Transportation Engineering -II
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Lecture - 1
Introduction to Railway Engineering

Dear students, I welcome you all to lecture series on course material of transportation engineering two. Transportation engineering two consists of two parts: the first part is relating to railway engineering and the second part relates to airport engineering. We will be taking up different aspects related to railway engineering and airport engineering in succession during these lecture series. Today, we will be starting with the introduction of railway engineering and in this introduction we will be taking up different aspects as mentioned here. We will be looking at the importance of the transportation systems. We will go through the history of the Indian railways, we will look at the zoning systems adopted by the Indian railways and then, we will also be looking at some of the important characteristics by which we can compare different transportation systems by the special reference to rail and road transport systems.

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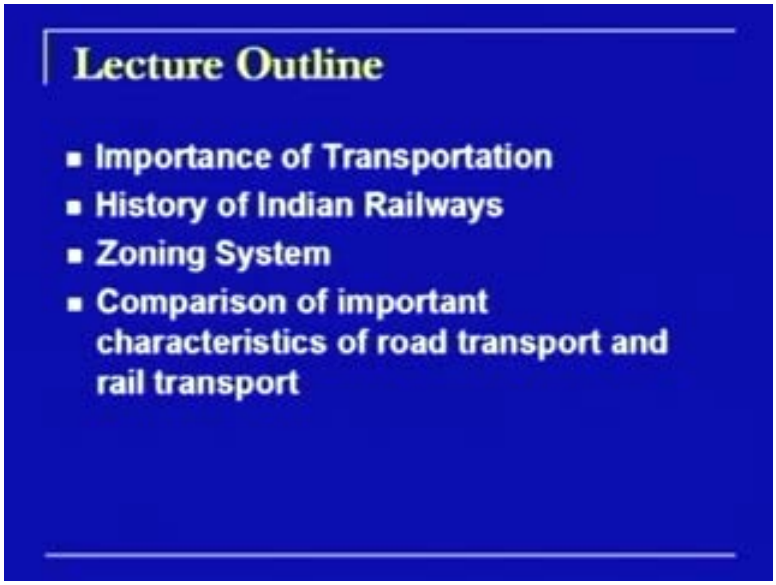

Now we start with the importance of transportation system. When we start with this one, as you have seen, we have different systems working by which we can transport not only the passengers but the goods. In general, the transportation system can be defined by using this definition which includes number of characteristics of any transportation system taken in general.

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It can be defined as, it is an optimum combination of Fixed facilities, Flow entities, Operational plans, Storage facilities and Control systems that permit people and goods to overcome the friction offered by geographical spaces in a most efficient, safe and convenient manner in order to achieve time and place utility for the desired activity.

Now, this is a definition which incorporates, as I told you, number of important characteristics of transportation system. It talks about the fixed facilities which are physical facilities, fixed and the space like a road way, like the track. The flow entities are the things which are moving over these facilities. We can talk about different types of the vehicles which are moving either on roads or on tracks, the trains. Operational plans by which they have been operated, the facilities for storing of these equipments when not in use. Control systems, another thing which is important is the friction. We have to

overcome the different frictions being imposed by different systems, being imposed by the geographical spaces. Now, if we can remove this friction then we can have the efficient system and not only the efficient system but that will be more safer and more convenient to the movement of passengers and goods. Along with that what we have to achieve is the different types of utilities so as to fulfill the activities for which we are transporting the things or we are moving ourselves.

Now, we look at the importance of transportation system. There are different things or different aspects which we can take up.

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We have to derive out of the system the Economic aspects, the Cultural and Social aspects, the Political aspects and the Environmental aspects.

In the case of economic aspects, we have to look at the various utilities which have been satisfied or which have been provided by the provision of that transportation system. In the case of utilities as we mentioned in the previous slide, it can be time utility, it can be place utility or it can be quality utility. So we have to look at whether we can transport the things in a system, in an environment where the utilities of transporting the things or

the utilities of transporting the passengers is not diminishing, it is not transforming into disutility. Another aspect here is the development of the area. As soon as the transportation system is been provided in an area, it is well but natural that the development of that area will start and this is one of the important factors why the transportation systems have provided. One more aspect which is of importance especially for the developing countries and of course not only for the developing countries but to developed countries also is taken. Employment generation, being offered by any of the transportation system which is utilized, which is being made operational.

In case of cultural and social aspects, we have to look at the effect of these transportation systems on the settings of any cultural traditions which will be there in any of the area. We have to try to preserve the things but to the extent that they should not become isolated. Therefore, the inter plunging of the cultures is very important. Another aspect is the social aspect where we have to look at different things. We have to talk about the settlement patterns, we can talk about the health of the persons, we can talk about the hygiene, we can talk about the emergency conditions where a facilities needs to be provided.

In the case of political aspects, political aspects are related more towards the governance of any area; it may be strategic purposes where you have to just take control of your boundaries or it may be the law and order situation which is to be controlled within the area. That is why, this is another important aspect and at times you have to fulfill this aspect by the provision of transportation system in that area.

Nowadays, another important thing which has been taken up again and again is the environmental issue. We have to look at what type of solutions will be generated out of provision of that transportation system. Whether that pollution is in terms of air pollution, in terms of the noise pollution, or in terms of the water pollution, or the land pollution, the sewerages or at times because of the migrations which are taking place. What we found is that small developed settlements takes place in the areas which are very near to the centers, which are basically employment generation centers. I am talking about the

slums. So we have to look from the environmental aspect on these things also, that any transportation system should not transform into a system which is creating environmental degradation in that area. So, that is why the transportation system, what are provision of transportation system is very much important for any of the areas.

Now, once we have the idea of what all the things which are going to be provided or the importance of the transportation systems, the next thing which we can look at is what all are the various types of transportation system available to us. The transportation systems which are available to us are public or mass transport systems.

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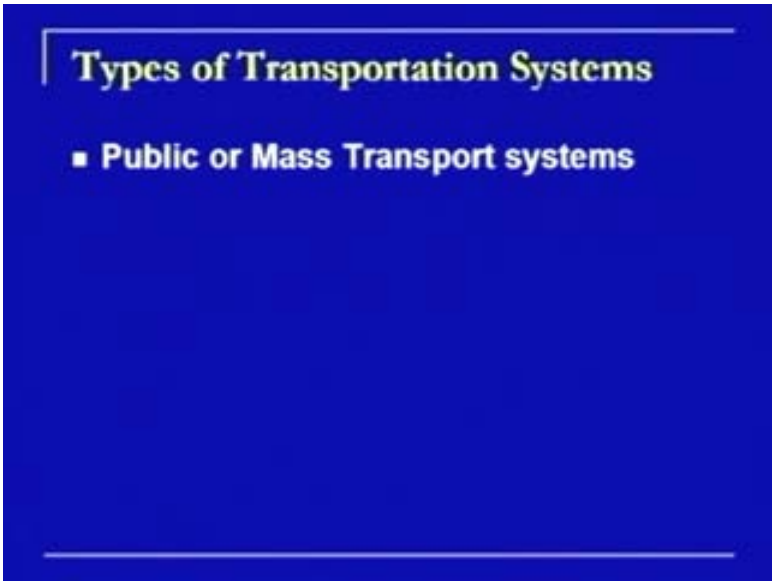

Where in more of the people can be grouped together that may be in terms of the public bus transport system or it may be in terms of the rail transport system like metros. Then there is a private transport system, where you are using your own vehicle. You may be using your car, you may be using your scooter, you may be using your bicycle so as to move to another place. That is the private transport system. In between private transport system and public transport system is the intermediate transport system. In the case of

intermediate transport system the vehicle is not being own by you but it is being used by you for a certain period of time.

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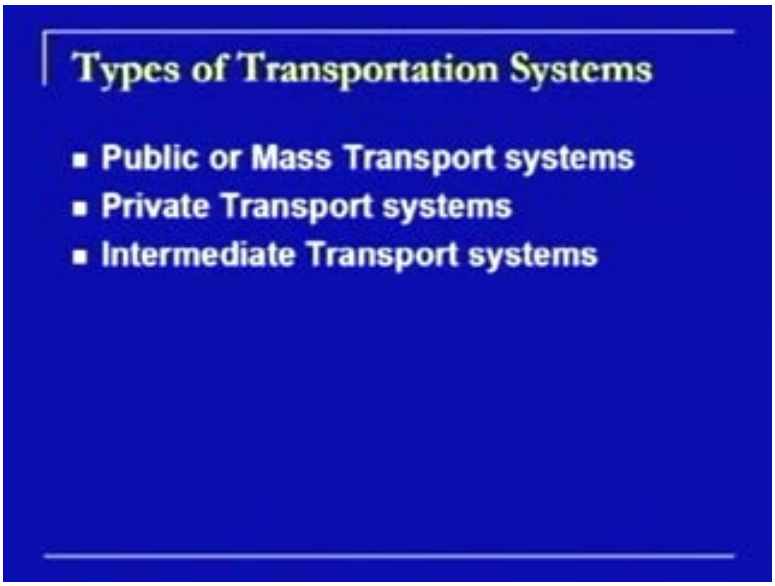

I am talking here about systems like taxis. The taxis are not being owned by the person who is utilizing that service, so that falls within the intermediate transport system. Other than these three systems, we have the coordination or combinations of all these systems. In the case of combinations and coordination we can look at the effect of taking the mass transport system.

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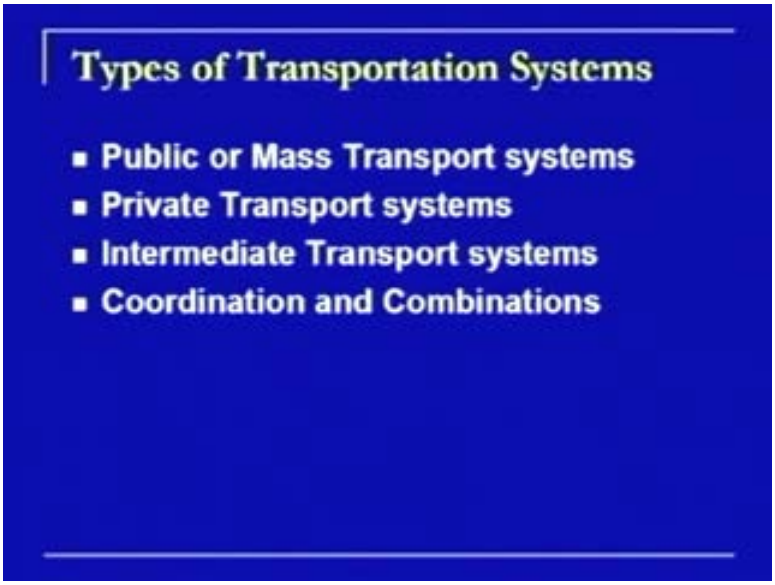

Mass transport system, not necessarily available to you at your door step. Therefore, when you have to take that system you have to reach the station from where you can get this facility. By taking this facility what you have to do is either you have to use your own private mode so as to reach the station or you can use the intermediate transport system like auto rickshaw so as to reach that point. Therefore, you will be having the combination or the coordination of different systems in this case. So these are the ways by which different systems can be utilized. Now, out of these systems we move to another one, that is, what are the modes which are available to us. In the case of different modes, we can classify them on the basis of the support system which they will be using. They will be land transport systems, the water transport systems, the air transport systems or some other systems. Again, we can have the classification within the land transport systems or water transport systems or other systems, as been shown here. Now we will be concentrating on the system which is termed as rail with flange systems, that is, the conventional train system.

