Introduction to Civil Engineering Profession
Prof. Ashwin Mahalingam
Department of Civil Engineering
Indian Institute of Technology, Madras

Lecture – 09
Infrastructure Management

Infrastructure Management see most of my you know lectures are a little bit interactive. So, I will sort of throw out a few questions at you and ask you to respond. Now of course, for those of you who are watching this online do not worry, I will trans I will sort of repeat what people are saying. So, you will get a gist of how the discussion happens, but do be prepared to a participate alright. So, we will go ahead get started I want to start off with some very simple questions ok.

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We going to talk about infrastructure management. So, my first question is very simple. What is infrastructure? What does it mean to you? Its a structural setup ok, what else? What are the I say somebody says infrastructure what comes into your mind? What is infrastructure? Its it is sort of a common sense question, does not require any deep civil engineering knowledge yeah.

Student: (Refer Time: 01:00).

Bit louder please.

Student: Buildings.

Buildings ok, buildings could be infrastructure. What else?

Student: Roads (Refer Time: 01:06).

Roads alright.

Student: Bridges (Refer Time: 01:08).

Bridges great.

Student: Dams.

Dams. What else?

Student: Interior.

Interior.

Student: (Refer Time: 01:15).

Sorry, I am not sure I got that ok, but a bunch of you have raised is sort of and some of you probably even seen the slides earlier I guess. So, you hit a lot of the things that were there on the slides, but essentially when we talk about infrastructure we talk about things like this right, we talk about you know roads which are parts of infrastructure dam somebody brought this out. All kinds of water supply systems this is a picture here of a of a sewage treatment plant which is used to treat waste water, but there are water treatment plants, water pipelines. I mean all of us need water right in our houses, in departments, in toilets and kitchens all of that right.

So, that water has to come from somewhere. So, pipelines are built treatment plants are built and also all kinds of what we call urban systems some of you brought up buildings right, but buildings are not the only form of infrastructure that we find in urban areas right. You have urban transport so this is a picture as you can see of a metro rail right that many cities in India are building.

So, all of this is infrastructure right roads, power plants, dams, urban systems etcetera. Why do we call them infrastructure any idea? Anyone know why we call them infrastructure what is so special about it? What is special about infrastructure let us ask it that way. Nothing special we can do without infrastructure, no everyone is saying no right. If you cannot do without infrastructure then there must be something special about it right so, what is special about it? Why is it important? What would happen if there is no infrastructure?

Student: Survive (Refer Time: 02:43).

Yeah, it is important for us to survive how does it make survival possible right

Student: To live.

You are right. So, food and water and all of that also are important for us to survive right, but infrastructure is is not important in the same way right. I mean without food we will all die by infrastructure is important for our survival, but in what way what does it do? It connects right wonderful it links multiple systems it connects right. It loves you see we are a very connected society connected economy right.

Farmers produce goods somewhere in a farm far away right all of those then need to be brought ultimately to your kitchen or the table in which you are where you are eating. So, it goes from the farm to you know maybe wholesale markets to your local vegetable store, where around the corner somebody buys it from the vegetable store, brings it to your kitchen cooks it and puts it on your table right.

A whole host of transportation infrastructure is necessary to make this happen, if you did not have transportation infrastructure, then either you would have to live right by the farm or you know somehow people would be able to lug it all the way to your kitchen. But probably a lot of the food would get spoiled and rotten and all of that on the way. Similarly with people going to work right, in the old days travelling about 3 4 kilometres was a herculean task right, it would take you an hour by bullock cart. Today with metro rails etcetera or you know good roads, good public transit systems you can do that in a couple of minutes right.

There are places in the world where people live about 100 kilometres away from where they work right. Because they like, I mean land prices are cheap or they have good facilities to live in and they work imagine about 100 kilometres away. A journey that used to take multiple days essentially can be done twice on a daily basis to and fro. Why because you have infrastructure right, similarly water supply systems ok.

We have these reservoirs which are full of water, but which are almost necessarily on the outskirts of many cities right. Because you need a large amount of area to store the water when it rains right, you cannot have that area within the city; because there is a lot of people living. Now if the water is stored so far away and you are living here, you need infrastructure to connect right. So, all of these kinds of infrastructure whether its airports or forts or water

supply systems whatever, essentially facilitate connectivity and have become what we call the underlying building block on which society exists.

If you did not have infrastructure we would still live, but we probably live in a very very different manner right. We would not be able to live in this sort of connected society that we live in. We have to probably live in very small settlements like we used to do several 1000 years ago right. Where each of us would be responsible for our water, our agriculture whatever and an relatively close societies ok, but with infrastructure we now enable connectivity right.

