Introduction to Civil Engineering Profession

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Lecture – 14
Scope for Highway Engineers in Civil Engineering Profession

Good afternoon. So, what we are going to see the next 45 minutes are so is that, is there a Scope for Highway Engineers in a Civil Engineering Profession? I am aware of the fact that many of you would have chosen civil engineering out of compulsion; maybe somebody forced you to take the profession.

Either anyone who has chosen civil engineering as the first choice anyone? Good, there are at least 2 or 3 are there out of the 100, but nonetheless. I think you will look back and at the end of the talk you will understand the importance of civil engineer in the highway engineering profession. But by the by are you able to see any improvement in the quality of the roads in the country?

Student: No.

No, let me take you over what has happened over a period last 15 years or 20 years by now and then, you will realize what are the changes that, we have made in the profession.

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So, if you look back in 2001, this was the condition of the national highways.

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The condition of the national highways from this condition in 2001 has improved over a period of time.

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We look at the conditions of the highways what we realized from America is that; America is the rich because it has got better quality roads, not that America is rich and hence itself it got better quality roads.

The country's economy depends upon the quality of the roads. If you have good quality roads; that means, the country is prosperous. I think India is now learnt from USA, this is well known saying from John F Kennedy; that it is not the wealth that build the roads, but the roads that built our wealth.

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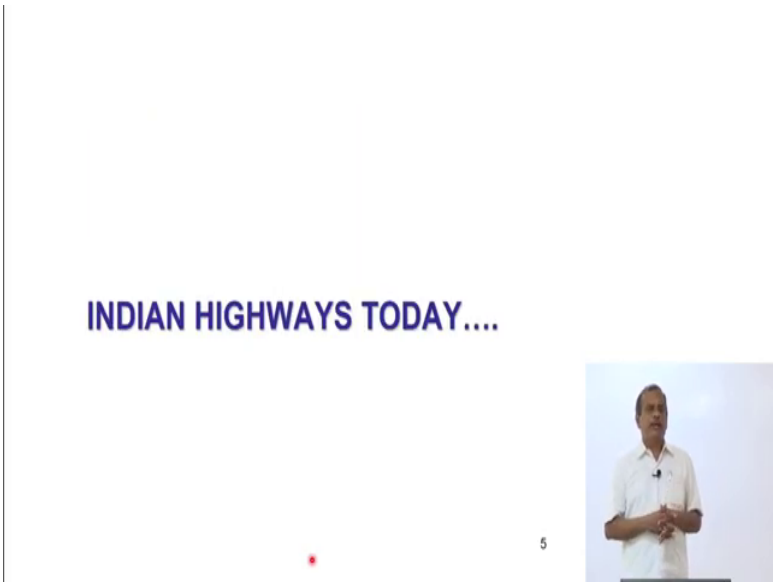

Indian highways today you said that, there is has not been any significant improvement in the quality of the roads; let me show some photographs of the roads today. The conditions are road which were very bad earlier has improved today.

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This is a classic example of the Mumbai-Pune expressway.

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We have other highways which are comparable to any other developed country of the world.

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We are able to see beautiful roads scenic roads in the country today is a classic example of the Yamuna expressway today.

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Having seen this, do you still believe that there is no improvement in the quality of the roads? Do you believe or do you think that there is an improvement in the quality of the roads? There has been improvement in the quality of the roads.

But what do you do not understand is that; what is the cost of constructing these highways, what are the design factors, what are the issues or challenges which a civil engineering civil engineering professional will face in the country during the construction, maintenance, operation of these highways. Let me take you over to the issues one by one.

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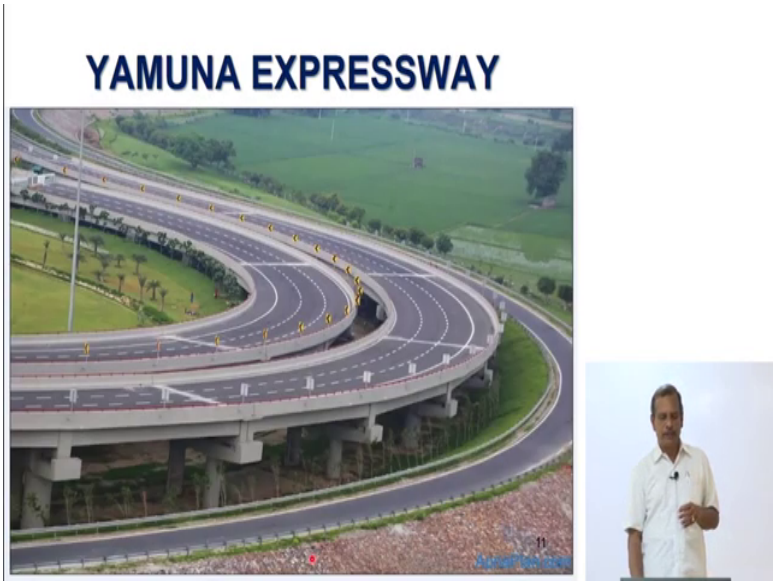

We look at the roads the country today this is Yamuna express way here; India has got the second largest road network in the world. They carry about 85 percent of the passenger traffic and about 70 percent of the freight traffic.

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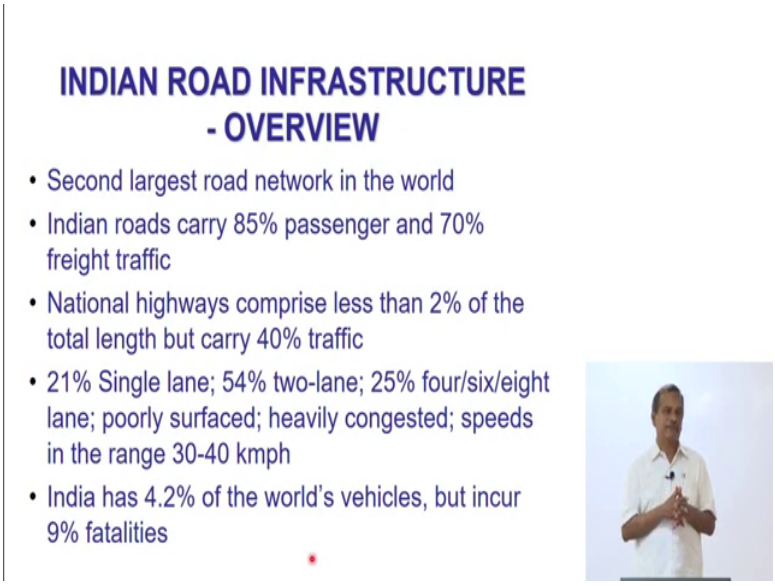

National highways is around 1 lakh and odd to a meter, I will come to the statistics which consists less than 2 percent of the country's road network carries 40 percent of the traffic.

Many of the highways are single lane, two lane; only a fraction of them are only four lane, six lane or eight lane highways. Many of them were poorly surface, highly congested, speeds are very low. If we go to any other developed country of the world, you will be able to travel at an average around 80 to 100 kilometers per hour; but in India we were able to travel only at the speed of around 30 to 40 kilometers per hour.

The other agony or the problem that we face in the country today is that, India has got nearly 4.2 percent of the world's vehicles; but contribute nearly about 9 to 10 percent of the fatalities. So, the question arises at this point of time; good quality roads, high speeds, more

fatalities; poor quality roads, less speed and less accidents, less fatalities. So, what is that you need; you need safety or you need faster movement of people and goods?

But as they are aware Indian traffic is heterogeneous in character. There are nearly 14 to 15 types of vehicles using the same carriageway. The speed difference between vehicles are more with the result there are several road crashes. So, the challenge before us is that, we cannot copy any standards from any other country developed country of the world to India; we need our own specifications, geometry design standards.

So, there come and moreover we our Indian drivers are not that well educated as other countries of the world. So, with the result we need to design forgiving highways. How to design a forgiving highway is a challenge before us.

