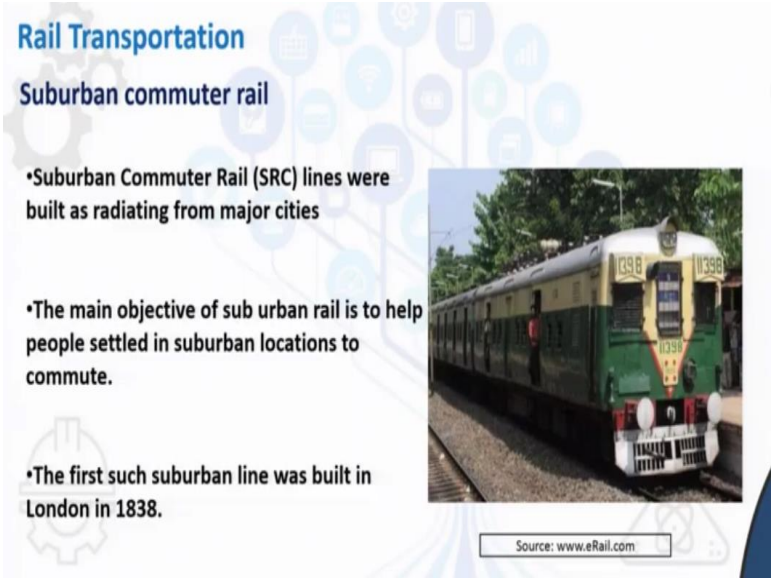
(Refer Slide Time: 01:10)



So in India when we talk about urban rail transport, we are usually talking about either suburban commuter rails, which are available in some of the large metropolitan cities, or talking about rapid rail transit, which we otherwise call metro rail. We are also talking about light rail transit in India, not many cities have it, but we are now planning for light rail transit in some of the cities and also monorail systems, which exist only in one city in India.

But we will give you an idea about what monorail systems are and what are their capacities and how they can be planned?

(Refer Slide Time: 02:00)



So suburban rails are something that have been there for long period of time in India. They are primarily in all the 4 large metropolitan cities and now they are coming up in couple more cities as well. The main objective of the suburban rail is to help people settled in the suburban locations. As the city started expanding, people started living further and further away. So in order to connect all of the suburban areas to the city it was envisioned that there should specific rail systems for everyday commuters.

We already have intercity rail transport but those are for longer distances of travel whereas if you are within an hour or an hour and half or even 2 hours, sometimes beyond that too, it becomes even more tiring, but ideally around 2 hours away, you are usually connected by some sort of a suburban rail transport system. First one of course was built way back in 1838 in London.

(Refer Slide Time: 03:14)

Currently suburban rail has lot of issues in India especially centering on overcrowding because of the lack of any other mode of reliable transport from these large suburban areas. The rail system is almost always overcrowded, a very popular picture that you often see the overcrowded suburban rails of Mumbai which face a lot of safety issues as well, concerns during flooding, concerns during peak hours of travel, and so on and so forth..

So suburban rails although have a very high capacity of around 20,000 to 40,000 passengers per hour in each direction. But due to the frequency of the rail, or due to the number of trains that can be run on each line, they almost always face a lot of overcrowding.

(Refer Slide Time: 04:26)

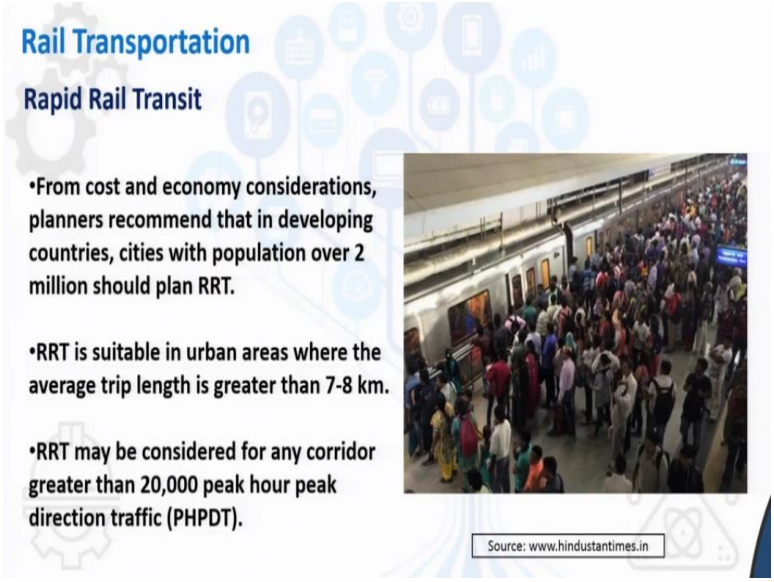
So in order to modernize or in order to improve the quality of provided by rail transportation, people have now started to look at metro rail systems across different cities. Metro rail systems are rail systems that can travel faster, they can attain higher speed than suburban rail systems and in doing so it can then transport more number of people per hour per direction. The first metro rail system in India was developed in Kolkata.