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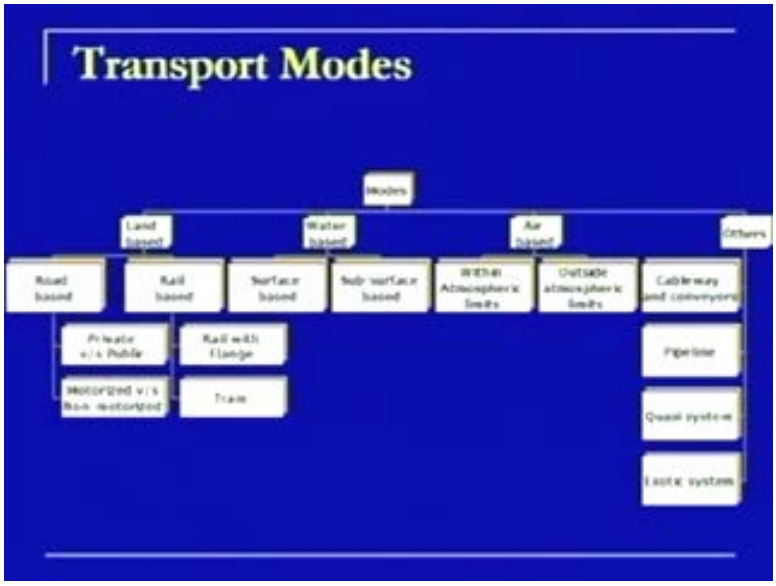

Now onwards whatever discussion we will be dealing, that will be concentrated on only the railways which have been shown here.

Now we move to the history of Indian railways. Of course, railways started way back as far as the global concern is there but when we have to look here; we were talking about only the Indian railways. The history of Indian railway starts from 1822 when the first proposal for the railways in India was meet for Madras, but somehow it could not take place. Then there was one of the committee which was named the Macdonald Stephenson's committee which has given, submitted the report, so as to look at the practicability or feasibility of providing railways in British India, let in eighteen forty four. Then there was a great Indian peninsular railway which was enacted by the act of parliament in 1849.

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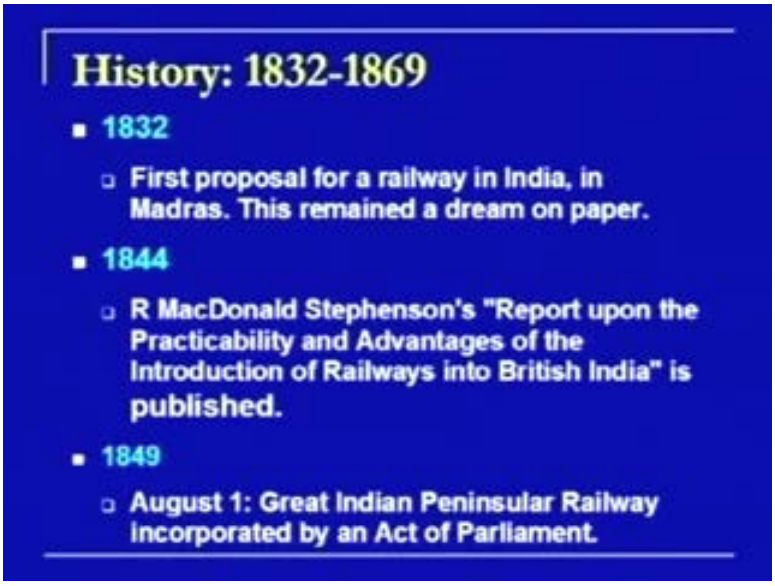

I am taking only some important aspects of the history of Indian railways here. Here one thing which we can see is that in 1851 there was the first movement of train in India, that was in Roorkee. It was done for the Solani viaduct when the construction of that was going on. Of course it was a very small track and the main concern here was the transportation of the material for the construction purposes.

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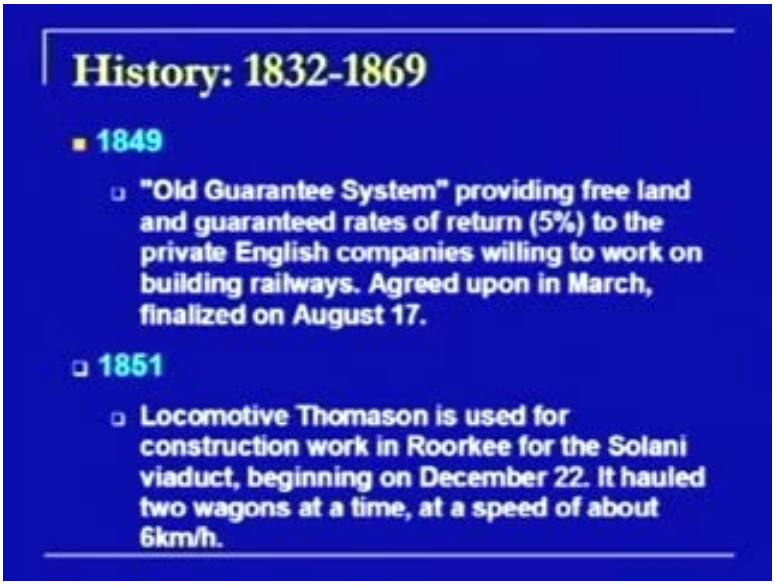

Then another aspect which has been there was the construction of a line in the Bombay. Then came in 1853 the first train which started as a passenger train in India, which moved between Boribunder and Thane. It was moved by 3 locomotives and they were given the names as Sindh, Sultan and Sahib. There were 400 passengers or the guests who had accompanied this journey.

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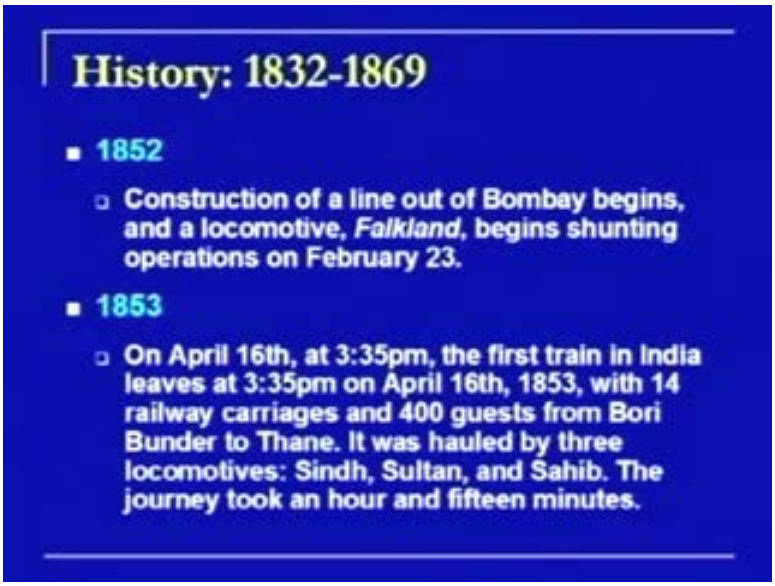
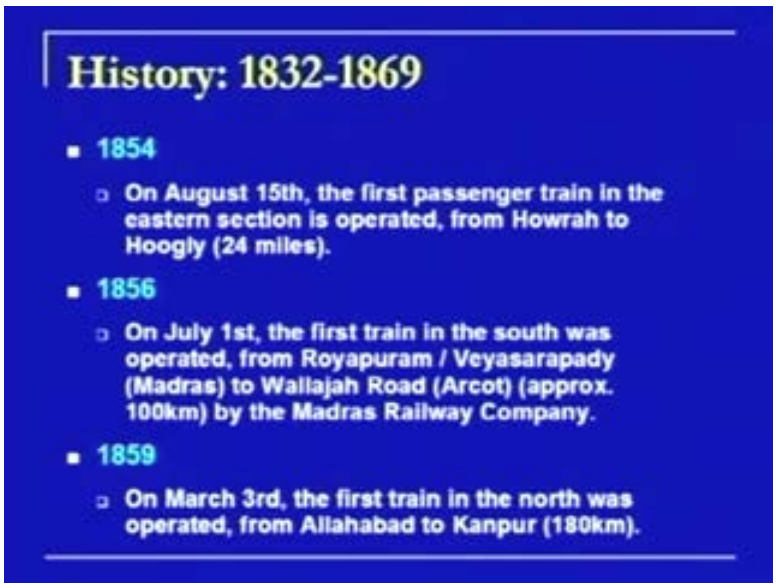


On August 15 the first passenger train was started in the eastern section; that was from Howrah to Hooghly. Then there was the first train in the southern region, it was for around 100 kilometers distance and it was done by the Madras railway company. Then there was a train in the north, it was started in 1859 and it was from Allahabad to Kanpur for a distance of around 180 kilometers.



While all these developments were going on, it was observed that there is a need of constructing or setting up of the different workshops or the loco works which can take up the maintenance of different locomotives or wagons which are in use. Here we can see that the Jamalpur loco works was established in 1862 and the Alambagh workshop was set up in 1865. While all these things were going on, in 1864 the first train came to Delhi.

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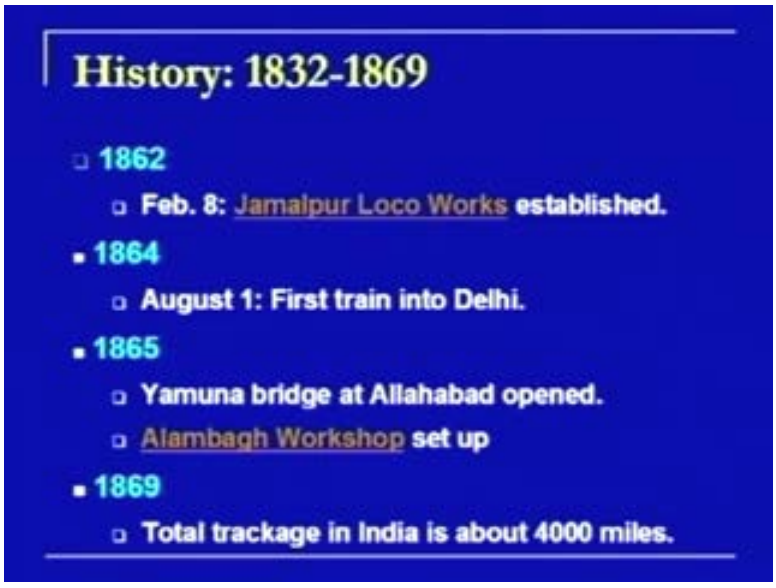

Now, we come to 1870 onwards, and in this case we see that there was connectivity between Bombay and Calcutta; the things were going on as such. 1870 and onwards also has seen the implementation and the construction of meter gauges. The first commercial meter gauge service was started between Delhi and Rewari in 1873. Then there were also horse drawn tram systems which were operated in Mumbai previously known as Bombay in 1874.

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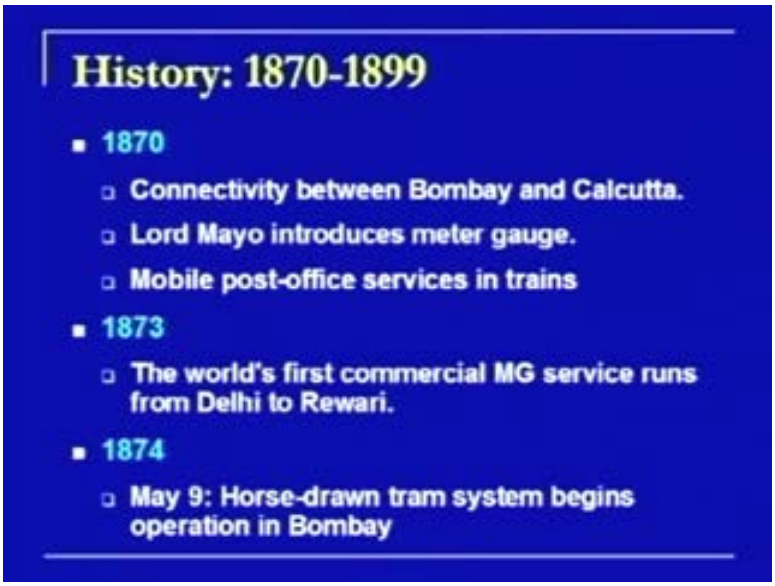

Continuing with the history of Indian railways, what we see is that, at number of station the book stores with the name of A H wheeler and company Harwinsy bias. This company was set up in 1877 by a French author and an Indian businessman, so it has a long history. In 1882 the post of the director general of the railway was created in the central public works department which was controlling at that time the operation and construction of Indian railways.