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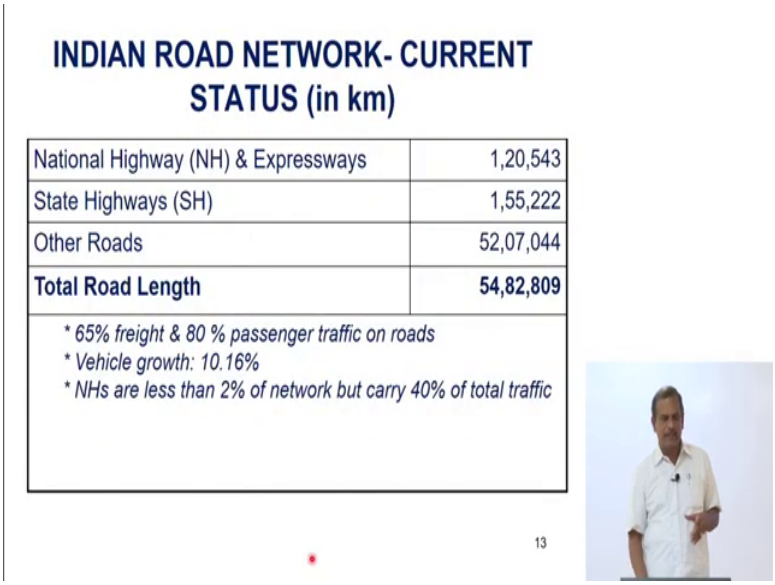

So, having said this about the quality of the roads here; in India we have nearly 120543 kilometer of national highways. If we talk about two lane, four lane, six lane they come under this category of 120543. State highways constitute nearly about 1.55 lakh kilometers.

So, the out of the 54 lakh kilometers or 5.4 million kilometer of road in the country, less than 2 kilometers are only national highways or state highways 3 lakh kilometers; the balance of 52 lakh kilometer or 5.2 million kilometer of roads are other roads, rural roads. So, the question arise at this point of time; when the volume of traffic using these highways are different, we have to design differently all these categories of roads.

So, out of the 54.82 lakh kilometers of road in the country, nearly about 65 percent of fright and 80 percent of passenger is carried on the roads and the vehicle growth is of the order of 10 to one point 10.16 percent. So, with the result, when the vehicles grow at the rate of around 10 percent per year; your single lane road will become a two lane road, your two lane road will become a four lane highway, four lane highway will become six lane and eight lane.

So, there is no stoppage of this growth of vehicles; which means, you have before you several highways which have to be converted from a single lane which is around 3.5 meter to two lane which is 7 meters, to a four lane to six lane and eight lane this will be the challenges that you will face in the years to come. The when you want to do this, what are the challenges and problems that you will face?

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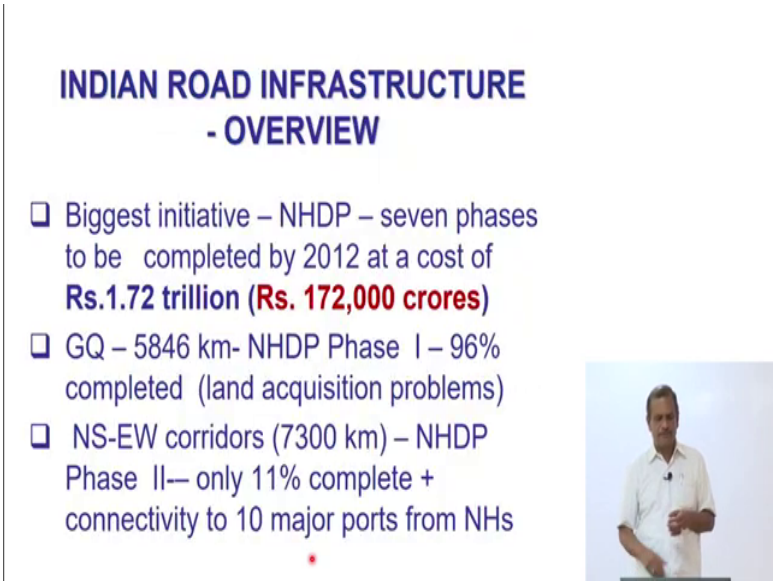

What you are done is that, since we learned that the country's economy depends upon the roads, we have taken several road building initiatives. The first one that we took up in the year 2003-2004 was that, the National Highway Development Program or NHDP. Under this NHDP there are about seven phases of this NHDP to be completed by 2012; but out of this a part we could complete, a majority we could not complete because of many many challenges and problems. I will come to the issues of challenges, risks problems that we faced.

But the investment of this NHDP or a National Highway Develop Program is other rock 1.72 trillion about 172000 crores; we can put zero and count the number of zeros. One of the costliest civil engineering infrastructure is a road. So, here this NHDP consists of two major components; one is called as the golden quadrilateral connecting Delhi, Mumbai, Bangalore, Chennai, Kolkata and Delhi. So, this is around 5846 kilometers called as NHDP phase I.

On the phase II we have the north south east west corridor called as a NSEW corridor, starting from Kashmir to Kanyakumari and from Porbandar to Silchar. So, this is a golden quadrilateral sorry, it is NSEW corridor connecting the north south and east west; this is a phase II of the NHDP program.

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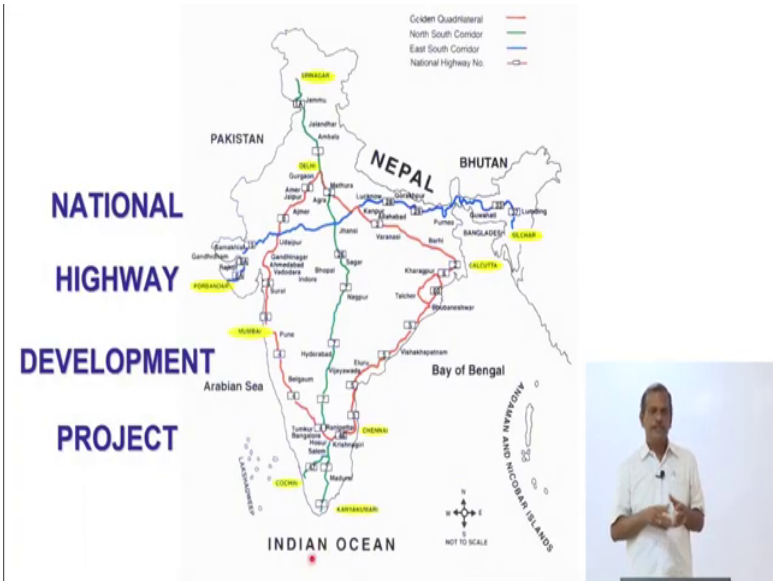

So, this is what you are able to see in this graph the NHDP program, where you are able to see the from Srinagar to Kanyakumari and from Porbandar to Silchar is a NSEW corridor. And we have the north south east west quadrilateral calling connecting Delhi, Mumbai, Bangalore, Chennai, Kolkata and back Delhi.

So, all these highways are either four lane or six lane or eight lane depending upon the volume of traffic. Understand at this point of time that, as the volume of traffic increases; you might have widen the carriageway from two lane to four lane to six lane.

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In addition we have it is one of the most ambitious road development program taken up by any country of the world. We have divided carriage ways, service roads wherever it is required, grade separators; we will talk about the grade separator subsequently.

Over bridges, under passes, by passes around the congested cities, wayside amenities also enhance safety features. When you have different types of vehicles operating at different speeds, safety ensuring safety for all this category of road is a real challenge. So, we want to

built in this design, the safety features as well. So, we can compare the Indian highways with any other country of the world they are comparable.

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So, under the NHDP phase III we taken up four laning of around 12109 kilometers of NH, the cost is around 80,626 crores.

NHDP phase IV is improvement of 20,000 kilometer of national highways; V is widening of the golden quadrilateral connecting Delhi, Mumbai, Chennai and Kolkata from four lane to six lane; phase VI is construction of 1000 kilometers of expressways.

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And are these projects VI and VII is construction of bypasses, ring roads, flyovers around 16680 crores; in addition the north east that got a special privilege of having an accelerated road development program.

The beauty of this is that, all this fine till about 2001; the design, construction, operate maintenance and operation of all these highways where taken up by the government of India. But in the real life is that, the government cannot afford to construct these highways. So, what do you that on the deep project under the NHDP is that, all these projects are taken up under the scheme called as a BOT, Build Operate and Transfer. So, we requires the concessioner you can bids for the projects; you can design, you can build, you can operate at end of the considering period which will be 20 years, 25 years, 30 years till transfer the asset back to the government.