And now we have several metro rail systems in India in multiple cities and the network is also very well developed. For example, the New Delhi metro rail network is one of the most widely reached network in the country.

(Refer Slide Time: 05:30)

There are specific subsystems within the metro rail system. It has to have separate stations, it cannot have same stations as suburban rails; signal systems are much more efficient; it has specialized fare collection systems that have been introduced; and also the boarding and alighting facilities are controlled through automated doors. The suburban rail capacity was somewhere between 20,000 to 40,000 passenger per hour per direction whereas this can go up to, for eg. in peak hours, metro rail can take up to 60,000 passenger per hour.

(Refer Slide Time: 06:23)



From the cost and economy considerations, planners recommend that once your population of your city grows anywhere beyond 2 million, we should start thinking about rapid rail transit or metro rails. Now this one of the main drivers of public transportation. The population and also

the population density, if you do not have enough population density in your city it becomes challenging to efficiently or financially efficiently operate your mass rapid transit system.

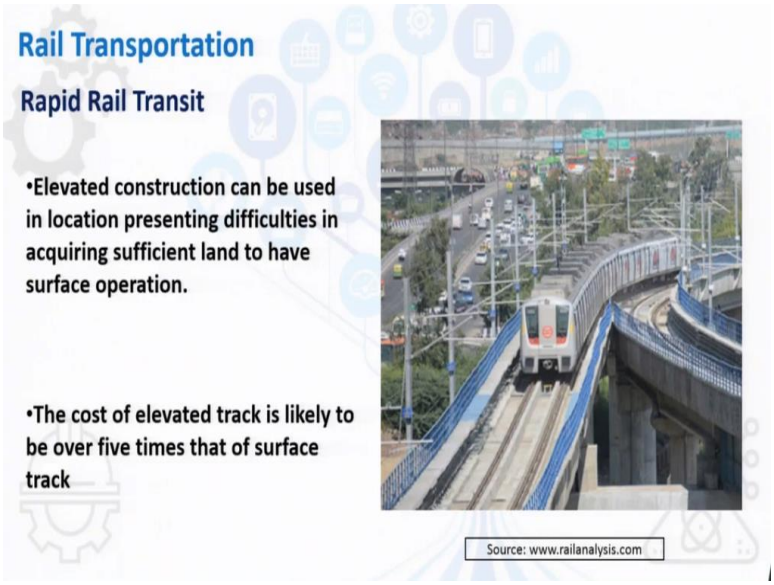
So, if you see larger cities that have sprawled out, across the world, they cannot sustain mass rapid transit system just because of their population density. So if you have sprawled out city with lower densities mass metro rail system becomes inefficient whereas if you have dense above high population density, which is the case with most of our urban areas in India, metro rail does become very viable.

However you have to have certain threshold because construction of metro rails usually is very expensive. And so to make it financially viable you have to have certain amount of ridership that can be attractive. It is also seen that if in your city the average length of each of the trips that your citizen take is around 7 to 8 kilometers, only then metro rail can be really beneficial.

So if people are travelling longer distances then metro rail can help reduce the travel time between these distances and so attract more and more people to your system, whereas if you have a city where the travel distance is already very short, metro rail cannot be of much help. So that is another very important point that you have to keep in mind. Then you have to design the metro rail system for traffic greater than 20,000 people in peak hour, in peak direction.

If there is more than 20,000 people that are travelling in the peak hour in the peak direction then metro becomes really beneficial. So it is not only the per hour ridership that you are worried, but it is about peak hour as well as the peak direction ridership, which is a metric or a benchmark that people look at for the existing system when they try to start planning for metro rail. So, 3 important things to remember is population size, the average trip length in your cities and also the peak hour peak direction traffic.

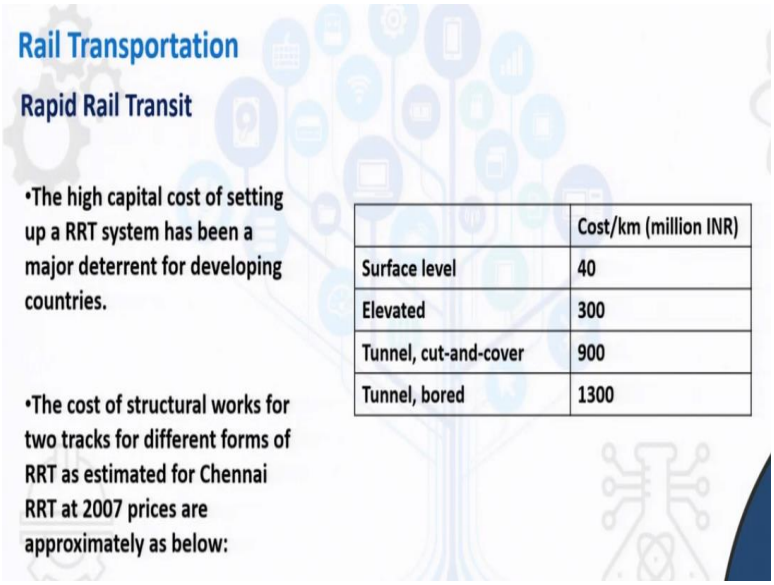
(Refer Slide Time: 09:24)