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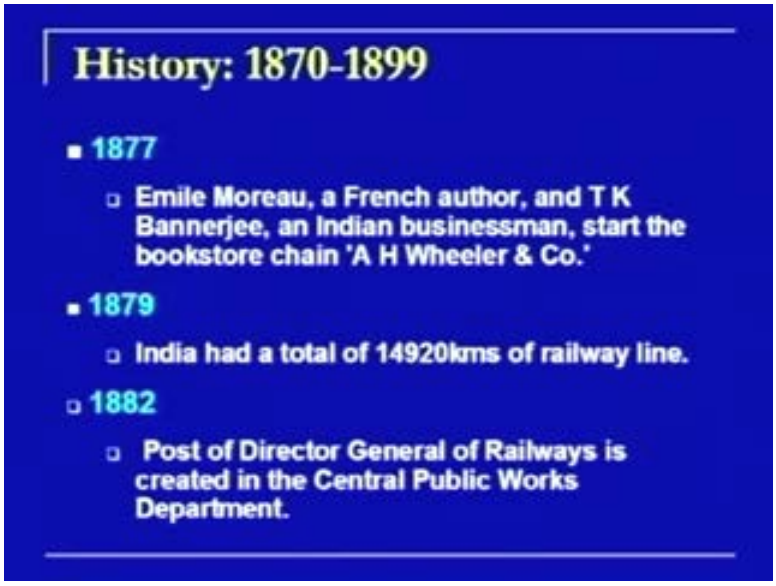

Another aspect, big expect which has come up in 1888 was the construction of Victoria Terminus building in Bombay, today it is named as Chatrapathi Shivaji Terminus. The first locomotive was build in India at the Ajmer works in 1895, then Jamalpur workshop officially begin its production of steam locomotives in 1899.

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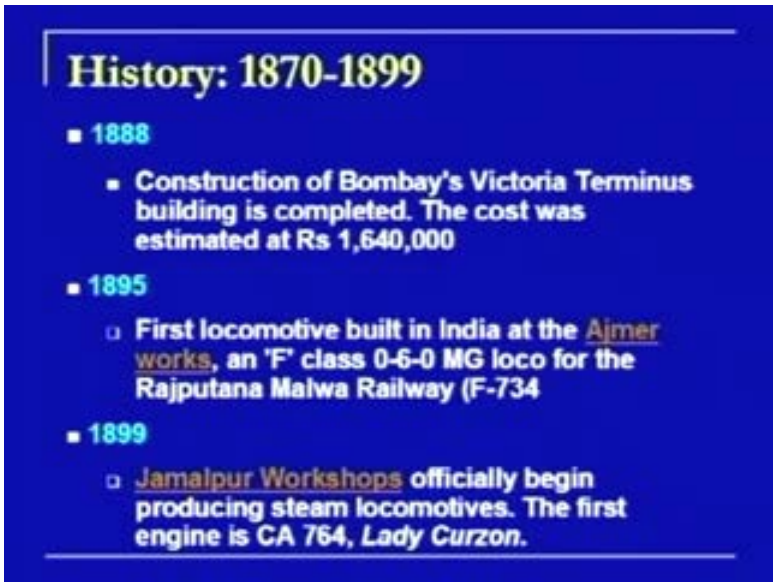

There were some more committees which tried to improve the administrative and operational aspects of the Indian railways, that is, the British railways at that time. Railway mileages were kept on increasing at most 24750 miles in 1901. Interlocking was introduced, this was the safety aspect which was taken up slowly and slowly, and 1903 was the first time when for a certain section that system was provided.

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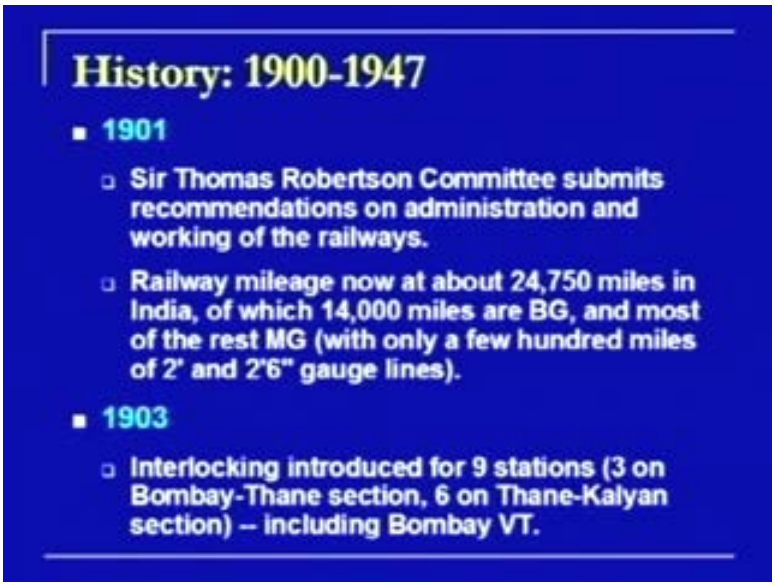

Railway board, the main board which is controlling the total operations and policies of the railways that was formalized in 1905; then the general rules were framed and Indian standard time came into force in 1906. The British systems standards were adopted so as to keep on constructing the Indian railways and their tracks.

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The first ever diesel locomotive in India was provided or constructed in 1915. Then we have some more things in the case of safety aspects which were taken place; they were in the form of vacuum breaking systems, track circuiting systems or the telephones which were provided for the controlling of the operations of trains on the tracks. The Indian railway committee, also which was termed as the Acworth committee, it has pointed out that we have to have a unified management of the entire railway system. What was happening before this was

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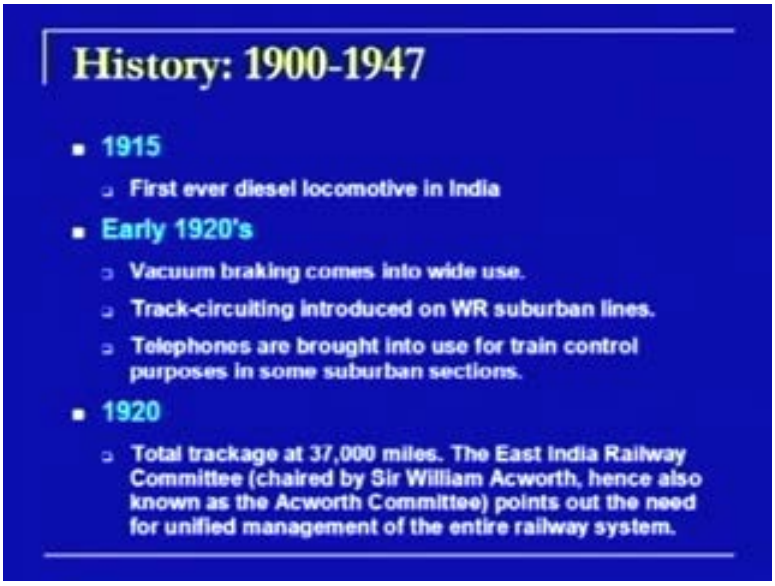

that there were different railway companies which were operating their services in different regions. So, a unified approach was required, so that each and every thing can be taken up in a balanced manner. That is why this was suggested in 1920 by this committee. Again, on these sides, what we see is the track length was increasing and it was 61220 root kilometers in nineteen twenty one. Further, the railway board was organized by the chief commissioner of railways who was having more powers than before.

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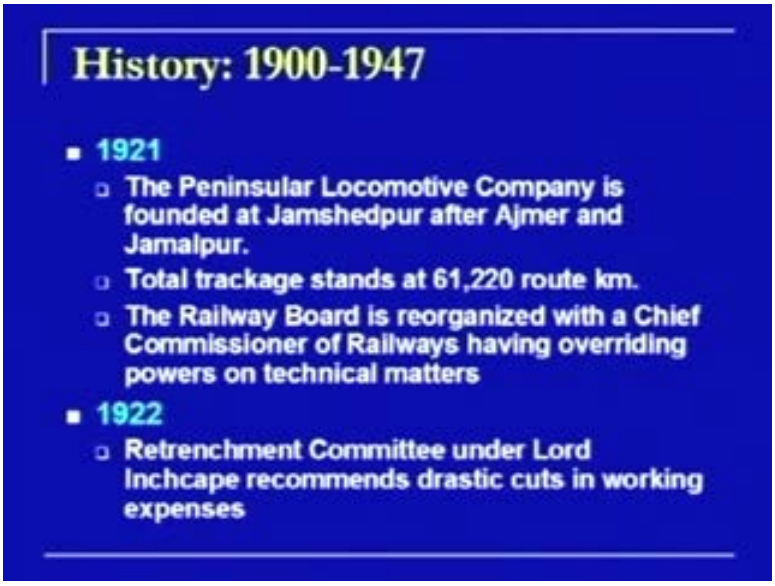

Now, if we take the finances in the case of Indian railways, they were taken up in 1924 and uniform system of loco classification codes, because whatever locomotors we are using, whether they are a steam locomotives, whether they are a diesel locomotives or nowadays we are using the electric locomotives, they have been classified on the basis of their characteristics. So, a uniform system is required to do that. In this case this uniform system was adopted from 1924 onwards and, of course, it has been changed or modified from time to time. The first electric railway got operated in 1925. Then, there was locomotive standards committee which adopted several Indian railway specifications loco classes as standards.

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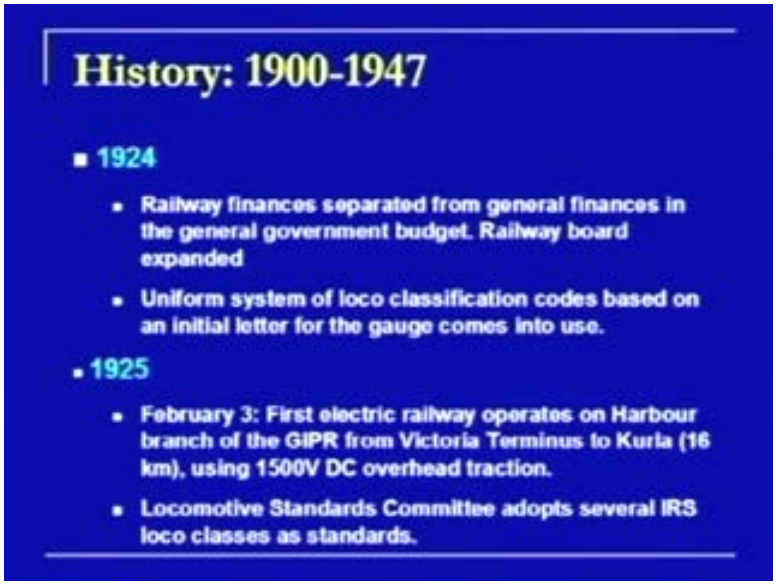

We also see the back coming of the passenger facilities; it was in the terms of the air conditioned facilities being provided from 1936 onwards. Then there was certain recommendation in the case of the more better passenger services and expansion of the freight activities. A committee was formed for this which was named as Wedgwood committee; that was the time 1937.

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The ministry, the minister of transport and communication in the post of this created so as to control the overall operations of transport systems in 1937 and the Indian standard was renamed as Indian government railway standards in 1945. Before that most of the standards which we adopted were from British India and the British standards which have been followed in their country.