So, infrastructure is super important without infrastructure we just cannot function right by the way even telecommunication systems are also part of infrastructure right. So, unless you have telecommunication towers and satellites and all of that you cannot send and receive WhatsApps or emails or any of that right which are also now basic to our existence right. Anyone here can survive without WhatsApp?

Student: (Refer Time: 05:37).

Right no one can right yeah. So, essentially so you need telecommunications infrastructure as well. So, infrastructure is critical ok.

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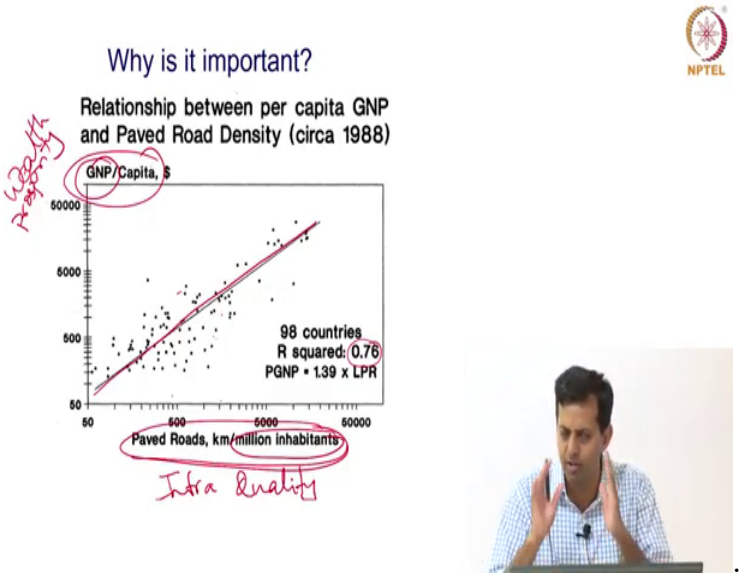

We talked about why it is important, but a lot of people will say this is just sort of casual discussion ok. Yeah infrastructure is important so are many other things, entertainment is important. Can you prove that infrastructure is important ok? There is been a lot of studies that have been done, but I will show you one that was done by the World Bank about 20 years ago. There is a guy called Casar Quiros, who plotted a graph ok.

The x and the y axis, on the y on the x axis he has a measure of infrastructure, as a measure of infrastructure his measure of infrastructure is take any country what is the total length of paved roads that they have; right because paved roads are a measure of infrastructure that is a we can come up with different measures, but this is one measure. How much by way of paved roads does a country have? That is the x axis ok. On the y axis is the what we call the GNP, what is the GNP? Anyone know what the GNP is Gross National Product ok. It is similar to

there is another term that economists often use right which we often see in the where its called the GDP the Gross Domestic Product right.

We want sort of split hairs defining the 2, but on the y axis is this gross national product gross domestic product. What is that what is that gross national product indicate? Somebody says India's GDP is x and Americas GDP is y and Sri Lanka's GDP is z, what does that mean? What does that number indicate? Net income it is a proxy, it is a measure for so if that number is really high what can you say about that country right. It is a developed country or it is a wealthy country right.

So, in other words the GNP or the GDP is a measure of how prosperous developed wealthy you are ok. So, on the one hand on the y axis you have a measure of let us say wealth or prosperity. On the x axis you have a measure of the infrastructure quality there is the infrastructure quality here alright. Now I say infrastructure quality because that is why we are emphasizing paved roads right, I can have some [FL] roads and say if I my country is fully connected right, but that is low quality infrastructure; paved roads indicates some quality.

So, he tried to plot this graph and said take any country how many kilometres of paved roads do they have what is their GDP line. Now there was one initial problem because people said, hey wait a second larger countries are likely to have more kilometres of paved roads right. You can say Switzerland is far more developed than India, but Switzerland is tiny right it is not even the size of Tamil Nadu right. And therefore, India will always have more paved roads than Switzerland right. So obviously, that is an unfair comparison right so how do you reduce that unfairness divided by.

Student: Area of village.

Divided by area is one the other is divided by population which is what is been done here right you divide by population. So, you say yeah, I mean India is a much larger country you will have larger number of paved roads, but you also have more people. So, you look at the number of kilometres of roads that you have per person right and then you will probably find

that yes Switzerland is a small country, but it also has very very few people. And therefore, the number of the kilometre of paved roads per person is quite high right.

So, that is a that is a fairer measure of measuring against countries because each country has a different size and shape ok. Similarly you do it with the gross national product as well again same reason the absolute production of a country like India might be much higher than many other countries just because we are large. So, you divide it by population to normalize ok. So, he plots GNP per capita by paved roads per million inhabitants right. So, he normalizes the 2, but still on the y axis you have wealth on the x axis you have quality of infrastructure right. And what does he find can you guys interpret this graph, what does it tell you?