Now metro rail systems, as you may already know can be either above ground or also below ground. The costs vary significantly but that is a call that has to be taken by your local administration or the agency that is constructing the metro. There are pros and cons, for both of them although the elevated structure costs less when compared to digging underground tunnels where the metro would run, but people are averse to over ground structures because they may create lot of noise, and also visually they may not be very appealing for any city to have lot of lines running on top of them, just like we do not like the overhead electric wires hanging around on top of us. Similarly, many cities have made this observation that if a metro system is to be build, it has to be put underground.

But then underground systems are very expensive. So if you want a ballpark figure you can say that the cost of elevated track is likely to be over 5 times than that of just surface track. But very few metro stations are at grade, most of them are either above grade or below the surface. But if you have to compare it with, for example, a suburban rail which is at grade, so metro rail would almost have cost 5 times, i.e. the elevated metro rail would have cost almost 5 times.

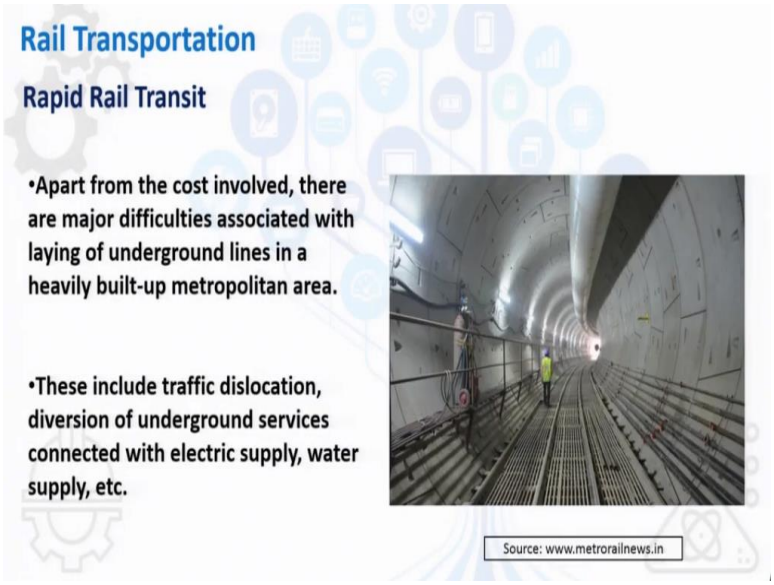
(Refer Slide Time: 11:18)



Given here is an example of prices which were looked at back in 2007 when Chennai rapid rail or Chennai metro rail was being envisioned. You could see the cost per kilometer in 2007 numbers. So if you have it on the surface it would be 40 million rupees per kilometer, whereas if you had to put it underground it would be almost 900 million rupees. So that is a huge cost, and keeping in mind the huge costs in the metro rail, usually what many planning authorities or agencies do is to have alternative assessments.

For example, a light rail transit system can be more cost effective when compared to metro rail or even BRTS could be more cost effective when compared to metro rail. So always alternative are assessed because of the prohibitive nature of the cost involved in building metro rail systems.

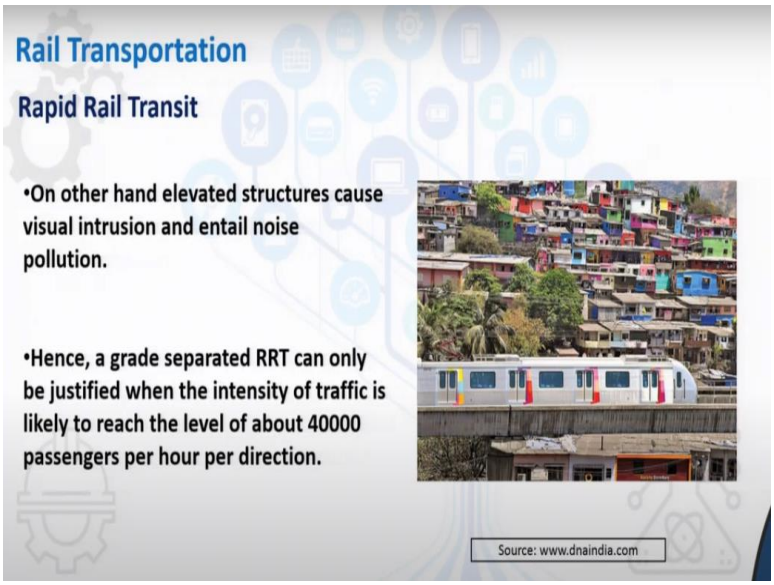
(Refer Slide Time: 12:28)



So you this is an example of an underground tunnel that has to be constructed in order to have metro rail lines underground. Kolkata's first metro lines was underground. However, extensions to the first line are all mostly over ground, apart from a small stretch which is now going to go under the river Hooghly to connect to the Howrah railway station.