The question arises at this point of time, why should you do this? Will anyone being interesting to take up the profession of designing, constructing and operating a road. If you have money you can construct a factory, you can do a business, you can run a medical college. But do if we have money, do you think that investing money on road construction will be a profit making business, yeah?

Student: (Refer Time: 11:27)

Will anyone take up the profession, yeah?

Student: Toll roads.

Toll roads, yes there I am coming exactly to the toll roads. The question arises at this point of time; people ask why should I pay a toll, I should pay a tax, should I pay a toll. Do you still feel that you should pay a toll? So, we use electricity we pay, we use water, we use a mobile phone you charge; but when you want to use a road, you do not wish to pay a toll. But the issue arises at this point of time; how much will it cost to construct a road? Why should a private sector invest his money for designing and constructing a road?

So, when the government was designing the highway and operate requesting the contractor to build; the risk after perform of the road rest are with a government, because they were design the highway, but they would blaming the contractor for the bad quality road. On the other hand, if you ask the contractor or a concessioner will you find will maintain, operate and transfer; the risk is being transferred from the government to the private concessioner.

By the by when you try to do this project, will it be a profit making business? How much is the profit one can get is the question that will arise in your mind.

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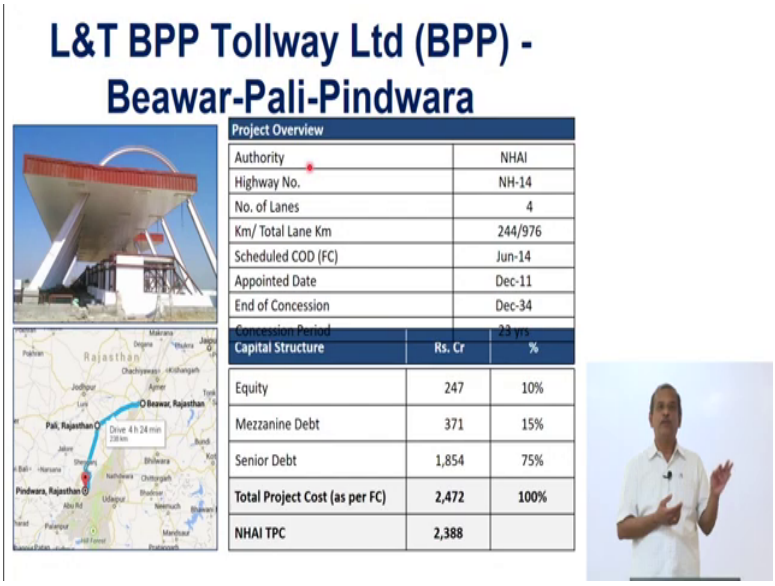

What are the NHDP projects? To give an example of how much their road roadway will cost. Let us take a example of a road project taken up by L and T, IDPL infrastructure development project limiter; this road is a Beawer-Pali-Pindwara toll way limited, every highway under the build operate transfer is given to a road company. The road company has got the board of directors, they collect the road, they operate, they maintain, at the end they will transfer.

So, this highway is around 240 kilometers, 240 kilometers; the total project cost of this is 2472 crores. On an average the cost of the constructing this highway a for a four lane highway of 240 kilometers is around 2472 crores; which means, the cost of constructing 1 kilometer of a four lane highway is around 10 crores. Now you know that we now 125000 kilometers of highways.

Actually that I want to convert them into four lane and six lane, you can work out what will be the amount that we require for constructing these highways. So, up to certain some point of time when I have money of 2472 crores in the pockets; I can you can put it deposit in a bank and I can get a 10 percent interest 17 percent interest may I get. So, but do you think that investing this money in a road sector will get you a higher return than do a business or investing in the bank (Refer Slide Time: 14:31) from you. Let me take you to have over what are the issues and concern when you want to design and constructing the highways.

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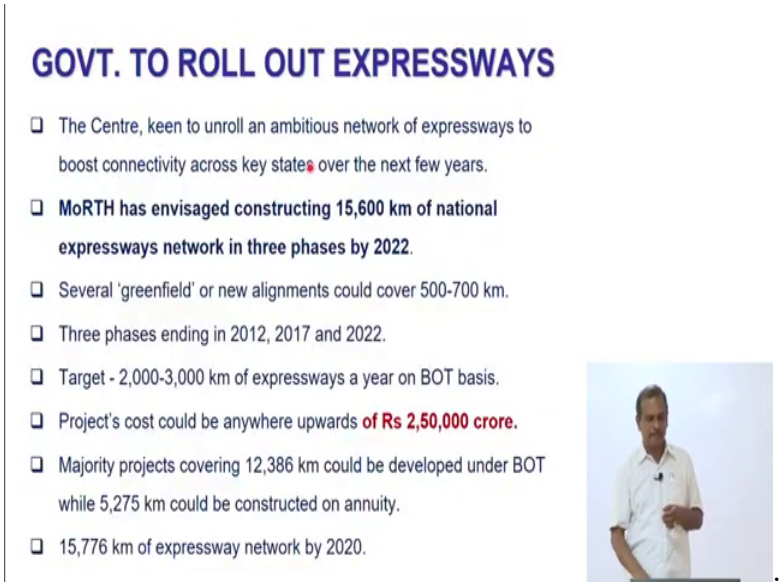

In addition to this NHDP projects what the government has realized is that, it is time that we construct more and more kilometers of expressways. So, these expressways will have, we want to construct nearly 15600 kilometer of expressways national highway expressway

network by 2022, we have just started. So, this is a huge potential for all of you; you will find more lengths of highways being converted or being constructed as a new expressway.

But this project of the 15600 kilometers of express ways, will cost nearly 2,50,000 crores; you can divide by the 15600 to know how much will it cost to construct 1 kilometer of an expressing way. So, we will get back later, these express ways can be constructed as a greenfield expressway or can be constructed as a brownfield express way. Green field is one where the alignment is new; green field is one where we will convert an NHDP into an express way. Your four lane existing highway will be converted into an express way.

But the design speed on all this highways express ways will be 3.6 meters will be the lane width of each lane; it will be four lane, six lane, six lane express ways. So, you will see more and more lengths of expressways in the years to come; so designing these expressways, catering to different vehicles operating at different speeds.

So, this will be the challenge from you. So, we will have a nearly around 16000 kilometer right express ways in the years to come.

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So, if I want this highways to be constructed by the concessioner, what that you need? The government thought over the issues and concerns what they found is that; in this as highway construction 100 percent foreign direct investment is possible. Secondly, government had carries out all the preparatory works; the land is given free of charge, you need not buy the land. Your job is only design, construction, operation and maintenance.

The government does all the preparatory work for you to design and construct the highway. The NHDP provides capital grants of 40 percent; which means, if 1000 crores is a project 400 crores will be given by the government. So, your tax loan liability will only be 600 crores. So, you have to work out, will I get this money back in terms of from toll revenue. It is Beawer-Pali-Pindwara which I just made a mention; the toll revenue is order of around 1 crore per day, then the toll revenue is of around 6300 plus crores every year.

When you get that money out of 2004 crores as a loan, how much can I pay repay back in terms of the principal, interest; how much money do I require for operation maintenance is the challenge before us. In addition the government also permits here, yeah housing real estate development, duty free import of a equipment machinery that you require. So, government has framed a structure in which private concessioner can take road building, as a business as a profit making business. As I mentioned these projects are under the Design, Build, Operate and Transfer DBOT projects.