Student: (Refer Time: 09:26).

Right it seems like there is a wonderful correlation right you guys have probably studied correlation, regression I am sure you did it in 11, 12 standard you will probably do a little bit more of it when you do more statistics right. But essentially what it says is and you know is that the fact that this line is so nice and straight and all of these points are more or less you know all of these points are more or less close to the line seems to indicate that there is a very good correlation right. And there is a statistical metric called the R squared which is also quite high. I mean R square of 1 would be perfect correlation so it is not perfect correlation, but it is quite high.

What that means is there is a correlation between the quality of your infrastructure and the wealth of a cut ok. Now we can debate which way is that correlation right there is a very important term in statistics that says or a phrase which people say correlation is not causation right. So, which way does the does the arrow point because I have good quality infrastructure am I a wealthy country or because I am a wealthy country do I have money to invest and I do I have better infrastructure right, we are not going to enter that debate. But the point is the 2 are related which means if you want to become a developed country do we all agree that we want to become a developed country that we want to become a you know rich country comfortable lifestyles like everyone wants to do that right there is nothing wrong there.

What that means is you cannot do that with poor quality infrastructure right. Infrastructure is the key I mean there are many other things that are key as well. Yes you have to set up more industries there should be more manufacturing you should improve agricultural productivity literacy needs to be improved. There many other things as well, but clearly one aspect right that concerns all of us in this room because we are all civil engineers is infrastructure is very clear that infrastructure is extremely critical to the growth of the country right. And that is why this community that we are all a part of the civil engineering community has an important role to play in India's development because we are essentially in charge of India's infrastructure development.

By the way successive governments in India have also I quote the same statement. Right for the last 20 years we have been constantly been pushing on infrastructure growth right. Say we need to develop more infrastructure more roads more this more that national highways we are trying to develop we are trying to develop more power infrastructure, we are trying to develop metro rails there is a lot of infrastructure development and every government has set itself targets.

From the time of the whole planning commission to NITI Aayog currently right. So, it is not that I am the only one saying right we all recognize at the highest level the prime ministers of this country have also recognized. So, infrastructure is key right let there be no doubt about that ok.

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Next question infrastructure is key, how is India's infrastructure? Good, bad, ugly how many of you say good; India's infrastructure is good maybe 11. We have class size of about 100 right ok. India's infrastructure is bad ok. So, that is about 42 I am very experienced in doing this. India's infrastructure is ugly no one thinks its ugly good. So that means, a bunch of you have not voted this is like our Indian elections no right. Everyone is checking that last I do not want to the nota or whatever we call that ok.

But essentially how is India's infrastructure. This is what it looks like right these are pictures that I am sure you could snap with your camera right most roads are highly congested. So, I had a meeting today 6 kilometres away right and it took me almost before this class it took me almost 50 minutes right to get from my meeting to here right. And if you do the calculations I

was probably travelling at for about 7.2 kilometres an hour right extremely slow right people run faster than that.

Housing we all know there is a huge housing shortage, there lots of sort of slums of course, government is addressing all of this you have something called the Pradhan Mantri Awas Yojana we are trying to build the houses, but there still is as of today huge housing sort of shortage right. Lots of taps do not have water running through them right because we have a large population we probably not managed our water resources as well, rainfall patterns are varying. In Chennai right now we have been in a crisis for quite some time right, all of us are praying to various gods and doing various things hoping that in about a month we will get a good northeast monsoon otherwise I do not know IIT Madras might have to be relocated ok.

So and of course, we all know this right this is a picture as you can imagine from Delhi, but because of you know poor infrastructure there is also pollution etcetera. So, essentially I think there are certain parts of India's infrastructure which are not bad some of our national highways are good. It is good that we are getting metro systems our telecommunication systems have evolved quite well all of that, but; obviously, there is still a lot of work to do right. So, if you have a report card we are not getting a distinction just yet right, we still have a lot that we need to do ok.