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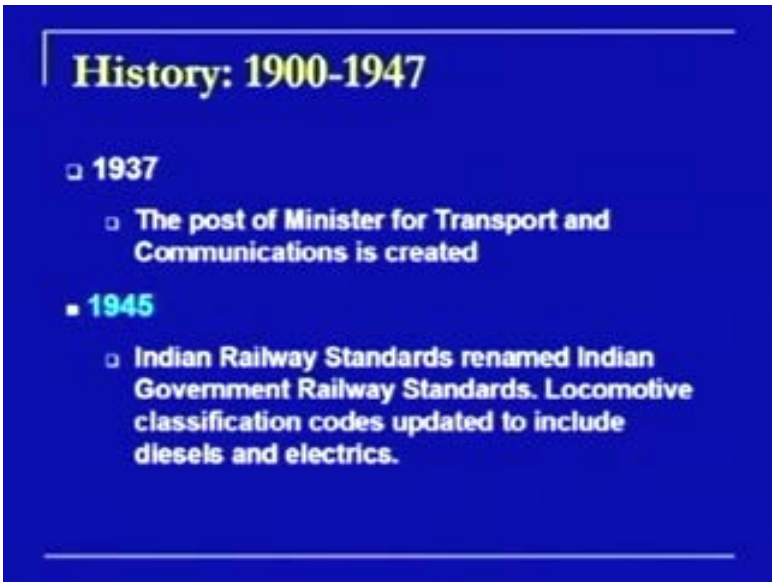

Slowly and slowly we started taking up our own initiatives and to have our own standards. Then the integrate design coaches was come into use. There was possibility of AC traction, before we were having DC tractions and we were also starting the sleeping accommodations from 1954 onwards. The passenger fare was standardized in terms of different money for per mile of the routes which have been taken up. The platform tickets were also started in 1956.

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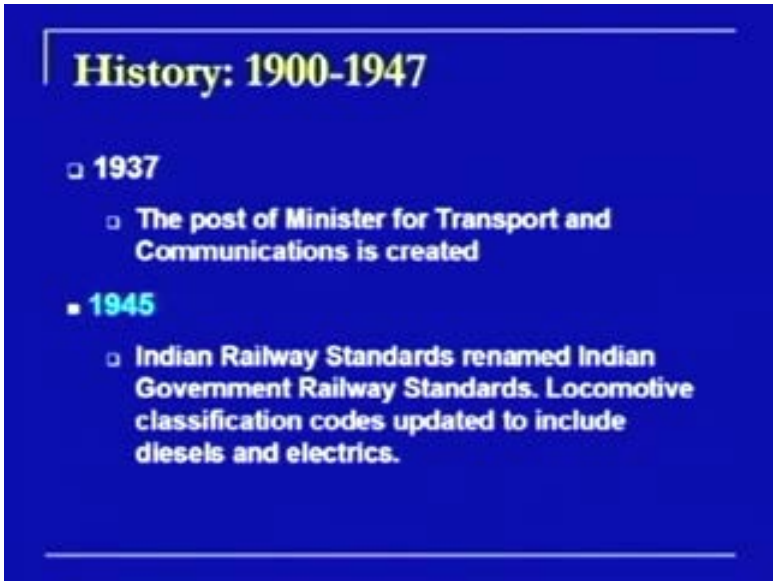

There was certain development in the area of research and other design aspects. They were in terms of RDSO. There was signal engineering in telecommunication which was established at Secunderabad, so as to impart training to the persons who are working in these areas. This is the one of the important areas where the total control of movements of trains are taking care of.

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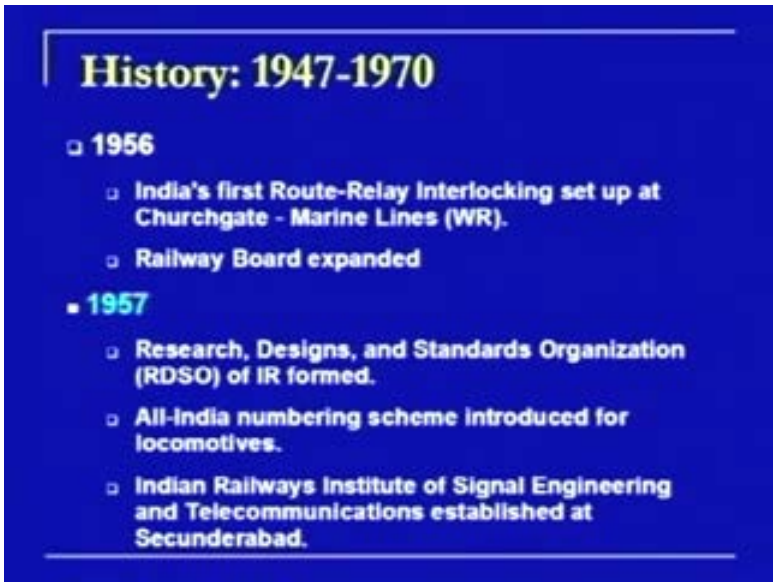

The permanent way training school was also set up. Then slowly and slowly some more facilities have been provided in the passenger coaches; they were in terms of the fans and lights. Chittaranjan locomotive works started producing electric locomotives and the loco works at Varanasi was also set up in 1961.

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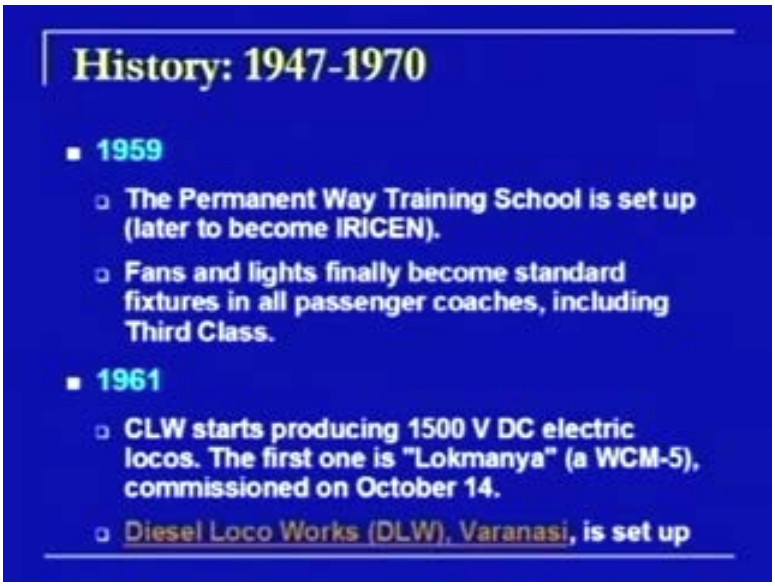

The Kunzru committee which investigated level crossing accidents; this is the one of the important safety aspects which is still creating problems in to the Indian railways. There were some more workshops which started manufacturing wagons. Then there was committee which investigated the benefits of electrification in 1963.

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Some more changes were made to the railway board. One change which was made in terms of vigilance; the first freight services was provided and containerized freight services were provided between Bombay and Ahmadabad and long welded rail was introduced in many areas. Illustrate that having the short rails having the length of 13 meters, now we started using rails which were having much more length as compared to this one that was done by the welding of different rail sections.

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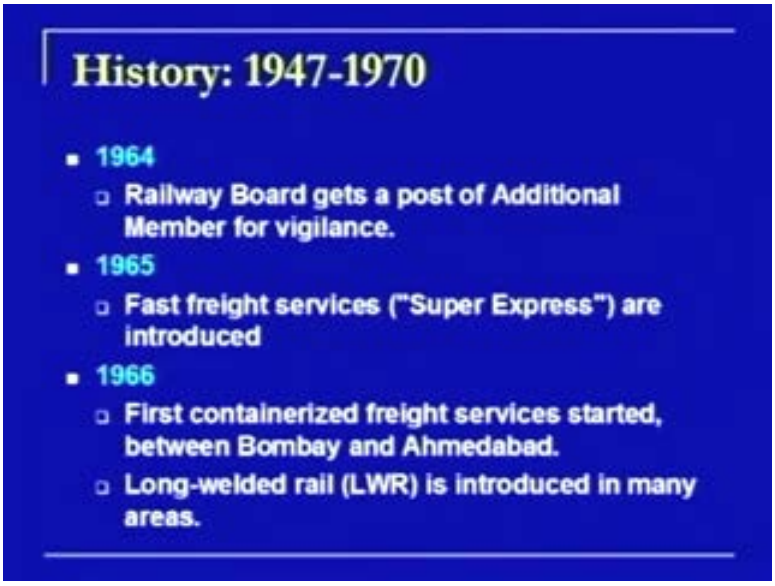

In 1969, the New Delhi Howrah Rajdhani express is started. It was having a maximum speed of 120 kilometers per hour.

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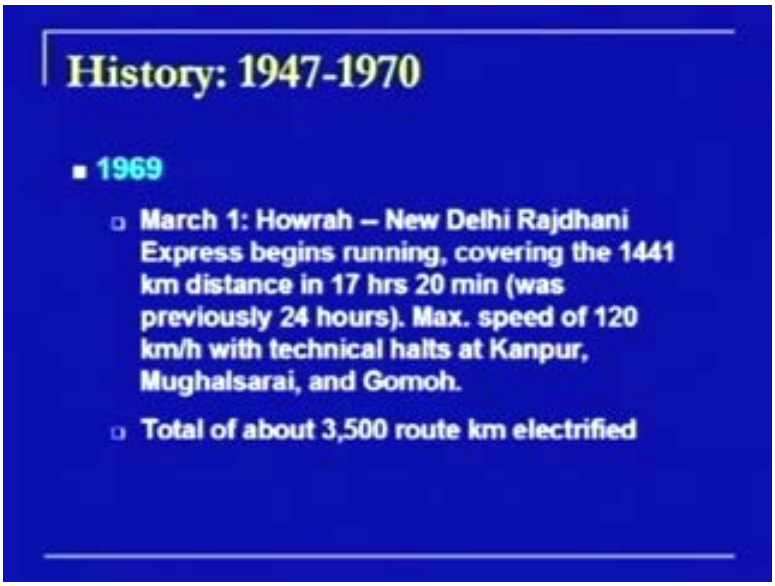

Then there was Farakka railway bridge which is one of the longest prestressed concrete bridges, it was opened. Calcutta metro started working; it was the construction phase which was started for this one. The Bombay Rajdhani also started its services and again there was modification in the railway board in 1972. RITES was formed for taking of the research and consultancy services in the area of not only on the Indian railways but others also, that was in the year 1974.

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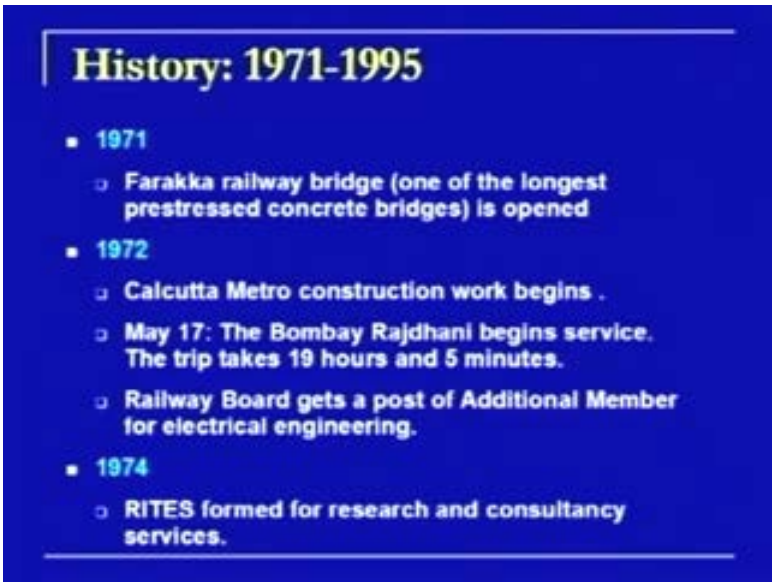

IRS standards for rails are also laid down. They are related to 52 kg per meter rail section of the broad gauge or 75 pounds per yards sections for meter gauge. Railway boards again gets modified into its member in terms of health electrification coaches reaches New Delhi making the New Delhi-Howrah route making the first trunk route which was completely electrified, that was the year 1976.