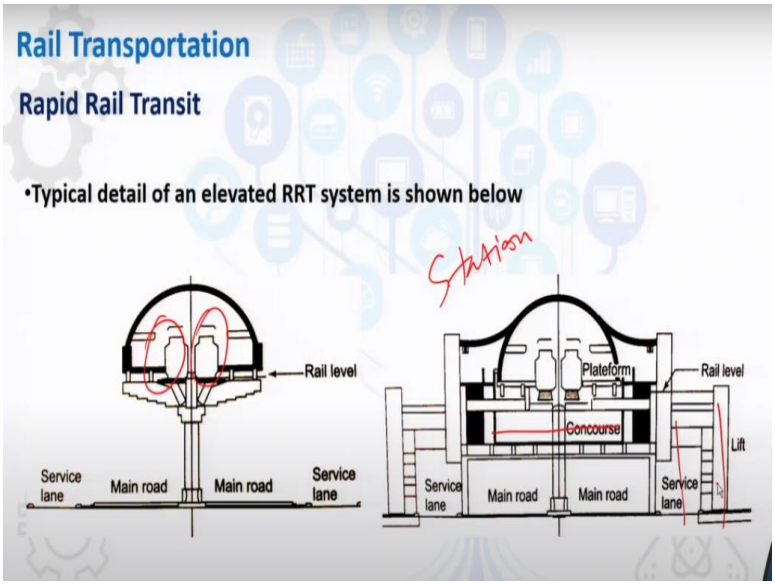
So the underground construction costs include not only traffic diversion, but diversion of other underground services electric supply, water supply. So this relocation of utility also takes lot of cost when you are trying to put something underground.

(Refer Slide Time: 13:25)



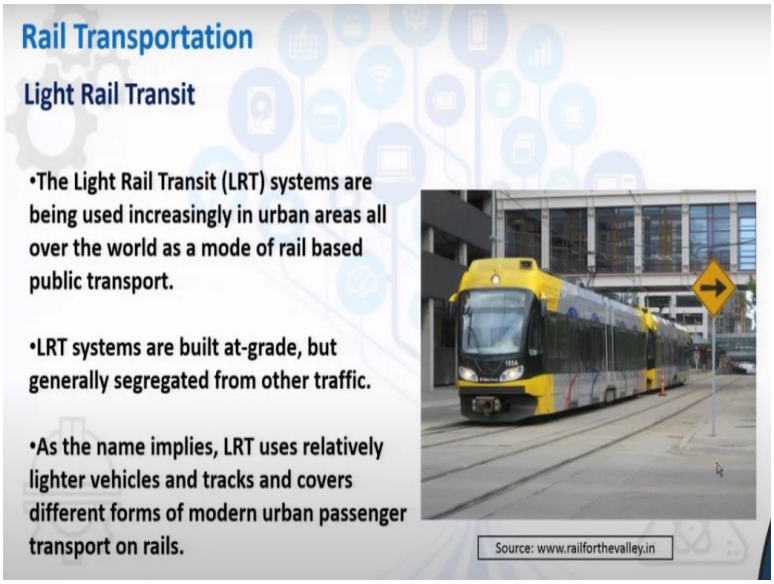
We have already talked about the implication of over ground metro system where it may create noise and not a great visual.

(Refer Slide Time: 13:39)



A typical cross section of elevated metro rail system and at grade metro rail system is shown here. So you see that at least you have to have for a metro rail system, you have to have enough space for 2 lines up and down and also at a station. So this is a cross section of metro station at grade. You have to have a concourse level as well and have all the other amenities such as lifts and stairs that take you on and off a metro.