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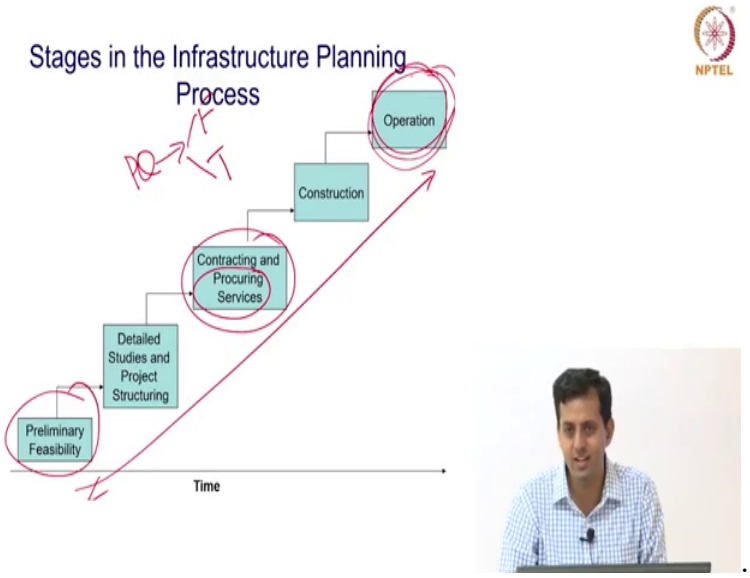

Ah So how do you go about building this infrastructure right. There is typically a process that we follow right. So, I will just quickly take you through the stages of this process. If you want to build anything it could be a desalination plant, or road, or a power plant, a dam you know housing whatever it is. You often start off with what we call a preliminary feasibility study right. First we have got to establish is this piece of infrastructure even required ok. So, I want to build a desalination plant right, you guys know what a desalination plant is right.

Is this big plant that we normally built of the coast which takes seawater and through you know essentially removes the salt which is where the term desalination comes from and creates drinking water right. So, I want to build a desalination plant. So, the question is this even feasible, first is it necessary right do you need a desalination plant right. Can you show that you have a water you know water sort of risk.

Second are you even close to a to an area which can be desalinated do you have a coastal presence how expensive will it be will there be people who want to buy this water so, a lot of initial questions need to be asked right. Just because somebody says I went to a conference abroad and I learnt about this desalination technology let us build one right does not mean you have to jump in and build. So, you do a bit of preliminary feasibility do you have the land availability, do you have the requirement, roughly what is it going to cost do you have the money for it etcetera right. If at the end of preliminary feasibility you might say this project is probably not going to happen; I mean it is an interesting project, but its way too expensive we do not have the money to do it right or its an interesting project, but I do not have land. I mean I really like to build a road that connects a to b; but that entire you know path passes through some very fertile farmland and therefore, I cannot really build that road.

So, we might say no right, but if you say yes this project is feasible then you actually go into stage 2 where you actually start doing some detailed analysis. And this is where a lot of the civil engineering that we study comes into use right; because I have to build you know I do not know you know a desalination plant. Let us just use that example, I have to do some structural design right, I have got to figure out you know I got to put the plant somewhere on the coast, I have to design the foundations, I have to design the structure, I have to design the water treatment systems what kind of filter am I going to use, you know all of those kinds of things where will the water flow how many pumps do I use where will the electricity come from.

So, you have to start doing some detailed engineering design and also figure out for instance where is this money going to come from right, if it is going to cost me say 5000 crores right. Where is the 5000 crores going to come from? Anyone here have 5000 crores in your back pocket? Ok no, I thought not if you do, please come and talk to me after class ok. So yeah so this money needs to come from somewhere maybe government has some money that it can put aside right, but maybe government does not have money right. In which case you might have to sort of look at can the private sector give me some money, can banks lend me some money, can I go to people like the World Bank right.

Who are trying to help countries develop and ask them for some money of course, all of this is not free money right, it is a loan. Which means do I have the capability to repay that loan the taxes that I am collecting is that enough to repay and therefore, you know this water that I am generating out of the desalination plant, what is the price that I should sell that water at so that I will get enough money to repay my loan.

So, all of these are calculations that you need to do right and then are they are iterative right you will say ok. Looks like I if I charge 40 rupees a kilo litre this project will work, but then people around might say 40 rupees a kilo litre for water that is ridiculously expensive right, I cannot pay that I am not willing to pay more than 20 rupees a kilo litre right.

So, if you charge 40 nobody will buy your water right. So, then you charge 20, but if you charge 20 you cannot pay the loan right. So, how do you have got to figure out a solution to this right either you find another source of funds or you negotiate with people somewhere or the other you have to solve this problem. So, it is a bit of an iterative kind of problem. Once you come to that and you figured out that yes this really works it was feasible and I have now found a way for it to work I have designed it I know exactly what it is going to cost.

I know exactly where I am going to get all my materials and components from I know exactly who is going to give me money, who is going to give me loan, what interest rate are they going to give me at, how am I going to pay back. Once I decide all of that, I can go to stage 3 which is actually finding somebody to build the project right. Because when we say this has been built by government right. Government has not built it right, it is not less of the chief minister or the prime minister is there every day pouring concrete vibrating etcetera right; obviously that is not the case right you got a contractor to build it for you right.