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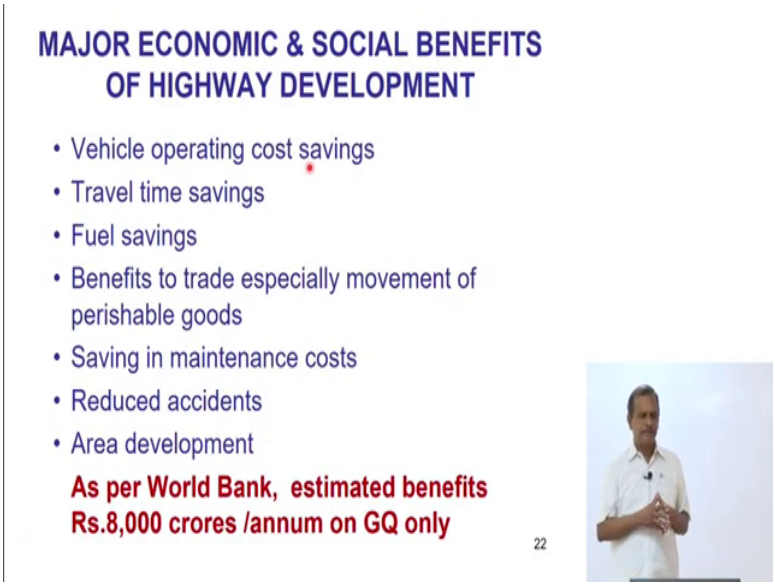

So, these projects there are many economic benefits. So, why should I do this? What are the benefits with the government can I get which road user will get? As a road user the question arises at this point of time; why should I pay a toll? Any can anyone tell us why do you pay a

toll? Not do not say that, I want to use the toll; but question is why do you pay a toll, anyone, yeah?

Student: (Refer Slide Time: 18:38).

That is by moderation, but why do you pay a toll?

Student: (Refer Slide Time: 18:47)

I ask, the question arise at this point of time how much will you pay? Assume that you have to travel 100 kilometers of travel, how much will you pay? Yes can anyone tell me if you travel 100 kilometers how much will you pay? No how much you will pay. Ok you tell for a car, car; two wheelers do not pay. So, that is how the question of two wheeler paying toll does not arise, yeah.

Student: (Refer Slide Time: 19:19)

I am telling 100 kilometers.

Student: (Refer Slide Time: 19:23)

100 kilometers of travel you have to make.

Student: (Refer Slide Time: 19:29).

For a car.

Student: Car.

Yeah.

Student: 65.

65 right. So, if you pay 65 rupees per day, per lane for travel, you should be able to work out will I get back the revenue which I want. What is that will balance between; the question next question arises why do you pay 65, what the basis for the 65?

We look at the why you think in terms of paying 65 rupees is because you save money in terms of vehicle operating cost, two times the road is safer. So, you feel that paying 65 rupees is a reasonable, right. So, issue arises at the benefit of road user in terms of savings in vehicle operating costs, savings in travel time, fuel savings, benefit to trade in terms of movement of perishable goods; the same bus will be able to take make 2 or 3 turnarounds. Same lorry which will travels around 40 kilometers per day will be able to travel 1000 kilometers per day today because of better quality roads. So, the fleet is being better utilized; there is savings and maintenance costs, road becomes more safer because of safety appurtenances, area gets overall developed.

So, from the golden quadrilateral alone, we found the benefits are of the around 8,000 crores annually from one golden quadrilateral. Now you can imagine the benefit to the society as a whole, when we convert this NHDP as well as other highway projects. So, there is significant improvement of society, society will benefit by constructing these highways.

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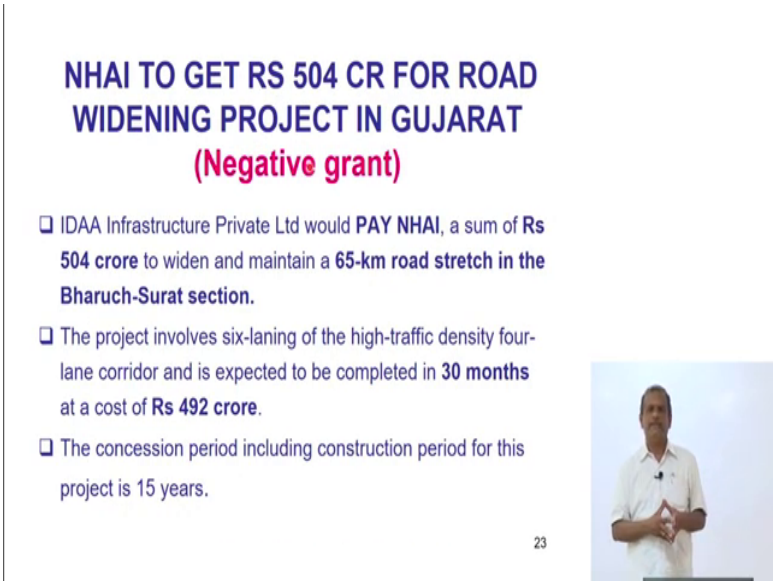

Other issue is that, how I have been paying so far is about a project phase of a DBOT project, where they Design, Build, Operate and Transfer; where I said the government makes all preparatory works, give the land free of cost and you should only collect the toll for 20 years or 30 years. There are projects which will get you a higher returns with the result be the concessioner are willing to share their profit with the government.

So, these projects are called as a negative grant projects. A classy example is a project of a widening project in Gujarat is a Bharuch-Surat section 65 kilometers. The concessioners IDAA infrastructure has said that, the project cost is 492 crores; they say that they will pay back to NHAI National Highway Authority of India a sum of 504 crores. So, the in a nutshell, road building is a profit making business. Many cases it can be a win situation, the government

also gets money in terms of negative grant by avoiding the work to a concessions; it not only the concessional who makes money, the government also makes money.

So, this money I can use it elsewhere. I will tell us where to use this money elsewhere. So, in a nutshell, road construction, road building, operation, maintenance is a profit making business.

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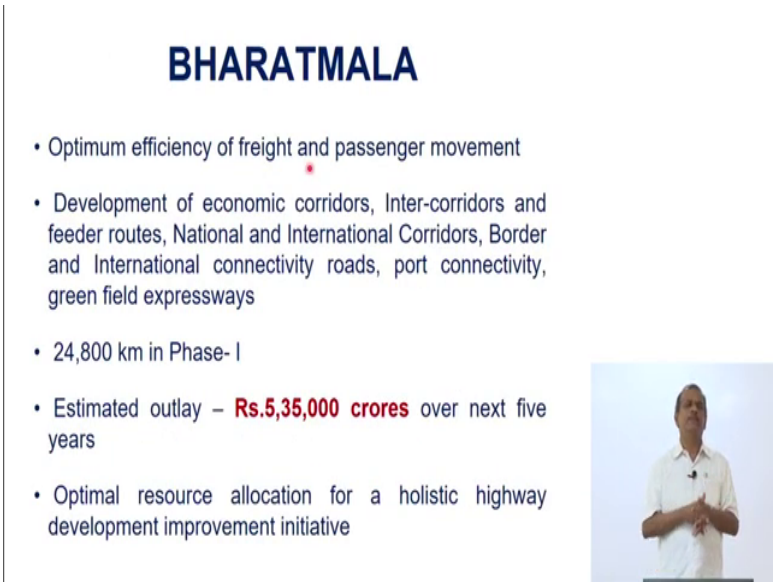

When you go further to the projects which are taken up currently today in the country today, the major project that we are taken up in the country is a Bharathmala project; wherein we thought about optimal movement of freight and passenger. We want to develop economic corridors, inter corridors, feeder routes, we want to connect more districts, ports are to be connected, greenfield expressways are to be constructed.

So, this Bharathmala project consists of 24800 kilometers in phase I and estimated outlay is 535000 crores for the next five years this is where your challenge lies. When you graduate from here, you can be a concessioner, you can be a contractor, you can be a businessman taking up Bharathmala projects. So, there is an out the issue is that, how should the resources be optimally utilized?

The major challenge that we face in the country today is, how to optimally utilize the resources that are available? Number one in terms of money, number 2 in terms of materials, number 3 in terms of manpower how do you do that? I think the end of the four year program that, you study here, you should be able to design, construct, operate and maintain the highway facilities.