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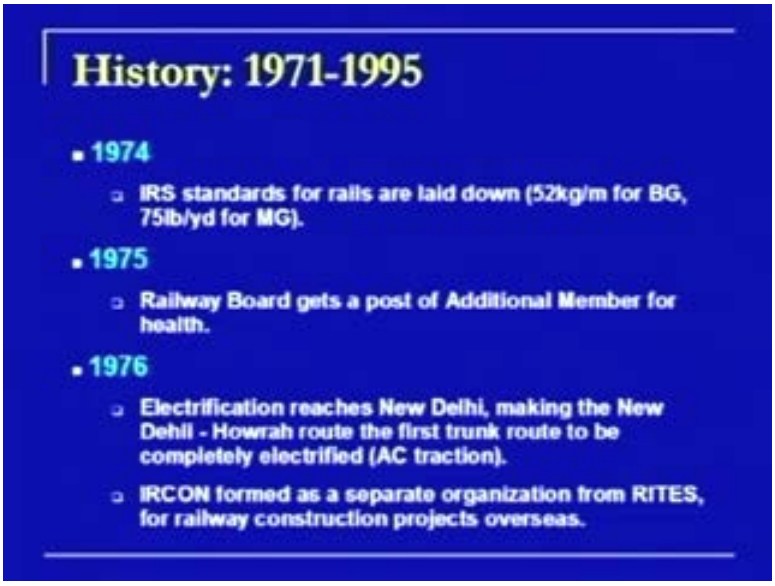

Complete sleepers came into use from 1977 onwards and now still we are using the complete sleepers. They have better qualities as we will be looking at these things when we take up the sleepers in detail. There were some more modification to the railway board and then there were the issue of economics of electrification because whether we should go to this one or to continue with the diesel locomotives or the steam locomotives, which are in use that time.

Another area, another thing which was set up was the central organization for railway electrification, that was core in 1979.

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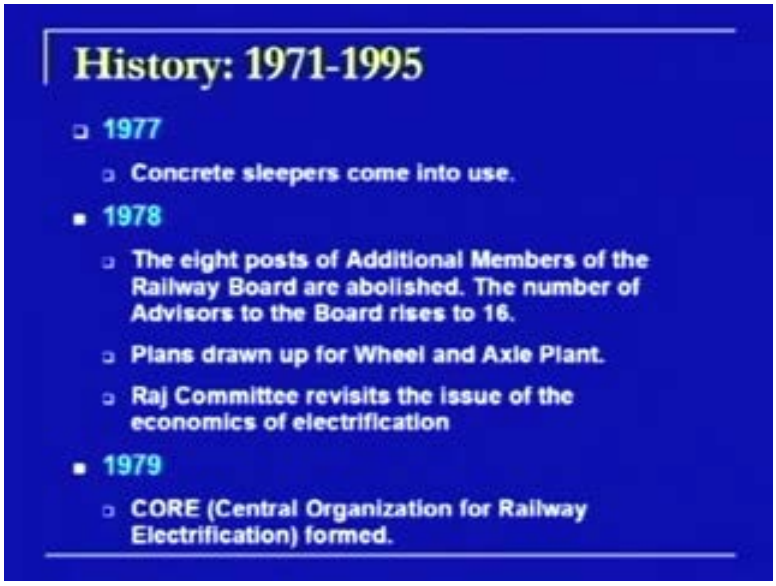

Then there was energy policy being defined. There were some changes in the case of southern railways. At Patiala, diesel component works was set up and first ISO was hauled by Indian railways. Then Indian railways also begin their studies in the area of telecommunication or IT as well as in the case of information management systems.

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The Wheels and Axle plant, Yelahanka, started its production in 1984. Railway reforms committee suggested that we should go for more creation of zones. So as to handle the operation of the train traffic more efficiently that was begin in 1984. Southern railways became the first zone to eliminate the broad gauge steam operations, that was in 1985.

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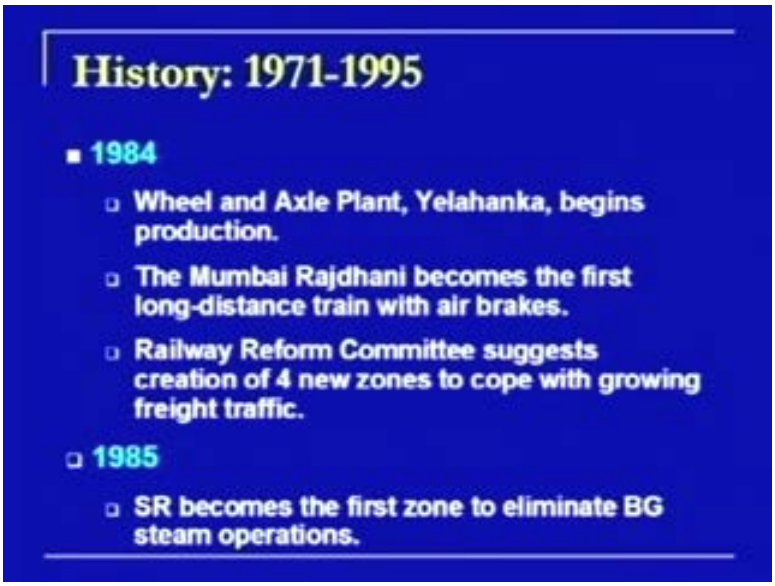

Then there was the telecom division of Indian railways which was named as IRCOT and that was founded in 1986. Ticketing system was made available from 1986 onwards. There was automatic signaling system, another safety aspect which was taken up and then the next safety aspect was in terms of solid state interlocking system which was made operational. The electrification was 7275 route kilometers in the year 1987.

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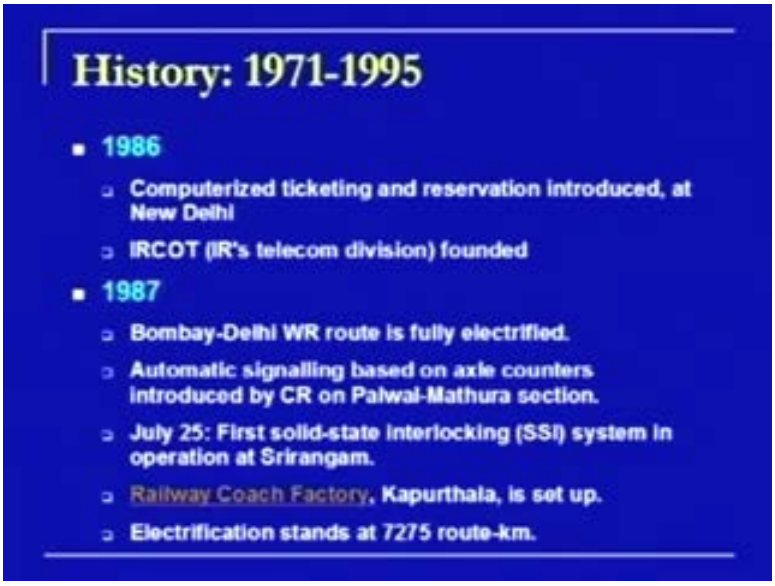

Further improvements in the area of passenger transportation took place, that was in 1988 when the first Shatabdi express was operated. There was also modification in the area of pre transportation in terms of the setting up of on car that is the Container Corporation of India. This was a big step in this direction. In 1989, the train services were made universal by adopting new four digit scheme as it is stands today. Railway act was enacted in 1989. It updated the legal frame work for railways in India and it replaced the previous one.

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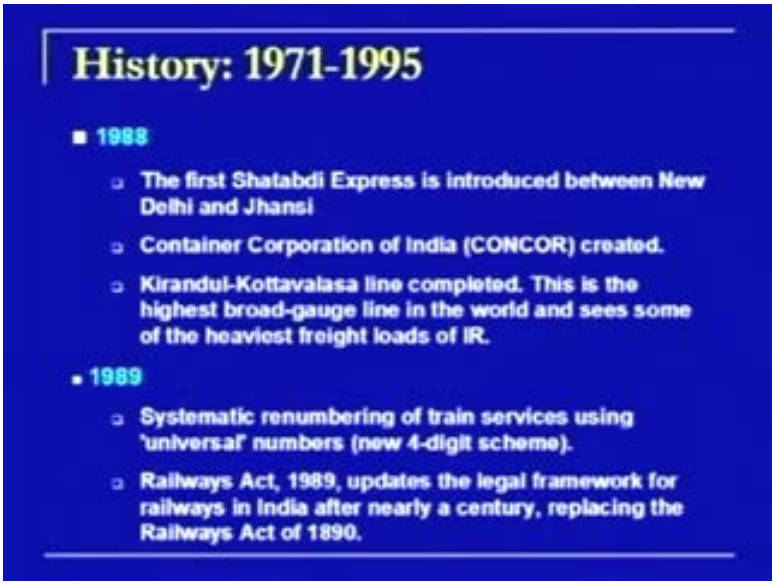

Then in 1990, the central railway route was made fully electrified. Further the ticket machine was self printing ticket machine; we consider they are introduced in New Delhi. Railway capital fund was established in 1993 and royal orient train was introduced by western railway in Gujarat in 1994.

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That was from the tourist point of view. In 1996 further there was a change in the zoning system and some more zones were created. The proposal of Delhi metro got approval from the union cabinet again in 1996. The services of the freight movement in Konkan railway, they started in 1997. This was again one of the biggest step which have taken place because this was the railway system which was made, which was having different

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types of dealing and of course by the provision of this railway line, we have reduced the distances, we have reduced the time frame in which we are reaching the different parts. One more safety aspect, which was there was radio communication between the driver and the guard conduct, was introduced in 1997.

In 1998, Konkan railway construction was completed. Then Indian railway begins its upgradation communication links along high traffic routes using the optic fibers in 1998. Further the new zone was created in 1999 and credit cards were started to be accepted for booking the tickets and reservations.

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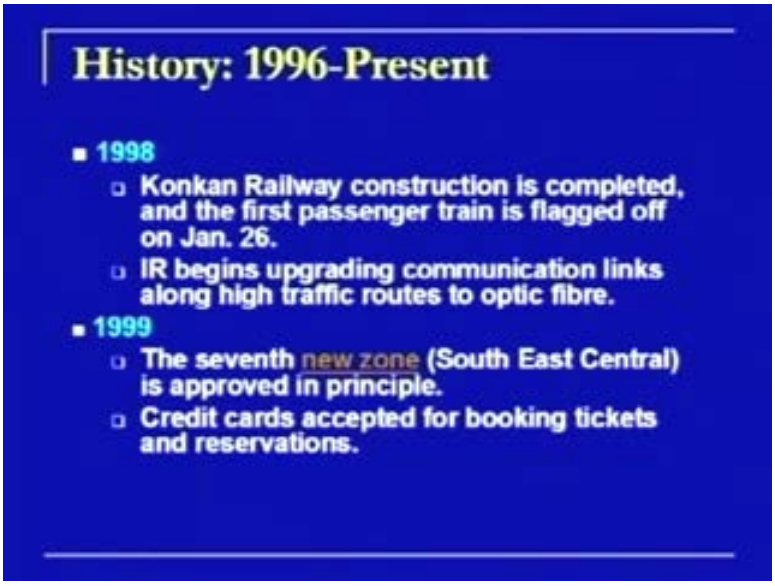

There were some more changes in the freight transportation. The Indian railways started their website and there was a Rakesh Mohan committee in 2001 which recommended the splitting the Indian railways into an operational body and a regulatory body, rationalization of the fares, closure of unprofitable lines and a corporate approach to finances, man power reduction and privatization. The Interactive Voice Response System, IVRS, this was made available from 2001 onwards by which we can meet telephonic inquiries about the trains.