So, you have to then go through a process of selecting the appropriate person right and that is not you know that is not very easy; obviously, you want somebody who is cheap right, but also high quality, but also reliable right. So, all of these kinds of things right sometimes the cheapest fellow is cheap because he is not high quality right. So, this is this is fact of fact of life right. So, or he has good quality, but is not highly not reliable right. So, how do you find

and you know there is some times you are all searching for this mythical contractor who is cheap, high quality and reliable etcetera it is difficult.

So, you have to try to find out who is the best person possible, it might also be that such a person exists, but because this person is high you know high quality reliable and cheap. He already has a number of other projects he or she that they are performing right. Which means, when your project comes up the person says sorry I have only. So, many people in my organization we are already spread too thin working all across the country I cannot work for you.

So, this process of what we call procurement right is a is an interesting process right on the one hand you want to be fair you want to give everyone a chance because you never know there is some innovative person with some ideas you want to sort of use them right, but unfortunately if you say who would like to build this for me. India is a large country of a billion plus people what if 1398 companies come and say we build it for you right. You got to find some way of selecting one right. So, you have various stages sometimes you might say let me do what we call a pre qualification process right.

Let me first select only those people so let us say I have I have to build a 100 million litre a day capacity desalination plant. Let me select people who have built a minimum of 50 litres per day desalination plant. In other words if you are a road contractor do not even come right because you clearly do not know how to build my project right. So, you have to have built some desalination plant and then further than that you can see it not just any desalination plant, do not build some small 5 million litres a day plant and try to build my 100 million litres a day plant, you should have at least built 50 right.

So, you have a pre qualification process, then after that you might look at both your financial and your technical competency. So, give me a technical proposal how are you going to build it and tell me how much it is going to cost right. Because like I said let us not just quickly does not just take only the low cost person; because they may not necessarily be the most high quality or reliable. So, you can this sometimes this process takes time finding Mr. or Miss right

and this is important because if you are stuck with the wrong person right, it is going to be trouble because these projects are going to take 2 3 years to construct.

So there is a procurement stage that becomes very important. Once you have procured it then you can actually start construction right and this is where a lot of what we generally teach and you will take this class when you come to the third year whatever on construction planning. So, you got to plan out the construction you got to sequence the various activities you got to make sure that when a particular activity needs to be constructed that material is available, people with that skill are available right. We like to talk about construction labourers right, but the point is that different kinds of labourers, there are carpenters right who are very good at wood work right. There are bar benders who work with reinforcing steel, there are masons who work with cement.

So, you cannot just say give me 10 labourers right you need if for a certain kind of job you need carpenters, you need bar benders, you need masons, you need you know people who can operate certain kinds of equipment right. None of us can just jump into a crane and start operating it right takes a little bit of skill. So, you got to sequence all of that plan make sure that the right person is available at the right time. The materials are available, some materials can be bought instantaneously right, you can buy material today and use it tomorrow; others will have to be ordered months in advance right you are building a palace with Italian marble right.

You cannot say I want to lay my marble today where is it right. You had to by definition you have to order it from Italy right, which means it will take its own time coming in and it will have to go through customs etcetera. So, all of this has to be planned right and finally, once you finished constructing right you have what we call operations right. Where you run and operate the facility know hardly anyone talks about this, but that is quite strange because it takes maybe a couple of years to build a desalination plant. How long do you think you want to use that desalination plant or a building it takes about a year to build your house? How long are you going to use your house?

Student: 20 years.

20 years, 30 years, 40 years 50 years for a long time right. Which means it is very important to take a lot of care in terms of how you operate it right. When do I do premade, how when do I maintain, how do I maintain all of this because it is not is enough to build something you are building something because it creates value right. And it is going to create value only if it is operated and maintained well right. So, this entire thing is the infrastructure life cycle right you start off with an idea right here and you end up with an operated facility there right; but although I have drawn a nice step ladder kind of diagram. The process unfortunately is not so linear right. The process ends up being far more messy and far more Iterative right.

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And the reason behind that is a very important word how many of you have come across this word before? How many of you have heard the word stakeholders? Yeah many of you, what

does stakeholder mean? Right definition is simple right person who has a stake who holds a stake in the project therefore, they are a stakeholder right.

So, if I take any project let us take a road; who are the stakeholders in that project? Right, who are the stakeholders in a road? I am going to build a road from A to B ok, who are all the stakeholders in that project? And you start thinking about this right you find there are lots of stakeholders of course, the government agency is clearly a stakeholder he is the agency has hired some consultants to do their designs etcetera that is a stakeholder you have hired a contractor.