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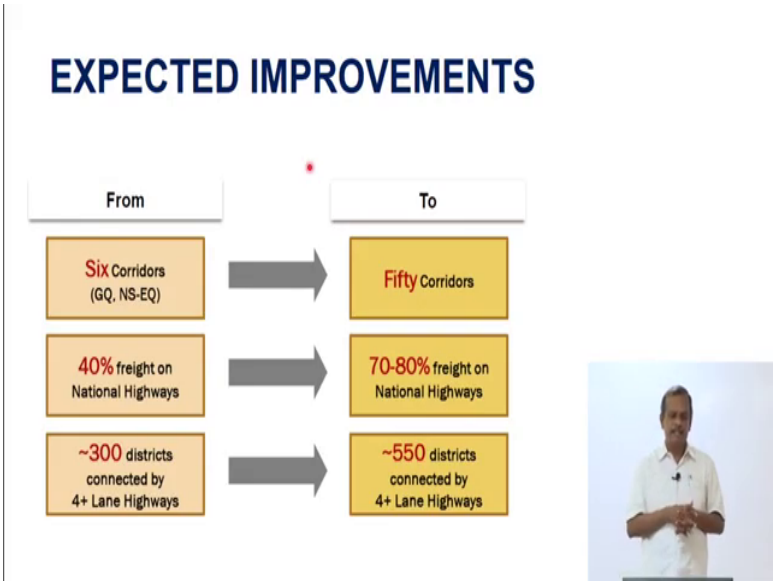

So, when you look at these projects Bharathmala projects earlier in the NHDP we had only six corridors; now that golden quadrilateral, north south east west corridors.

This will go from six corridors to fifty corridors by the end of the Bharathmala program. We have only 40 percent of the freight was carried by the national highways, this is expected to go from 70 to 80 percent. Thirdly only 300 districts are covered by the NHDP projects. Now more than 550 districts will be covered under the Bharathmala program. So, with a result the quality of the roads will improve, more districts will it have an expressways and highways connected through a better quality roads.

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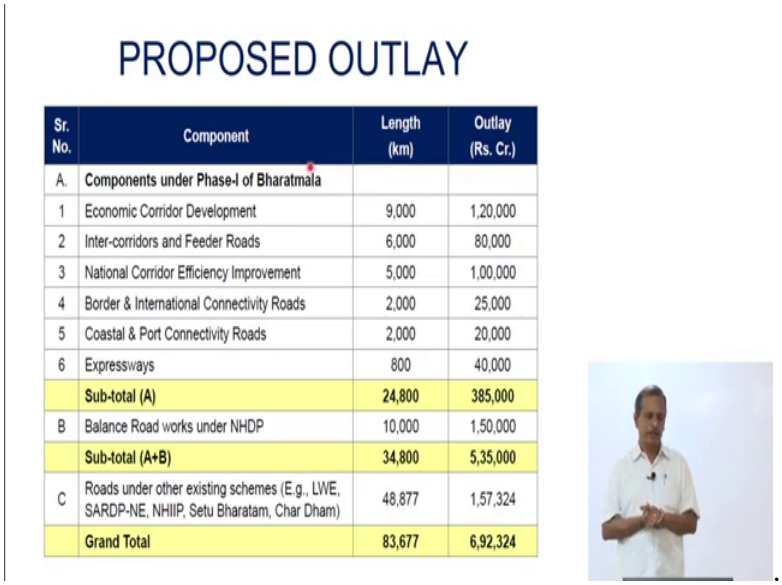

The outlay as it can be seen is an economic corridor development will have inter corridors, speeder roads which will connect to this Bharatmala program; National Corridor Efficiency Program, border roads, internationally connectivity roads, port connectivity, express ways. So,

all this will be taken up around 83677 kilometers will be taken up at a cost of nearly 7 lakh crores.

So, one of the huge investment of a civil engineering infrastructure is on designing and constructing these highways and expressways, that is what you should understand at the first point of time.

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Living along with the expressways; when it come to the next we talk about state highways. So, we need a system of hierarchy of roads; we have the village roads, we have the district roads, we have the state highways, we have national highways, we have express ways. So, that the hierarchy of roads in the country today.

Nearly 5000 kilometers of state highways need upgradation; from four lane to six lane or even two lane to four lane, so these have got a significant impact. But many of the projects of the state highways are taken up by funding from the international funding agencies like World Bank, Asian development bank; many other international agencies are coming forward to fund these NHDP projects.

So, we also taken up private sector participation, through private sector participation consist of many improvement of these state highways from two single lane to two lane, two lane to four lane they are being taken up depending upon the demand.

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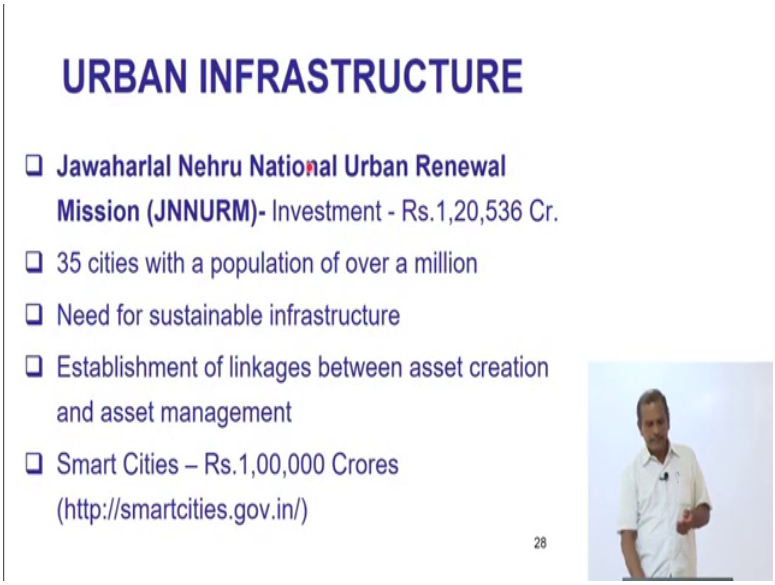

Other than that is urban infrastructure; one is express ways, we talked about national highways, we talk over state highway come to the urban roads.

So, we had a program called as a Jawaharlal Nehru National Urban Renewal Mission investment of rather of 120,000 crores; wherein be what would connect a improve 35 cities with a population of over a million. We need a sustainable developments, we need to linkage between the asset creation, asset management. On one hand the issue that you should understand or remember is that, creating an asset is not immediate issue; maintaining and preserving this asset is a major challenge, you need money, you need resources.

I will come to the issue of how this resources can be managed. So, in addition we also have a smart cities project. So, you can go to the smart cities dot government dot in, you will get more and more details about smart cities that we have identified; the improvement that we are going to take a improvement that will be take place in these cities, so that will have world class cities in the country in the years to come.

So, huge investment is being made for the construction of urban express ways or improvement of movement of people in urban areas.

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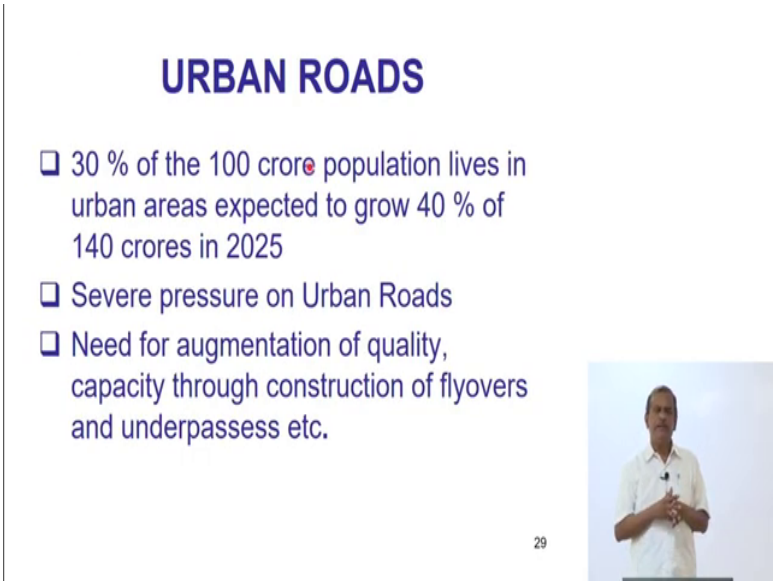

We found that only 30 percent of the 100 crore population lived in urban areas; but now more than 40 percent of the 140 crore populate by 2025 will live in urban areas. So, that will bring in will be a pressure on the urban roads. With a result more congestion, more delay, more accidents, with iron you will be invited to construct more and more flyovers, under passes, interchanges, bypasses, new roads, circular roads. A classy example as how the vehicle growth has impeded the movement of people and goods is can be seen from Bangalore.