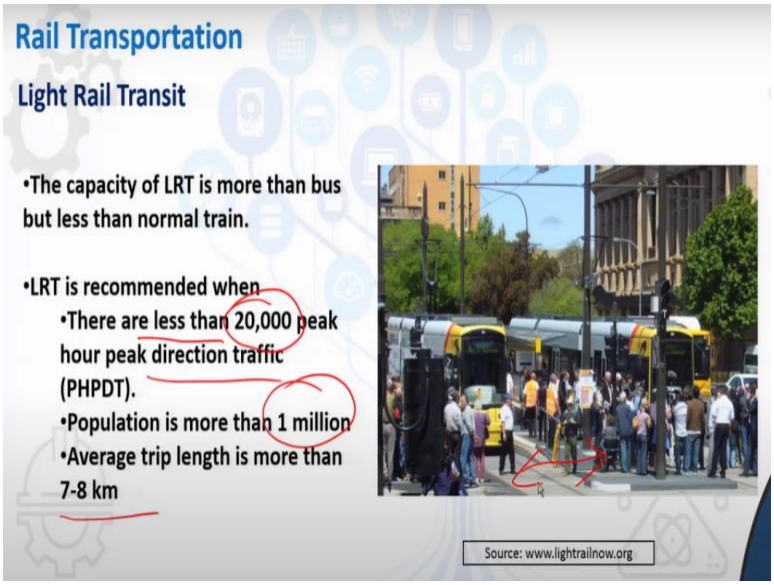
(Refer Slide Time: 14:21)



Now coming to the next type of urban public transportation system which is called light rail. Now many of you might have seen light rail systems from across the world. In India we do not have typical operating light rail system, what we have is a tram system in Kolkata which is similar to light rail system. But however they do not have a segregated ROW from other traffic, i.e. they do not have a dedicated right of way.

So the only difference between a light rail system and an LRT tram system is whereas tram mixes with other kinds of traffic, but LRT is generally segregated from other traffic. Both of them are built at grade. LRT usually uses lighter vehicles, so the costs are much lesser than the metro rail systems and being at-grade also helps in reducing the cost.

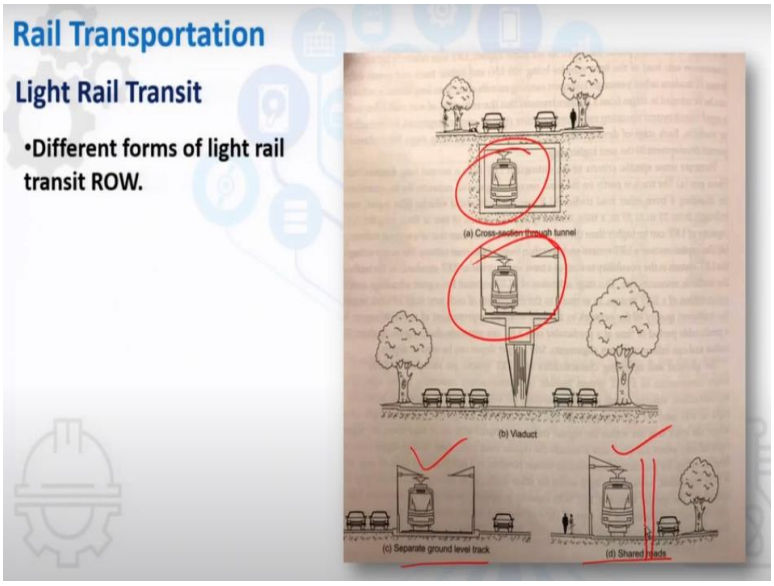
(Refer Slide Time: 15:31)



Unlike popular perception that they may carry fewer number of passenger it is not so. LRT is also recommended when traffic is around 20,000 but less that peak direction traffic and it can be planned at a threshold of 1 million population itself and the same average trip length of 7 to 8 kilometers that was used for metro rails systems can also justify putting in a light rail system.

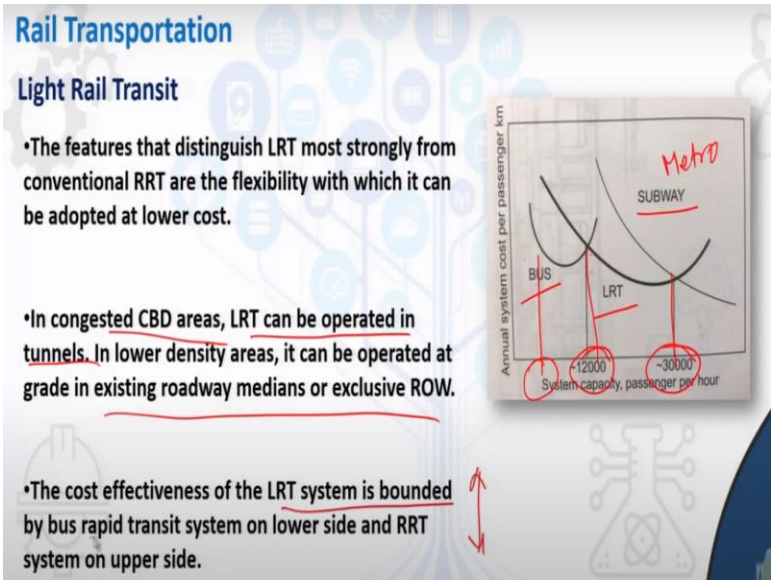
The only objection several time people have is they feel that light rail systems may intermingle with other modes just as shown here and hence they may be delayed. But usually it is not the case. So although it is at grade but it does have some kind of dedicated right of way where cars and other traffic cannot mingle with it, unlike tram system which have no dedicated right of way.