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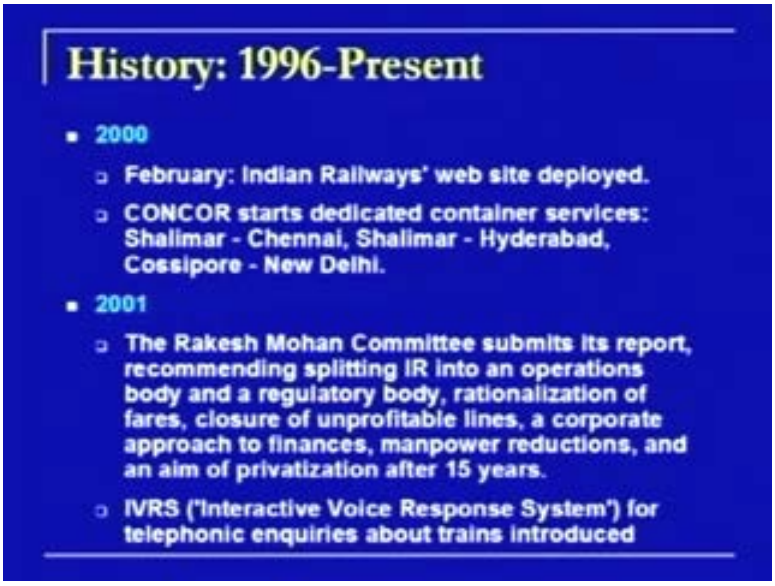

In 2002, another change in the passenger transportation came in the Indian railways, that was in form of provision of Jan Shatabdi trains which were made into force. This was the new type of the service which was provided for short distance commuting between the two major stations. It also changed its classification codes for diesel locomotives in 2002. Online train reservation and ticketing system over the internet was provided again from 2002 onwards. Konkan railway conducted a trial run of the Madgaon-Roha Express at 150 kilometers per hour, that was another mile stone in the area of Indian railways. Then there were some modifications in terms of the blends or the diesels which were used and there was five percent biodiesel blended fuel which was used for the first time in Indian railways in 2002, that was the Amritsar Shatabdi.

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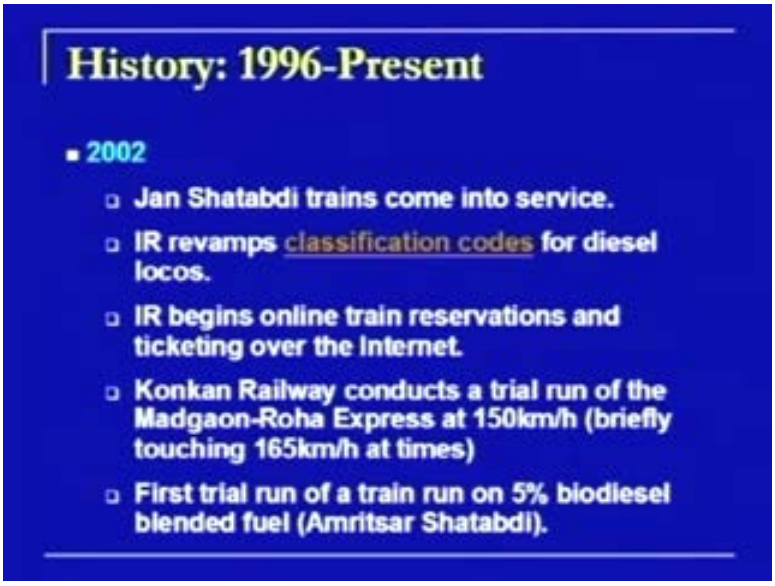

In 2004 the railway board expanded by the introduction of two more members, one for signaling and telecommunication and the other one for stores. First public trail of Konkan railways skybus project, this is skybus project is the project where we have some pillars being erected in the centre of the roadway for any other system and then from there we have the buses which move in the form of sort of a trolley. This was made to move and there was a demonstration project which was taken up in the initial condition where the vehicles move at the speed of 40 kilometers per hour for a distance of around 1 kilometer. First successful run of Delhi metro, the first underground section of the Delhi metro was inaugurated, that was between Delhi University and Kashmiri gate and this all took place in 2004.

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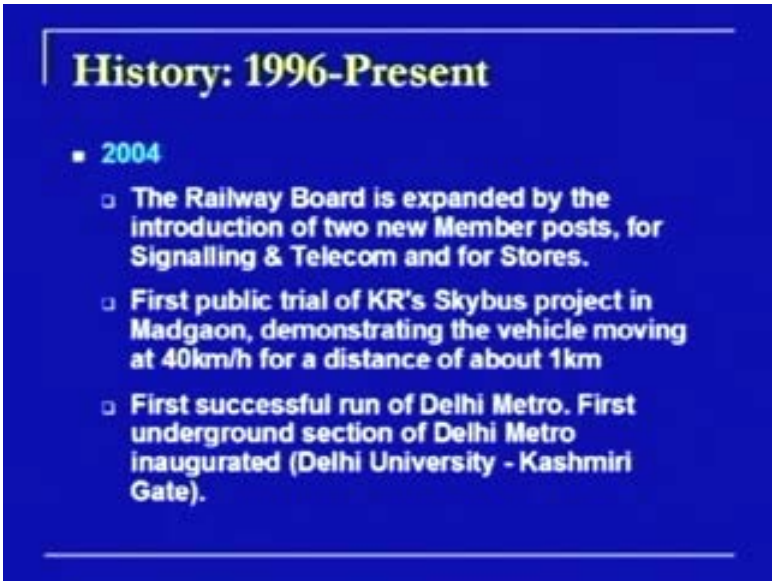

In 2005, this is another area where there has been a demand. The Jammu Tawi and Udhampur line section, as Udhampur line section reaches towards, it has the strategic importance and that is why there has been a demand for having this sort of a construction and it was not taken up previously. In 2005, Jammu Tawi- Udhampur line in Jammu and Kashmir was inaugurated. IRCTC introduced e-ticketing systems also by Indian railways and ticketing by SMS also begin in the year 2005.

2006 onwards what we found is that there is a New Delhi - Bhopal Shatabdi which was cleared for higher speeds , something like 150 kilometers per hour. That is the commercial speed, means they are allowed to move between New Delhi and Agra Cantt. stretched with this speed but for rest of the speed it was little lesser than this one, which was around 130, 135 kilometers per hour. The regular double stacked container services; they were started, so as to have, so as to move more containers, more trains in the same direction, this was in 2006.

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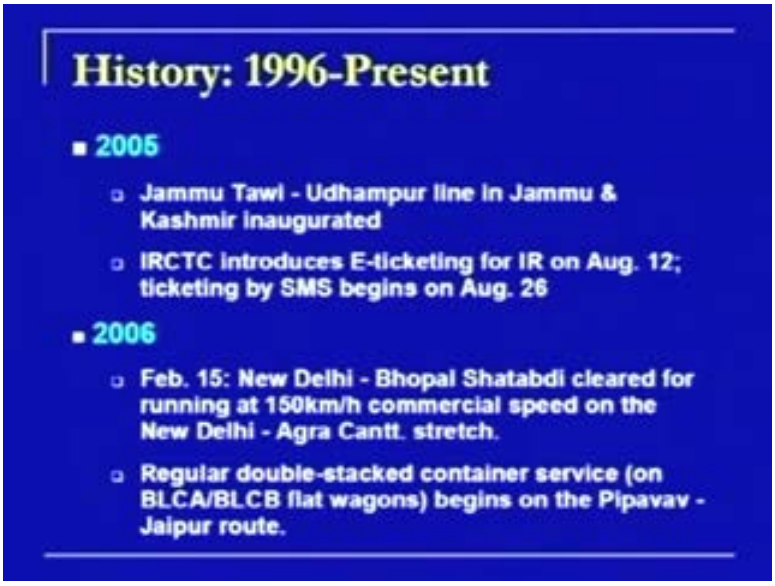

Now, we come to the salient features of the Indian railways. As on today, there is not been much difference in what is being shown here, which corresponds to that 2002 data. It is the railway covers around 63140 route kilometers. Out of these the broad gauge, meter gauge and narrow gauge which had been used in the Indian railways, they have different route kilometers and have been shown here. The Indian railways, today owns a fleet of number of wagons and the coaches and locomotives and they are managing to run 14444 trains daily and they are increasing with every year, and we have 8702 passenger trains. They carry more than a million tons of freight traffic and about 14 million passengers covering 6856 number of stations daily.

The railways are more energy efficient as compared to the other modes. They are 5 to 6 times more energy efficient in terms of the land use, they are 4 times more efficient and they have significant superior from the stand point of environment impact and safety. The degradation which is being caused because of the implementation of the railway system that is much less as compared to the other systems which are operated and at the same time safety aspects are also better because of the provision of the different kinds of the

control systems or operational systems which have been provided, as we have seen along with the history of the Indian railways.

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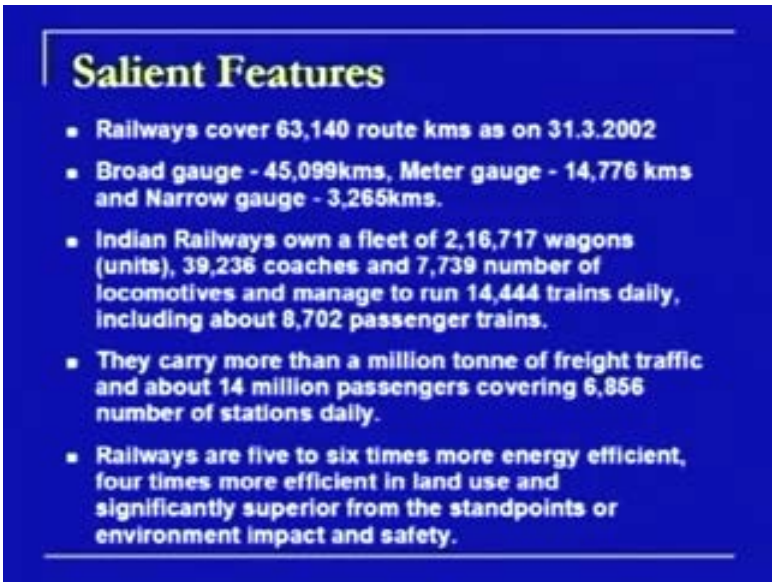

Some more features which are there for the Indian railways; they are, that they have the research designs and standards organization known as RDSO which is the one of the sole research and development wing of the Indian railways. This functions as a technical advisor and consultant to ministry or zonal railways and to the production units. The Indian railway system is being managed through the different zones and different operating divisions. We have 16 zones, 10 divisions and 6 production units which are engaged in manufacturing of rolling stock, wheels, axles other ancillary components to meet the requirements of the Indian railways.

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Now, we come to the different zone systems which have been adopted by the Indian railways. As we have seen previously that there has been a continuous change in the zoning system of the Indian railways and we based on the operational requirements or the administrative requirements we have been making these changes. In 2003, some new zones were created. They were east coast railway which was having it's headquarter at Bhubaneswar, the south western railway which was having it's headquarter at Hubli.