You will be able to travel maybe around 30 to 40 kilometer per hour maybe to 10 years back. Today the average speed of travel is not more than 10 kilometer per hour. If you want to travel one 15 kilometer, you are taking one and half one and half hours. So, you have vehicles, you have road; but you are not able to move. So, what is the solution that you can think of, is a challenge before us. So, the urban road, urban infrastructure improvement is a major third

major challenge that we will says, apart from expressways and NHDP state highways and urban roads.

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The fourth issue that comes before you is constructing up other roads outer ring roads; to give an example of how much we have spent for the outer ring road for Chennai. The outer ring road is around 30 kilometers, you can go around, Chennai if you want to go around the Chennai in the outer ring road you can try this outer ring road from Vandalur to Nemilichery.

The investment of this 30 kilometers around thousand crores; which means the cost of constructing each kilometer of this outer ring road is more than 30 crores. One if you want to construct this outer ring road, you need money; but more importantly we require materials. The challenge before you as a civil engineer is non availability of the materials or construction. I will come to that issue now.

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Apart from these NHDP projects, expressways, state highways, urban roads; as I mentioned in the beginning nearly 52 lakh kilometers of road in the country are rural roads. In maybe about 20 years back we flooded this rural road program called as a Pradhan Mantri gram Sadak Yojana, PMGSY.

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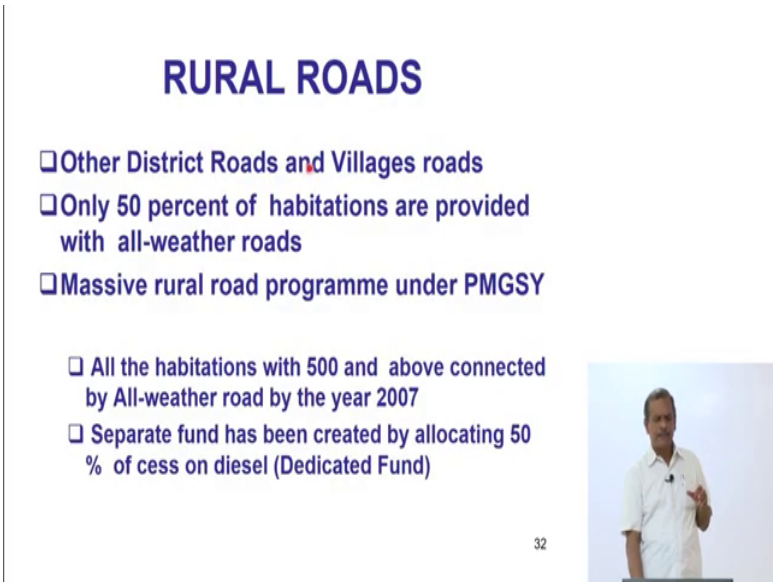

Under this PMGSY program, we wanted connect initially we want to provide an all weather road to all villages with a population of 1000; all weather means motorable all through the year. So, initially we want to connect all villages with a population of 1000 with an all weather road, we connected all villages. Then we took up the next phase to connect all villages with a population of 500, we connected all villages with a population of 500 in the country today. We have move forever.

All villages of populated 250 will be connected with an all-weather road; we are in the process of connecting all villages with the population of 250 with an all-weather road. So, separate fund has been created for the this road program. You should remember at this point of time, there are two components of payment of tax to the government; one is that tax conversional

tax which you pay when you buy every liter of petrol or diesel, but the issue is that when you pay a tax, that tax money can be used for any purpose by the government.

For example for defense, for education, or healthcare, you may pay a road tax, where the road tax can be used for any other component; whereas if you pay the money in terms of cess, the money has to be utilized only for the purpose for which it is collected. So, on every liter of petrol and diesel that you consume, you are paying 2 rupees as the cess; 1 rupee is earmarked for NHDP, 1 rupee is earmarked for rural roads.

So, dedicated fund is available. So, funding the rural road is not an issue number one; number two private sector will not come forward to construct rural roads, there is no question of tolling the rural road, nobody will pay a toll. If that is the case, who will construct the road? So, the connectivity to be is to be provided only by the government. So, we need to get money for constructing these rural roads.

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So, this was a conditional rural roads in 20 2001, they call it as the metal road. Now with the a growth in the economy, no bullock carts with a steel tires. Now every house in the state; for example in Tamilnadu more than 6, 7, 8 crore population, every house has got a motorized vehicle. If that is the case nobody would like to go in a road like this.

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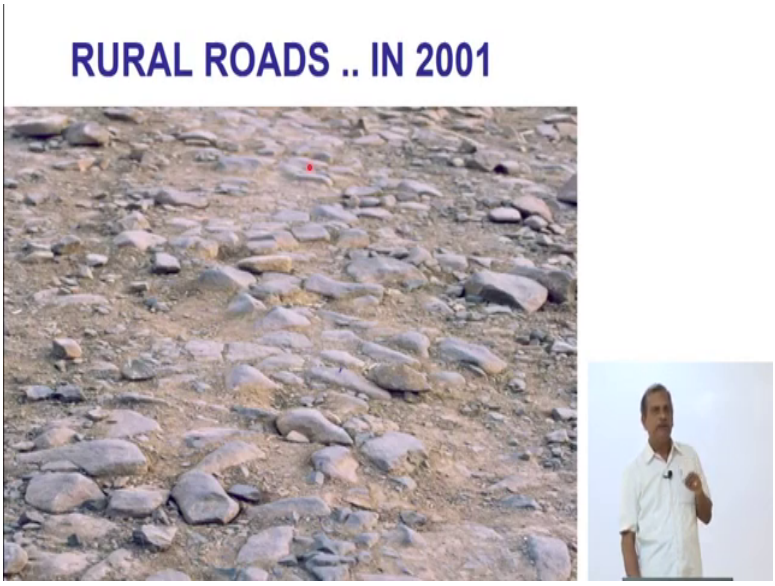

Every village has got so several vehicles; these were the condition of metal roads in the years in 2001.

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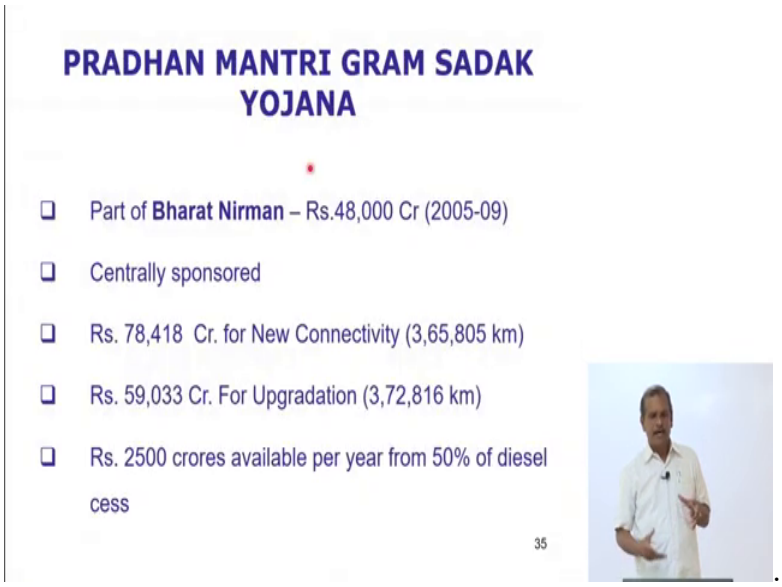

Under this Pradhan Manthri Grama Sadak Yojana later on called it as a Bharath Nirman Program, we have had different nearly 48,000 crores centrally sponsored. So, the money that we are getting is more than 2500 initially crores per year, more than 5000 crores money is being available every year from the petrol and cess; with the result we are able to provide better quality rural roads in the country today; out of the 589317 villages, unconnected habitations around 330000.