(Refer Slide Time: 16:42)



So again shown here are alternate types of LRT systems that you can also have. Some cities do have underground and over ground LRT systems. But usually again due to cost, those are not preferred. But they are usually at grade where they are separated at ground level and when they are shared with roads, although they share with roads but you see some kind of separation between themselves and the traffic.

(Refer Slide Time: 17:14)



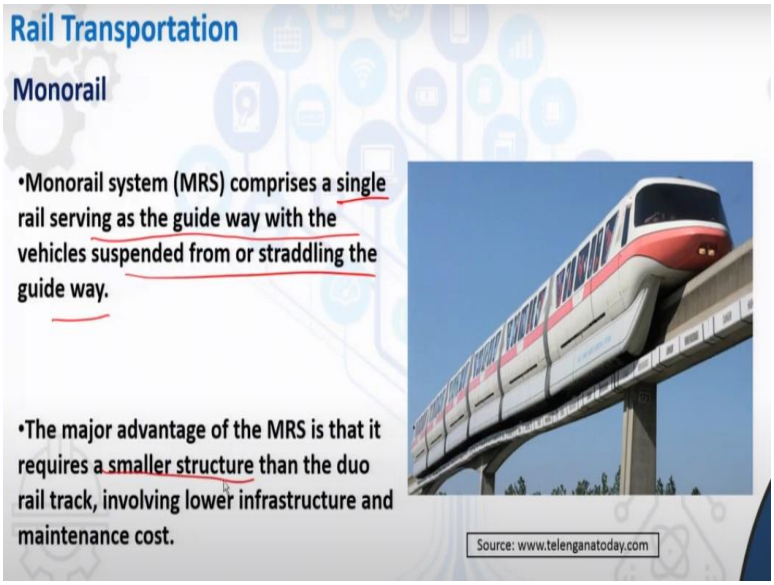
This chart shows you the different capacities, when you compare between bus rapid transit and LRT and a subway, which usually means some kind of metro rail system. So you see the capacities -- metro can carry very large capacity followed by LRT and followed by bus. So when you are trying to plan for your city, you first have to know those 3 parameters. First what is the

population density of your city, and what is the average trip length is, and also how many people are travelling in the peak hour in a peak direction right.

If you know all of these 3 then you can make an estimate as to how many people can any of the 3 systems proposed system carry, and which would be a more viable system for your city. In congested CBD areas especially, LRT can be operated in tunnels, however in lower density suburban areas it can be on existing medians of roads. Again tunnels do increase the cost, but there are instances where they are in tunnels.

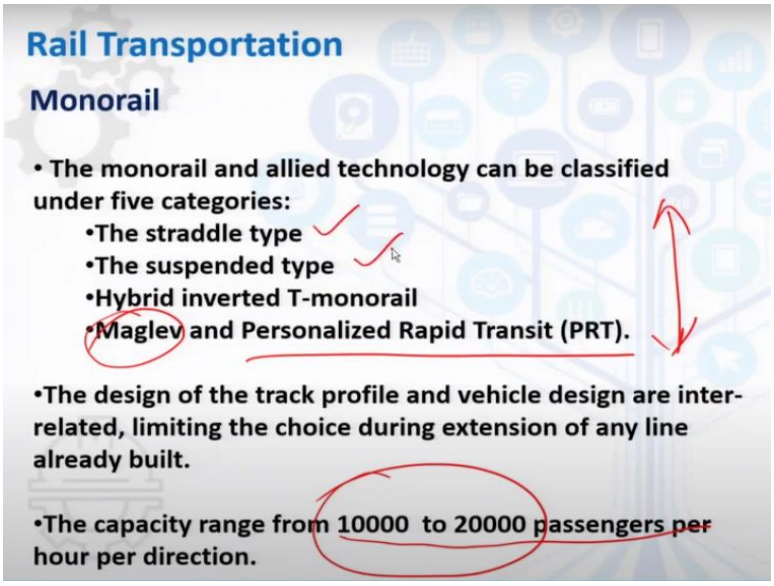
Bbroadly if you wanted to see where the cost of the LRT systems falls, you could say that the LRT system cost more than a bus rapid system but less than a metro rail system.

(Refer Slide Time: 18:46)



Finally, if you talk about another type of public transportation system, that could be monorails. It comprises of a single rail serving as a guide with the vehicle suspended from or straddling the guide way. So these are systems that have not become very popular across the world but are available at certain location within cities. The major advantage is that it requires a smaller structure, it does not require as large a structure as is required for a metro systems and hence the cost of constructing the infrastructure and also the maintenance cost is lower.