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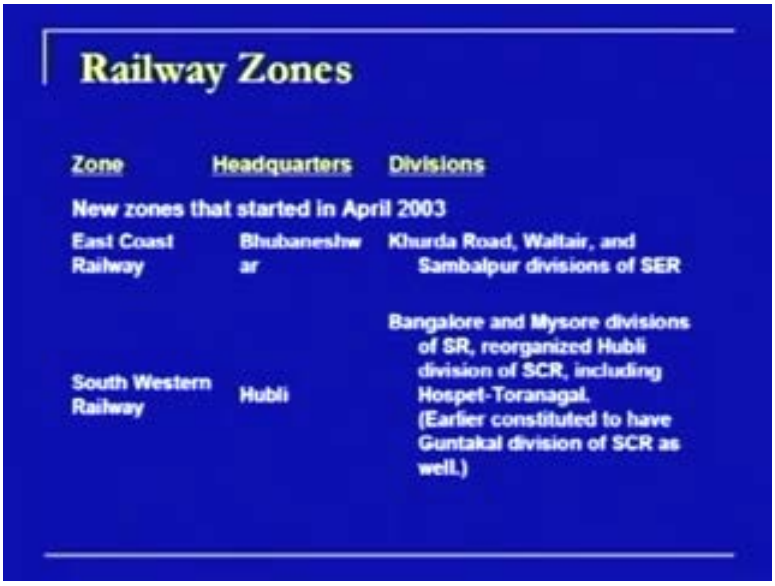

The west central railway with the head quarter at Jabalpur , the north central railway with the head quarter at Allahabad and the south east central railway with the head quarter at Bilaspur. The different sections or divisions which can come under the purview of all these zones, they have also been shown here.

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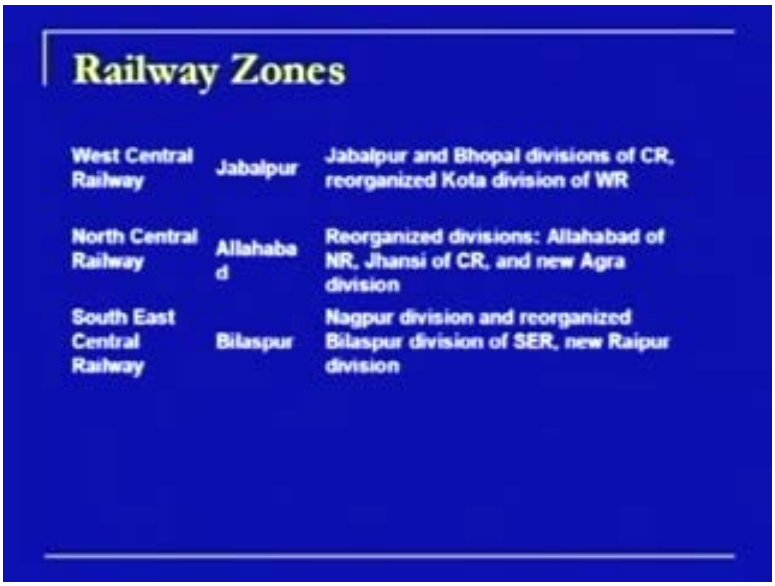

Then there were some zones which were created in 2002. These zones were north western railway zone with the headquarter at Jaipur, the east central railway zone which was held in head quarter at Hajipur. They were created by taking the different divisions or by creating the new divisions may be from the northern regions or the western regions in the case of north western railways or from the eastern regions or the central regions in the case of the east central railways.

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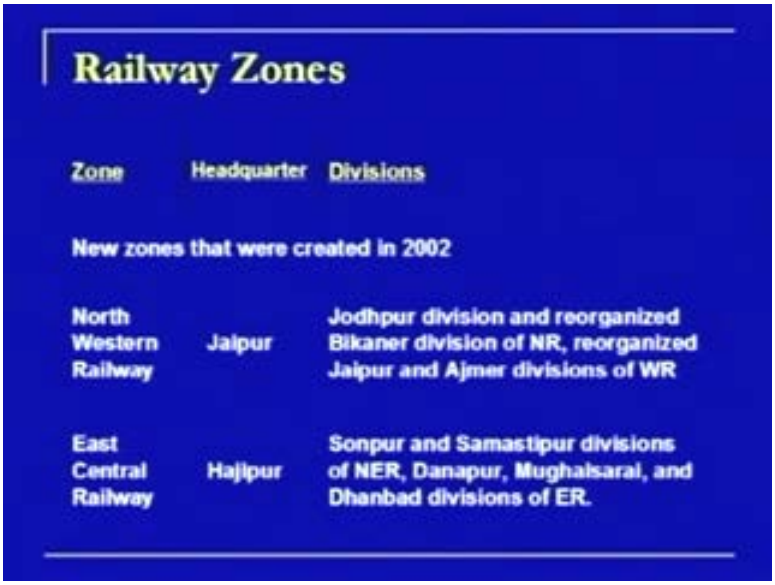

Old zones which were there modified because of the modification which has been made to the railway zones as being seen in the previous slides. They were the western railways, central railways, eastern railways and so on. Here, what we see is that the western railways which has having it's headquarter at Mumbai and are some modifications are made to its total divisions which were given the charge under the western railway. Similarly, in the case of central railway, they have their headquarter at Mumbai and again there was some change in the total divisions which have been provided to them for the operational point of view. Eastern railways having its headquarters at Kolkata.

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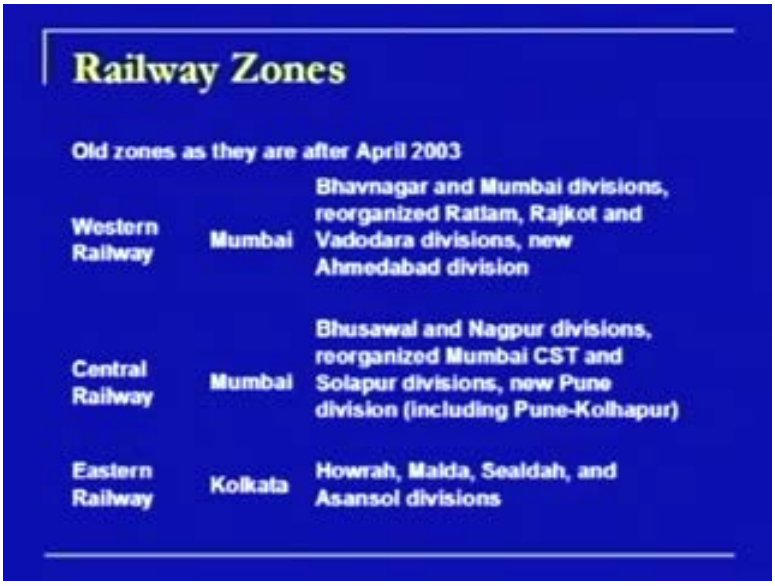

The southern railway is having its head quarters at Chennai and they have another division which was proposed and which was formed finally in 2006. That was the Salem division. Northern railway is having its headquarter at Delhi, the north eastern railway headquarter at Gorakhpur.

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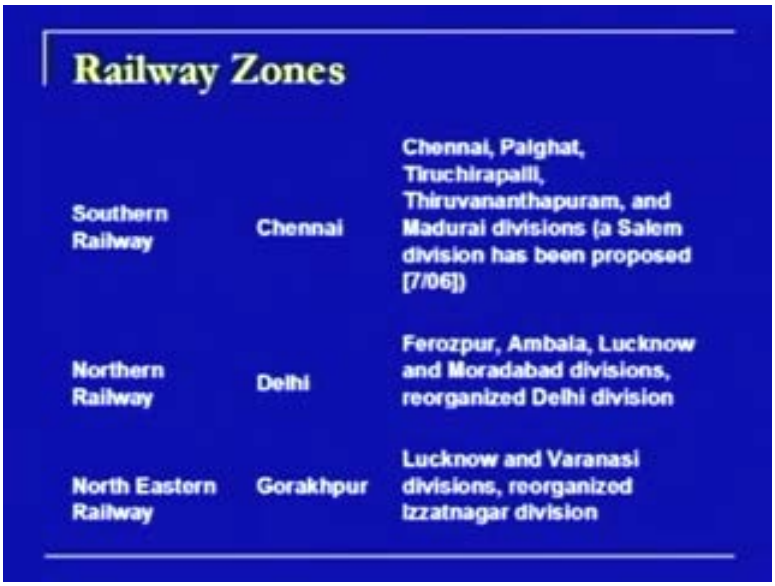

The south central railway is having its headquarter at Secunderabad, the south eastern railway having its headquarter at Kolkata and the north east frontier railway having its headquarters at Guwahati.

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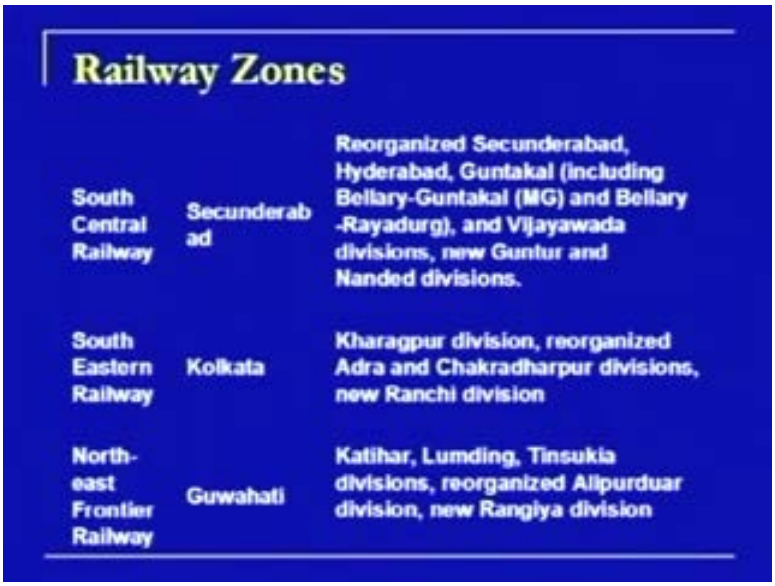

These are the zonal statistics which have been shown here with respect to the different rail zones. They show the total kilometers which have been operated by these zones and then there is a classification of these route kilometers in terms of the broad gauge kilometers, meter gauge kilometers and narrow gauge kilometers. Here, what we see is that the northern zone and western zone, they are having much higher route kilometers as compared to the other zone. In case of the broad gauge route kilometers, which are operated by these zones, what we see is that the northern zone is having very heavy broad gauge kilometers and this is followed closely by the southern, south eastern zone or the central zone.

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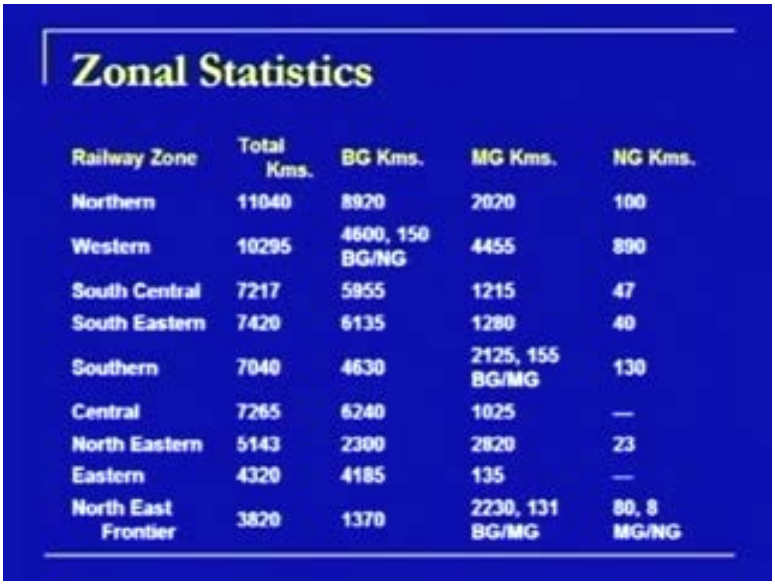

Here in this one, another statistics in terms of the route kilometer has been shown where the electrification of the track has been taken up. The running tracks have been shown in terms of the electrified tracks and net rutted tracks and the total track kilometers. They are the statistics being taken from the Indian railways and some of the statistics here; they include certain kilometers like in the case of track kilometers which have been shown at the end. They include the tracks which have been provided in the yards or in the sidings, crossings of the different stations.