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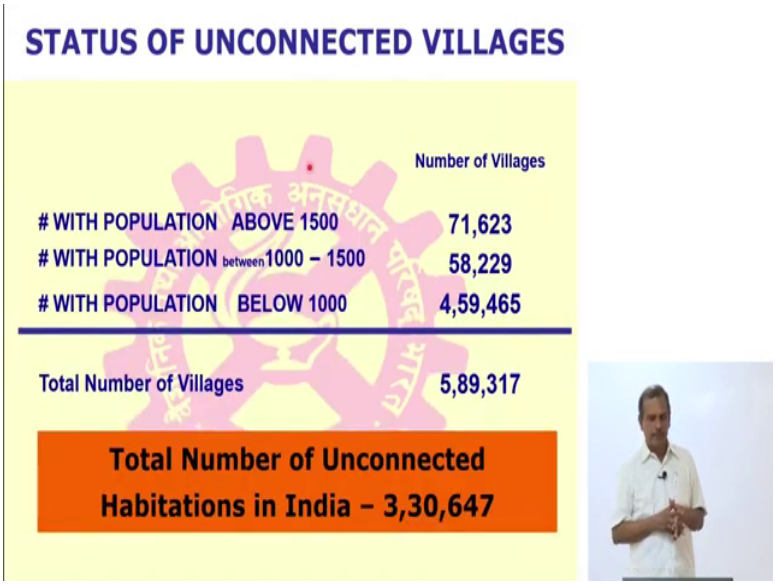

So, the country economy can grow if and only if, the rural place road are also improved. And one hand I talked about the savings in travel time, savings in vehicle operating cost; but we should also see what are the benefits of providing a better quality road to the villages. But providing a better quality roads to the villages, the education level of the village has improved, their health improves; they are able to sell the products at a much a better price.

So, the economy of the villages also grows in a way. So, in a nutshell what if understand is that more benefit, societal benefits will be there if we improve the quality of the village roads; more economic benefit you will gain, if you improve the quality of the highways.

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So, having said this about these roads today, this is the quality of the rural roads. Under the Pradhan Manthri Gram Sadak Yojana, we are able to see better quality roads connecting every village with a population of 250 by now like this.

So, issue arises at this point of time, what are the challenges before you, what is that, what is that to construct this? What you are seeing on the top is a black surface, but what has been buried below you do not understand, you do not know at this point of time.

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The major problem that is faced today in India is non-availability of materials for construction. So, I got I have money, I have the design; but I do not have materials to construct.

So, if we recover 150 million cubic meter of aggregate every year for road construction; where do we get materials? So, what you can do is ok, there are hillock, break the hillock, construct a road; but we are not looking at this point of time what are the damages that we caused to the environment by demolishing, breaking away a hill and making a road is a sustainable is a major challenge.

So, the other hand, other problem is that if you want to construct the road in Bengal, West Bengal; the aggregates of doing transport from Patna, Bihar. For transporting nearly for 60 kilometers per road development, guy require about 20 lakh tons of aggregates. On one hand the cost of aggregate, the second hand you have to transfer the aggregates throughout longer

distances. For transferring 200 kilometers, I will require about 180 lakh liters of diesel for transportation alone.

If that is the case, is the road building a sustainable proposition is what you should now think. Remember I am now talking about road construction; all you have to remember this infrastructure that we have created should last longer, it will require materials subsequently for doing the operation, road will undergo deterioration, you will find cracks, you will find potholes. So, if that is the case, again I need to provide an additional thickness of this pavement in terms of bituminous layers. If that is the case where do I get materials?

So, major first challenge faced by up will naturally faced by all of you many graduate is that, when materials are not available how am I going to construct these highways that is the may first are the major challenge before you.

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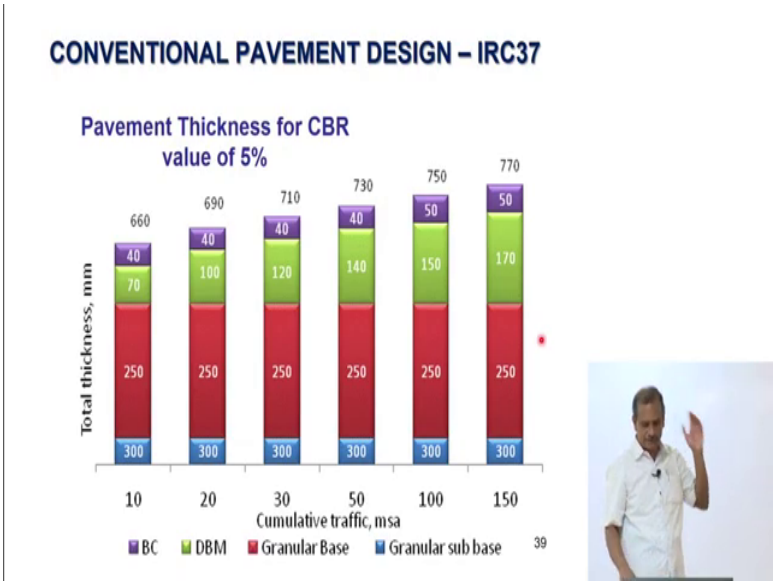

For designing a pavement for example, you estimate what is the traffic that is likely to use a highway. We express, we always consider only commercial vehicles for the design; trucks only we consider for the pavement design. If you look at the pavement design, the thickness of the different layers what you are seeing at the top is only the black layer; we have what you are seeing is only 750 is the top bituminous layer, 170 is again a bituminous layer, 250 may be a granular layer, 300 millimeter maybe a soil layer.

So, in all for a pavement whose strength is around 5 percent is the strength of subgrade, I require nearly 77 centimeter of a pavement thickness; is the traffic expected traffic is around 150 million standard axles. We express that number of commercial vehicle in terms of standard axles; your truck is supposed to carry 12 tones, if the truck carries 12 tones, the front axles suppose to carry 4 tones, the rear axles will carry nearly 8 tones. This I call as a standard truck.

When the vehicle carries the higher and higher loads, the damage that they caused to a pavement it increases exponentially. Suppose if we put in a number, the number of vehicles that are likely to use in a period of 15 or 20 years and 150 million, I will require about 770 millimeter is the thickness of the pavement layers. So, what?

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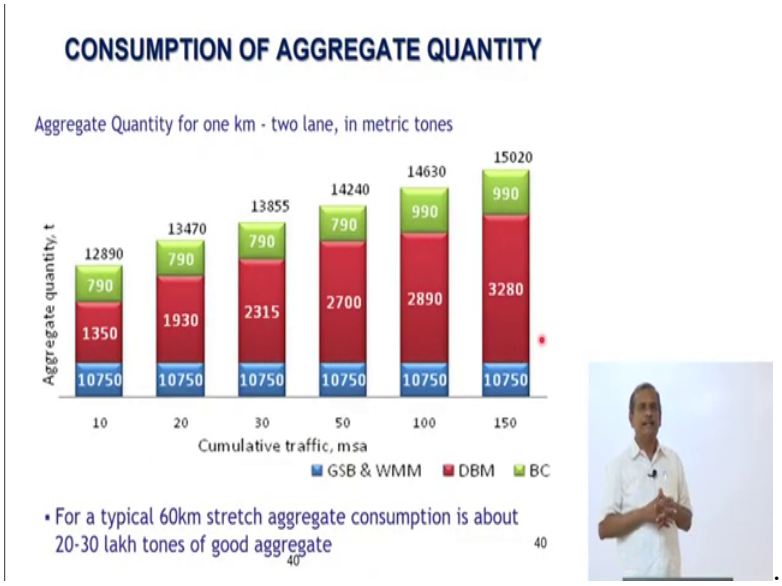

In this if you want construct, I will require nearly 15000 metric tones of aggregates for constructing 1 kilometer of a two lane highway. So, typically a 60 kilometer stretch will require about 20 to 30 lakh tones of aggregates; for constructing the outer ring road which I had mentioned a for Chennai, we are considered more than a lakh cubic meter of soil, we have a huge quantity of material there are they we consumed.

Where do we get this material, how to design constant different layers? What you are seeing at the top is only the blacktop; but what has in buried below is different layers, different materials. When materials not available, how to make the structure long lasting and sustainable is a challenge. As a road undergoes deterioration, your vehicle operating cost will also go up. So, the next challenge is that, how to ensure that the road that you are designing and

constructing lasts longer give a good riding course of comfort and you are able to travel smoothly, comfortably and safely is the challenge.