But to construct that road you are probably acquiring a lot of land right. Which means all of those people who own land are stakeholders, some of them will have to sell their land some of them will not sell their land and somehow see their land prices go up because now they are next to a road right. Some of that land might be farmland, that road might also be a corridor for certain wildlife going to and fro. Which means you have all kinds of environmental groups that might also be stakeholders; they have something to say about the project.

You might have existing water lines or telegraph lines or power lines along the alignment of that road which means those departments are also stakeholders because in order for you to build the road, you will have to shift the water line or whatever. So, there are tons of stakeholders and many stakeholders have their own interests ok, which they have to actually which they will want to protect right. So, stakeholder management is a there is a big challenge that appears in every single phase of the project right and if you want to know why stakeholder management is so difficult.

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Tell me what you see here? What do you guys see?

Student: Tree Tiger (Refer Time: 25:07).

Some of you see a tree right so this is a tree you know there is sort of a nice they seem to be two birds here on top, this is the root of the tree. What else do you see?

Student: Gorilla and lion (Refer Time: 25:17).

Right, others might say hey wait a second just look at the white part right this looks a bit like a I am probably messing it up, but this looks a bit like a lion or a lioness right and this looks a bit like a gorilla.

Student: Gorilla.

Ok This is a gorilla. So, it is a gorilla and a lioness looking at each other right with some black space in between and not you know a tree with birds ok.

(Refer Slide Time: 25:42)

So, there is multiple perspectives what do you see here? Ok. See an old woman how many of you see the old woman ok. Anyone see anything else? Ok, how many of you see a young lady with a face turned away from the picture yeah. So, for those of you who wanted to look at the old woman, this is the old woman's chin this is the nose whatever. For those of you looking at

the young lady, this is the young lady's nose this is the young lady's chin and this is her hair and these are her eyes right and she is turning away.

Right these are all called what we call gestalt images right and you guys have this slide. So, if you cannot see it right away you can sort of go back home and try to look left right centre etcetera.

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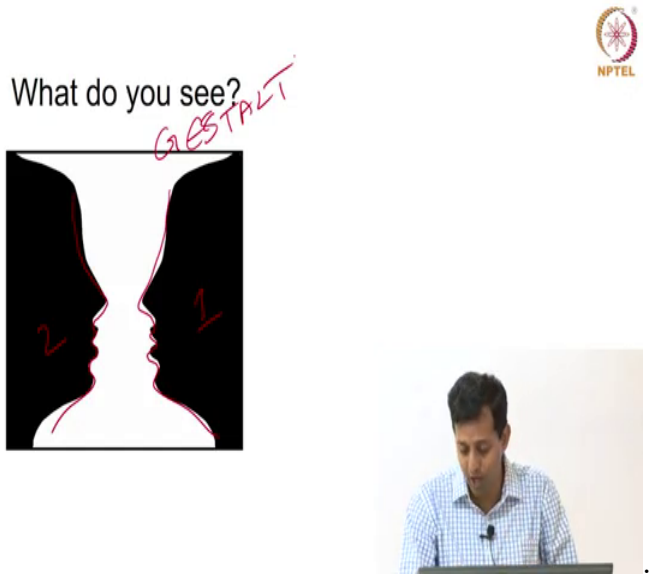

Last one what do you see.

Student: (Refer Time: 26:27).

All right so on the one hand some of you see two faces this is face 1 and face 2 as if they are talking to each other, but it probably also is if you look at it its sort of like a cup like or a

goblet or a chalice or you know something like that. So, just focus on the white well I cannot unfortunately closing it here does not close at this it does not work, but you know you just look at the centre sort of like a goblet right.

So, lots of these kinds of images view you want more fun go and Google gestalt G GE oops what happened GESTALT, GESTALT images and you will find a bunch of these right. The reason I am showing you guys this is one to keep you awake of course, but second also to show you that people can have multiple perspectives right.

On the same thing right some of you can say gorilla and lion, some of you can say tree some of you can say young lady some of you can say old lady, but I am showing you all the same thing right. Similar with stakeholders right its the same project, but different people perceive it differently right. You look at a so you look at for instance a dam right that your building, some people look at that dam and say wow, this is going to generate hydroelectricity right. It is going to sort of store water that we can use for irrigation etcetera. Others are going to look at the same project and say you are going to flood the nearby areas, you are going to displace people right, you are going to destroy environments right.

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So, same project people can look at very differently right and this is something that you will have to work with because whether you like it or not stakeholders can cause a lot of challenges on projects right. And in I am not saying the stakeholders are wrong, sometimes they have very good points of view. These are 2 newspaper clip clippings from projects that have been very recent from things that have happened very recently in Tamil Nadu right. Just because you guys are all at IIT madras right we you can pick your own state and you can find others right.