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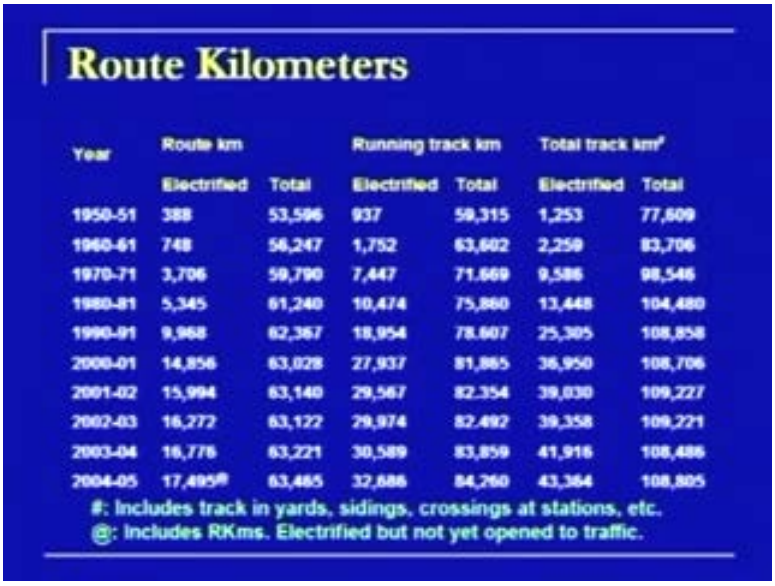

Now we come to the another important area as we listed for this introduction of the Indian railways, is that the comparison of the different modes. Here we try to look at the different characteristics which we can take up so as to compare the different modes across. One of the comparison which can be there is in terms of the cost of the provision of systems. When we look at the cost of provision of a system then it is in terms of cost of vehicles, the cost of the facilities, the fixed facilities which needs to be provided, the operation over those facilities and finally the maintenance of those facilities. Therefore, we have to look at the total cost component of all the summation of all these things which have been shown here.

Another aspect by which we have to compare the modes is the unit of transport. When we talk about the unit of transport then it had to be taken up in terms of the different units like the single unit, the multiple unit system or the continuous system. The single unit system is the system where only one unit is moving on which either passengers or the freight or the both , that is, the example which we can take is any truck or any bus or a private vehicle. In the case of the multiple unit, railways is the multiple unit system where we have different units being assembled together so as to move together. The

continuous system is the one where we have like pipe lines, conveyables where the things are moving in the continuous form. So in the case of the Indian railways, they have the multiple unit systems as compared to the other systems like for road transportation we have a single unit system.

Next point of comparison which is there is degree of freedom. Degree of freedom defines in how many directions vehicle can move. Now in most of the cases we are looking, we are just restricting ourselves to three degrees of freedom. In the x direction, in the y direction and the z direction. In the case of railways because the trains have to move on the track, therefore there is the restriction of the movements which is controlled by the provision of the tracks. If we compare it with respect to the road transport system, then in the case of road transport system the vehicles have the freedom to move in the transverse direction along with the longitudinal direction but that is not the case in the case of railways. Further, when we look at the air transportation system or we look at the water transportation system where the subsurface water transportation system can be taken. Then in that case what we see is that we have the three degree of freedoms which again is not in the case of the railways. So railways have a single degree of system freedom for its movement.

Next point of its comparison is dependability. Now how we define dependability is that whether the service can be used throughout the year and all the climatic conditions, in all the situations which will be there. In terms of this if we look at the railways, railways more or less provides you a more dependable services as compared to water transport system or as compared to the air transport system where they are much more dependent on weather conditions. When we compare it with the road transport systems, in the case of road transport system again, there is a problem with dependability but we found that they can be operated even in the case of the extreme power conditions with lower speed where in we have to at times suspend the services in the case of railways also.

Therefore, they have what we can say is that something like medium to better dependability as compared to the other modes, in the case of the railways. Another aspect of comparison is flexibility and adaptability. These are two things which are much important from the operational point of view. The flexibility can be talked off in two or three terms. We can talk in terms of the route flexibility, they can talk in terms of the vehicle flexibility and we can talk in terms of the time flexibility. The route flexibility is the case where we can take any of the routes at any point of the time. In the case of the railways, it is not possible to take different routes at any point of a time which are otherwise not there in the schedules. They are governed by the routes or the tracks which have been laid down. In the case of the time flexibility, again the scheduling is being done and this scheduling is dependent on the space scheduling aspect where a certain amount of distance needs to be maintained between the two trains which are moving on the same tracks in the same direction. Therefore, we have a very less amount of time flexibility in the case of the railways. They are predefined, prescheduled. Vehicle flexibility is also not there. In terms of the vehicle flexibility, what we see is that not the many types of the vehicles can be used on railways whereas if you compare it with respect to the road transport system, we have a large number of varieties of vehicles which can be used on roads. Adaptability is the case where we have to look at in terms of whether the system can be used in the extreme conditions like the gradients.

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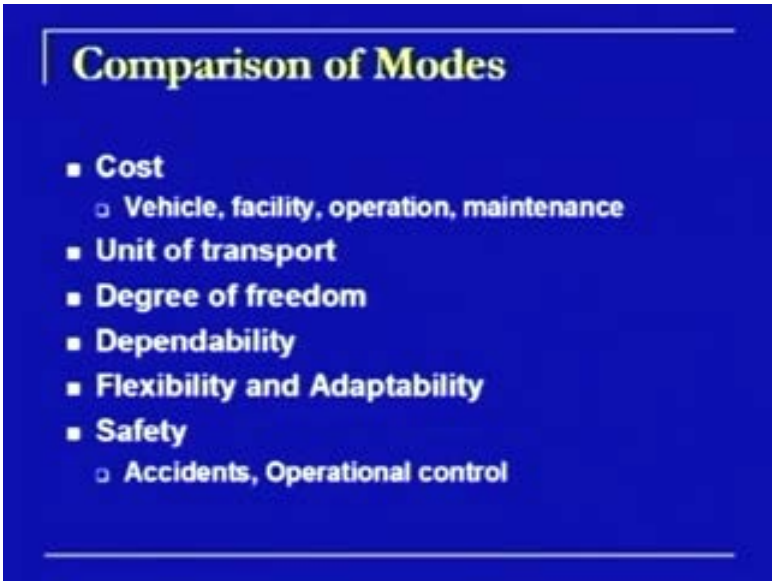

In the case of the gradients, we have stepper gradients where not the single locomotive contains the total load along with it. Therefore, we have to provide some safety measures or we have to provide more of the locomotives or we have to provide some other systems by which this transportation can take place. As steeper gradients, of course, can be traveled by the air transport system where we have different type of technologies available to us. That is not the case with the railways. One important aspect for comparison of the different modes is the safety. The safety of not only the vehicle but also the passengers or the freight which are to be transported. In the case of the safety, we can talk about two aspects in terms of accidents. One aspect relates to the total number of accidents which are taking place. Another one is the intensity of the accidents at which those are taking place. As far as total numbers of accidents taking place in Indian railways are concerned, they are not much but in terms of the intensity whenever a break accident takes place then there are various chances of survival or the total proportion of injuries or fatalities increases. That is not the case in the case of the road transportation. The reason is simple, that it is taking much of the load as compares to the road transportation where the vehicles are very small and therefore the total severity looks much less as compared to the railways, and in this case the operational control is one of the aspect by which we have to enhance the safety of the railways. We have seen in the

history of Indian railways that they were adapted from time to time, different safety measures starting from interlocking to vacuum breaks to the other systems. They are the operational controls.

One area where there is still a problem in the case of the Indian railways is the level crossings and they are trying to have better conditions, they are also more factors have been taken into consideration.

The next aspect of the comparison of different modes is the hauling distance, that is, the distance up to which we can transport the freight or the passengers. In general, the road transportation system can be used for shorter or short distance commuting at the maximum, for a minimum distance commuting whereas the railways can be used for the medium distance and the long distance commuting. If still the distance is a much more it is better to go for air transportation system. The water transportation system in this case can be taken up if the inlet water services or the ocean, the sea services are available to you. One aspect here is the speed or the total travel time which it takes from one point to the another point. Here as we see, as we have seen number of type systems are being utilized by Indian railways and there are still in the process of enhancing their speeds. They have touched the mark of 150 kilometers per hour in the case of Shatabdi and are looking for speed as high as 250 to 300 kilometers per hour on different sections for which the studies are going on and the works are suppose to start. As soon as these studies are over, so we will not be having the problem of the travel time and we will be moving at much faster speeds.

In this case the different technologies also have the role to play. What we see today that we have the choices of technology available to us. They are in the form of the air bubblesion systems or in the form of the magnetic levitation systems where in we can reach the speed of 500 kilometers per hour also. So that is why we are going to achieve much high speeds in the railways too. But that is not the case in the road transportation. The type of traffic of course and this case it can deal with the both type of traffic with the passenger traffic as well as the freight traffic. In the case of the road transportation again

it is dealing with the passenger as the freight traffic. Initially, it was observed that the amount of freight traffic was lesser in the road transportation which increased slowly and slowly as the services of the railways were not providing those better services, but again now what we see is there is a change in the proportions and there is a shift from road transportation to railway transportation.

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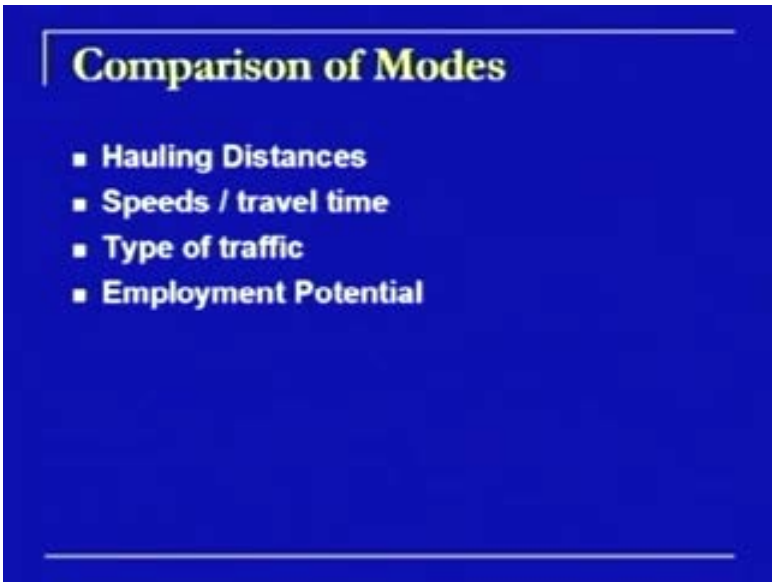

Employment potential is another area where we can have such comparison. In this case, we have to look at the system which provides the employment to more of the people. In the case of the Indian railways, it is providing employment to a much larger area. It is providing the employment in the area of construction, in the area of operation and in the area of management of the facilities. So that is why what we can say is that the railways are providing much better services and it is can be compared with the other modes.

Dear students, today in this lecture, we have introduced you to the railways and its specific aspects like history of Indian railways. We have also gone through the various comparisons of the different systems which can be there, ranging from the public systems to the intermediate system and private system or their combinations. We also looked at

the different zonings which have been created from time to time by the Indian railways. These zonings are created on the basis of the operational requirements and regulation and administrative requirements of Indian railways. In the last, we have compared the modes on the basis of the characteristics of different systems. Dear students, in the next series we will be moving with the other aspects of the railways. So we stop at this point. Thank you.