So, if not only designing and constructing is a challenge, operation, maintenance is also a challenge before you; how to construct the forgiving highway, how to build in safety features, how to ensure that the average speed is more than 100 kilometers per hour. So, when should I convert a two lane road into a four lane? So, when you convert a two lane into four lane, you require more quantity of materials, materials not available. If so, what is the challenge and how do we design this?

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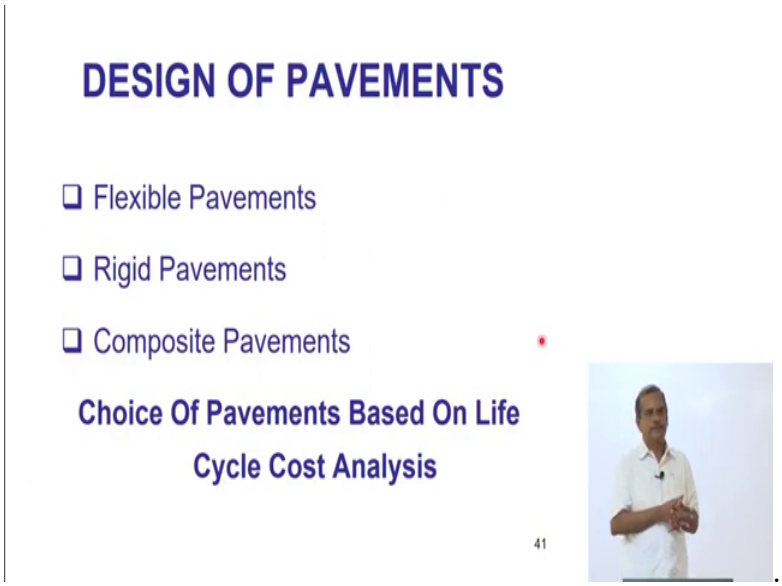

So, if you want to do this, the challenge before you is that selection of the pavement type. So, what you are see the blacktop which you are seeing is called as a bituminous surface, we use bitumen for road construction. Some Americans call is asphalt, British call as bitumen both are

one and the same; they are obtained by the districted distillation of petroleum, so you get different fractional distillation of petroleum, you will get the black residue of the bottom is the bitumen.

So, this we used it for road construction, but this bitumen which is a residue, which is a waste product of a refinery is being sold at a cost of 30 to 40000 rupees per metric tone. We request several thousand metric tones of bitumen. So, the in a pavement, the bitumen's layer alone will cost nearly 40 percent of the total payment cost. The issue arise at this point of time, we have to import crude, we have to get material for construction.

So, is bitumen road is only the option available to me for construction? We look at this, a the second question that you should understand is that, if you construct a road how many years will it last; will it last for 30 years, 20 years, 15 years, 10 years. So, when it feels early, it needs more early maintenance. So, you need to look at the design of the road which should last longer. If you are concessioner, you would like to construct the road and forget about it; for 30 years you should not warrant any maintenance.

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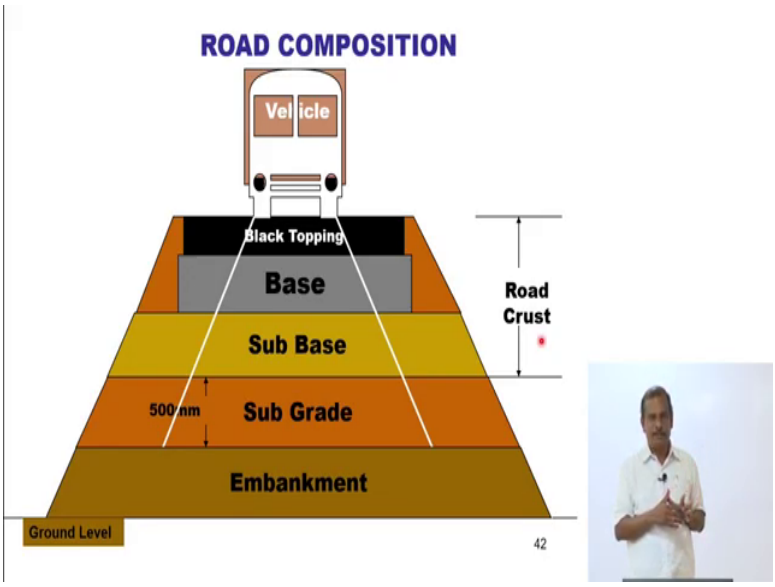

So, that is, is the case, you can design the road like a flexible pavement or a bituminous pavement. In a bituminous pavement I have the embankment, I have a sub grade, I got a sub base, I got a base pool and a bit of layer. The black top which is seeing at the top is the bituminous layer, whose thickness is maybe around 150 to 200 millimeter; but cost nearly 40 percent of the total costs. I need granular layer as the base coats, the granular layer sub base and about 500 millimeter of a sub grade; huge quantum material are required if you want to construct a bituminous road.

And second point that you understand is that, by the weight line that you are shown there; the load that comes on the top, just distributed over a wider area to the sub grade, finally subgrade that support the entire layers. The load distribution characteristics depends upon the thickness of each of the layers as well as the property or the materials used in different layers. Better quality materials world distribution of the stresses, big materials the load distribution will be

sharper, higher stresses will come at the bottom of the sub grade; which means the sub grade will be affected, you will find underrating surface of the top.

So, if you want the stresses to remind within the allowable limit, either you should increase the thickness or have better quality materials. So, one challenge or option before you is to choose the pavement which can be a bituminous pavement.

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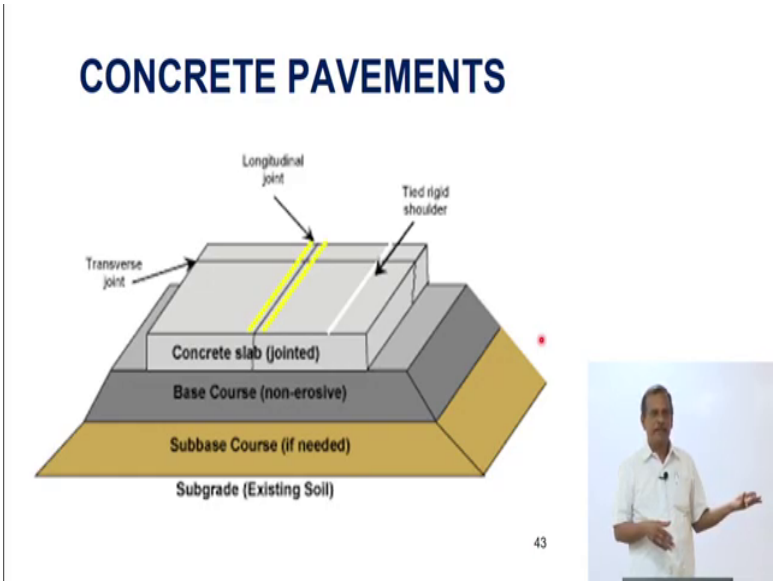

The other issue is that, I can also go in for a concrete pavement. Issuer is that, when I construct a bituminous pavement like this. The life of this bituminous pavement or a flexible pavement is around 15 years to 20 years, it cannot last more than that.

Alternatively if you can go in for a concrete pavement, it lasts nearly 30 years without major maintenance. So, the secondly, the thickness of the concrete pavement is much lower when

compared to a bituminous pavement. But the costs for constructing bituminous concrete pavement will be slightly higher than the bituminous pavement; the cost varies, the ripple varies has on today; when bitumen is around 30000 rupees per metric tone, the costs of the concrete pavement will be higher than the bituminous pavement, they are around 20 to 30 percent more.

The issue is that, should I spend more initially and spend less on maintenance, or spend less initially and spend more on maintenance subsequently. So, that is the challenge that we will face, you will face. So, no one will tell when you design the road, no one will tell design a bituminous road or design a concrete pavement. So, it is a job of the civil engineer to decide the appropriate pavement type, which will last for 30 years without major maintenance. So, when materials not available, how are we going to design the structure is a challenge before us.

I think it is time, 50 minutes of time is over; I will continue this subsequently the next class on 10th.