Sterlite had a industrial mining facility that they have just recently closed out because of stakeholder protests right ah. Recently we had something called a Chennai Salem greenfield corridor right between Chennai and Salem. Which farmers are opposing right because it essentially says it will destroy their forest, areas, lands etcetera right. So, you all have many of

these projects you can think of the Narmada Bachao Andolan some of you might recognize that right.

So, stakeholders are capable of protesting quite a bit to stop projects because not everyone sees infrastructure projects as beneficial. Globally we all agree that infrastructure is good, but what you need to understand is for every single infrastructure project there will be winners and there will be losers right, this is just how the world works right. This is great I built this road from A to B, I am able to go from Chennai to Bangalore in 4 hours, I do not need to fly, I do not need to take a congested train right. So, that sounds good to you, but there are some people who lost their land right. And those people probably do not view that as such a nice project right.

So, there are always winners and losers and losers are; obviously, not going to die quietly right. Nobody is going to say oh please take my land right, I will be unhappy that is fine right let that other fellow be happy right. Very very few very few people will actually you know say these kinds of things ok. People are going to try to protest and say why do you need my land, right why cannot you have an alternative road why is this project necessary right.

So, at every you remember that stepladder diagram I showed you every step of the way from preliminary feasibility to detailed studies to construction, stakeholders will keep coming and opposing projects. Which means if you want to talk about stakeholder management right you going to talk about how do I actually manage. all of these protests that comes in right and when you look at infrastructure management that is the hard part.

The rest of it designing your bridge etcetera can be done right. We have enough theories on how to do it today's software are strong enough that once you put in the right boundary conditions you can probably get a design out. But the stakeholder management part is far more difficult and the reason is people do not behave like electrons. Like electrons have the same behaviour irrespective whether it is an electron in the US or an electron in India or an electron in you know here versus there. Whereas, people are all different it is very difficult to control them ok.

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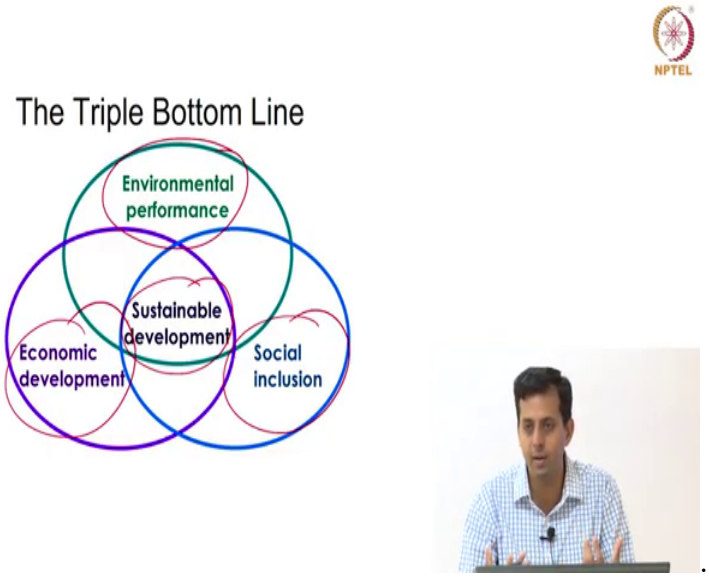

And if you want a project to be successful, it needs to be economically viable right there needs to be some economic benefit out of it, but it also needs to be beneficial to people everyone needs to sort of or a large majority of people need to be included in those benefits. And increasingly today we also need to be environmentally conscious ok. If you do that you get what we call a sustainable infrastructure project ok.

If you mess up on one of these it comes back to bite you if you got a project that is economically hugely beneficial right, but socially disastrous people are going to be charged huge amounts of money to use a particular road or you are acquiring a lot of prime farmland all of that. Then very often the protests will end up destroying the project as they done with several projects right. So, all 3 need to be balanced infrastructure development that is very very hard right.

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I gave you the example of a dam right, this is just a hypothetical dam like I said there are clearly economic benefits to a dam you can generate power you can sell power right. You can store water you can irrigate fields you can improve farming productivity right. You can supply water to people you can pay them for that I mean so you can charge them for that. So, there are economic benefits, but there could be social dis benefits because when you build a dam and the water actually. You know floods across a larger area you might be displacing people and villages who live at the borders of that dam of that river that is now being dam right.