(Refer Slide Time: 19:35)

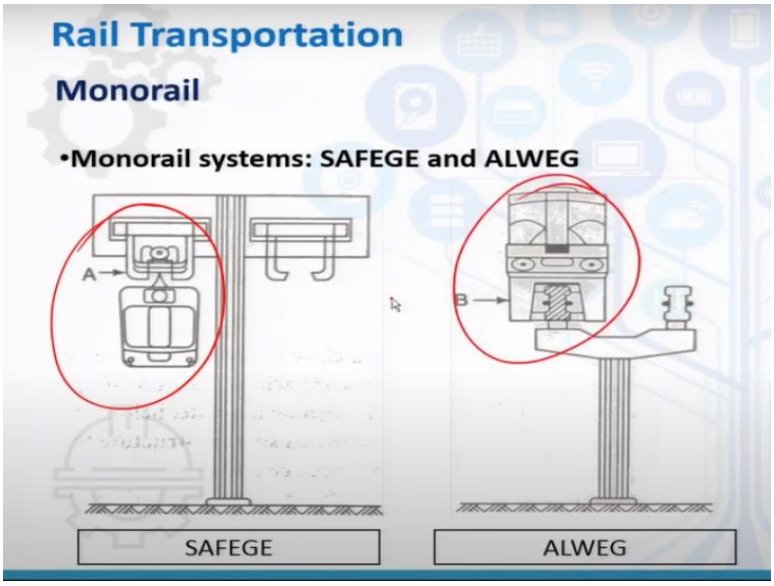


But at the same time it can carry fewer number of passengers. When you already have an overcrowded public transportation system and you want to enhance it, usually people do not go for a monorail system because they cannot carry too many people. However monorail systems are very popular especially at concentrated high intensity use areas. For example, you may have large airport systems and you may want to connect multiple terminals.

So in those cases you have monorails, which we are talking about, what form that is, etc. But only at such concentrated locations for shorter duration trips where the demand or the passenger is higher not more than 10,000 to 20,000 per hour per direction, that is a situation where you can use the monorail systems. There are different types of monorail systems. BRT is something that is being tried at many of the airport location that I was talking about recently where to connect between 2 terminals.

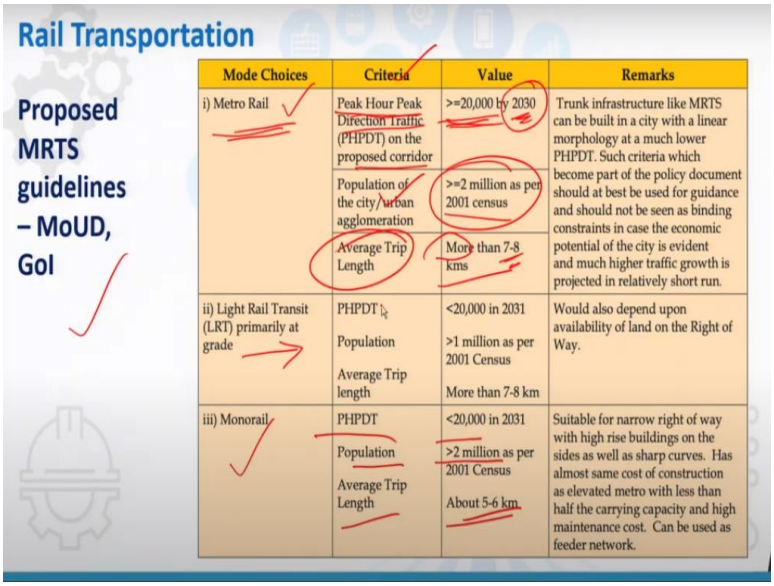
Maglev has been used in the past but mostly used for intercity kind of transport and the most popular type is straddle type or the suspended type.

(Refer Slide Time: 21:27)



So you would either see a monorail suspended from a tower or from a structure, or it is straddling on top of a structure -- that is the 2 different types of monorail systems that are very popular.

(Refer Slide Time: 21:43)



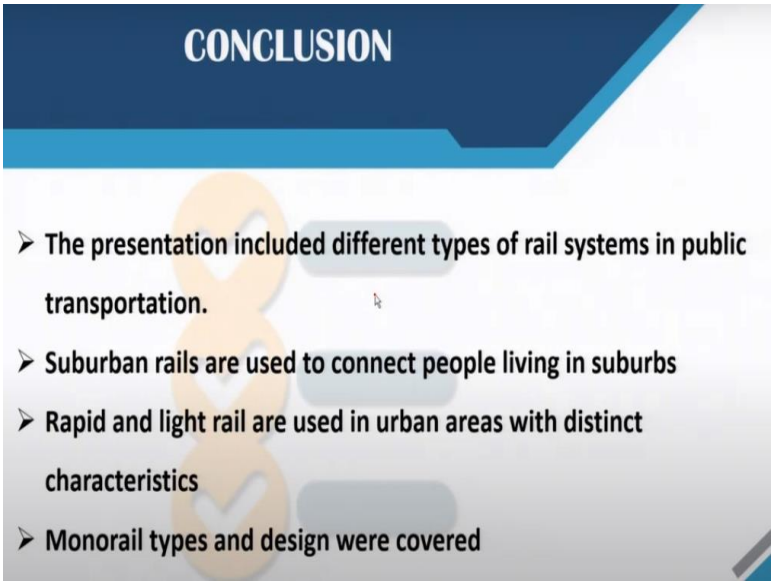
Mode Choices	Criteria	Value	Remarks
i) Metro Rail	Peak Hour Peak Direction Traffic (PHPDT) on the proposed corridor	>=20,000 by 2030	Trunk infrastructure like MRTS can be built in a city with a linear morphology at a much lower PHPDT. Such criteria which become part of the policy document should at best be used for guidance and should not be seen as binding constraints in case the economic potential of the city is evident and much higher traffic growth is projected in relatively short run.
	Population of the city/urban agglomeration	>=2 million as per 2001 census	
	Average Trip Length	More than 7-8 kms	
ii) Light Rail Transit (LRT) primarily at grade	PHPDT Population Average Trip length	<20,000 in 2031 >1 million as per 2001 Census More than 7-8 km	Would also depend upon availability of land on the Right of Way.
iii) Monorail	PHPDT Population Average Trip Length	<20,000 in 2031 >2 million as per 2001 Census About 5-6 km.	Suitable for narrow right of way with high rise buildings on the sides as well as sharp curves. Has almost same cost of construction as elevated metro with less than half the carrying capacity and high maintenance cost. Can be used as feeder network.

The last slide here is to give you an overview of a snapshot of what are some of the proposed MRTS guidelines by the Government of India. Like we have already discussed when it comes to metro rails you have to ensure that the criteria of peak hour peak direction traffic is met on the proposed corridor and usually what is being proposed in the guidelines, if you can project that there will be more than 20,000 people travelling in the peak hour in the peak direction by the year 2030, then you can start planning for a metro rail for your city. It also has to meet the

criteria of having more than 2 million people as per the 2001 census and also your average trip length should be more than 7 to 8 kilometers. So city where your average trip lengths are much shorter metro rail would not be very helpful. If you take the other extreme and trying to plan for monorail then you would see if there are less than 20,000 by 2031, you can try it a population could be more than 2 million.

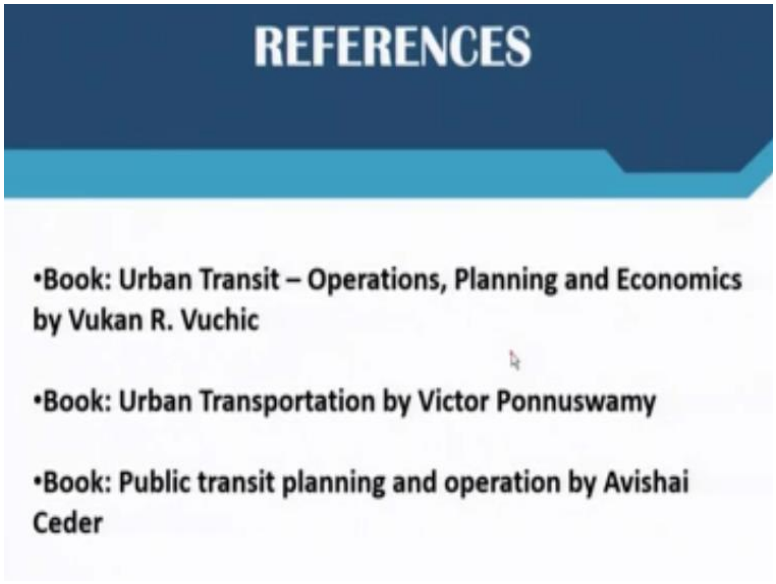
But your average trip length has to be much shorter trips then you can plan for monorail, and something in between is LRT, and the criteria again are given. So this gives you kind of a snapshot of the different types of urban rail transportation systems that you can choose from, for your city. These are guidelines at a very at a policy level and then you have to do your analysis to find out which fits your city.

(Refer Slide Time: 23:43)



So that brings us to the conclusion of an overview of the urban rail transport systems, where we have now looked at different type of rail transport system including the suburban metro rail, monorail as well as the LRT systems. We have looked at what are the criteria they have to fulfill before you plan for each of the systems. We have briefly looked at how they can be designed, i.e. over ground or underground, and the costs involved in each of those designs should also be kept in mind when you are planning for each of these systems.

(Refer Slide Time: 24:24)



Here are some of the references for further reading, which you can use. Thank you very much for your attention.