So, what happens to those people is an important question that you will have to answer. Similarly you will be destroying flora and fauna around that dam. What happens to those natural ecosystems which provides some service, right cutting down trees is not an answer right because trees help sequester carbon which is very important if you are trying to combat

global warming. So, you cannot just say the tree does not have a voice to protest let me cut it down ok.

So, if somehow you can keep people happy by maybe finding them an alternative place to live and an alternative livelihood and if you can find out a way to mitigate the environmental damage that you are causing, then dams can be hugely successful right. Otherwise in some cases all of these protests and the political machinations that follow might end up leading to a situation where the dam is not constructed or after its construction there are so many protests people try to sabotage the dam etcetera right.

So, building infrastructure managing infra when you say infrastructure management right, many of you probably came into this class thinking about what are the various civil engineering aspects to it and those are important. I do need to figure out how to design the foundation for this dam, I do need to figure out what is the strength of concrete that I need to use for this dam. But I also need to figure out and that is more difficult what are the economic benefits, what are the social benefits, what are the environmental benefits, what are the dis benefits and how can I mitigate and if you can do this then you are an infrastructure manager.

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Right and when you come to fourth year we will have I mean at least I teach a class which goes into detail in all of this and there are other classes that you can take as well to understand and understand this. So, what are some ways in which you can do this? I will give you a few examples and then we sort of maybe take a few questions today, but I think we will find some other time for more detailed discussion. One of the ways of doing this is to allow people to visualize right what this project is going to look like right in the future.

Very often we end we end up talking in the abstract right. So, I want to I got all of these poor people I want to resettle them I want to resettle them into these kinds of houses, people start protesting right. I do not I want a house like this I want to house like that all of it is conceptual. What if we could actually show people what it really looked like? In the past you have architects showing you 2 D drawings right 2 D blueprints many of you probably seen a

blueprint at some point or the other right. Maybe you had a house that you were building or your friends were building maybe you saw it in a movie right.

So, these are plans that try to indicate what the structure looks like, but guess what even an experienced civil engineer finds it difficult to understand what that blueprint is talking about right. It is a bunch of lines and grids and annotations etcetera I want to try to close my eyes and try to figure out what is this thing going to look like very very difficult. But today with technology I can actually build these kinds of 3 dimensional images of what the finished product might look like.

Whether it is a house or a dam or whatever and we can start doing simulations to say look here is the here is sort of the width of the river at this point. Here is what the width of the river is going to be like and therefore, all of you villagers here do not really need to worry right. The width of the river will not really encroach upon your village space and as a result of it you guys do not need to protest. If at all fishing etcetera is going to be easy for you because you are going to be closer to the river right.

So, you can actually start helping people visualize and that might be one way in which to get stakeholders together it might also be a good way for stakeholders to come in and give you suggestions on the project right. Let us not be on a any under any impression that there is this infrastructure project manager who knows the best way of building these projects there is no such thing right.

People sometimes have a wonderful idea of why cannot you know why do not you build the dam a little bit more downstream and you know that is probably a better location for the dam, because you are causing minimal environmental damage and by the way there is a natural slope. So, the hydroelectric power you generate might be higher right.

So, you never know when people will come up with ideas. So, showing them we are helping them visualize right is an approach that you can use to bring stakeholders together. Again 10 years ago, 15 years ago neither the hardware the computers nor the software were strong enough for us to really convincingly visualize. So, what people used to do they used to play

these kinds of movies right. So, you probably seen you know there will be a movie of walk through over building, people standing around playing basketball working and people will say look this is a wonderful facility that you are going to get.

So, those are essentially animations right, but we can go a step further today we can make these dynamic right we can actually have meetings where were sitting around with stakeholders and in that meeting we able to understand what happens if I move my dam up a little bit right. What does it do to the width of the river what does it do to the hydroelectric power that is generated right. And almost do a it is almost like a flight simulator right do a bunch of what if scenarios right. Or if you are going to build urban housing you have only a certain amount of budget you want to build low cost low income housing right.

You can quickly try out a few designs have people literally walk through these design. Today we are all familiar with 3D cinema right I mean almost anytime you go to a cinema theatre you most movies today are in 3D right so you wear these 3D glasses. Why cannot you do the same thing to a simulation right wear a 3D glass right and immerse yourself in the model. So, for a second right you are actually walking through right a simulation of the real model right. All of these technologies now exist and I believe you will have a talk later by Professor Khoshi on automation where he might touch upon some of this right.

But you can actually now really help immerse people into and a piece of infrastructure that you are going to build. And through that immersion process understand more what their concerns are and try to sort of dynamically redesign and come up with a design that everyone by enlarge signs off on. So, that as you start constructing you have fewer protests right. So, new technologies for better visualization is one key strategy.

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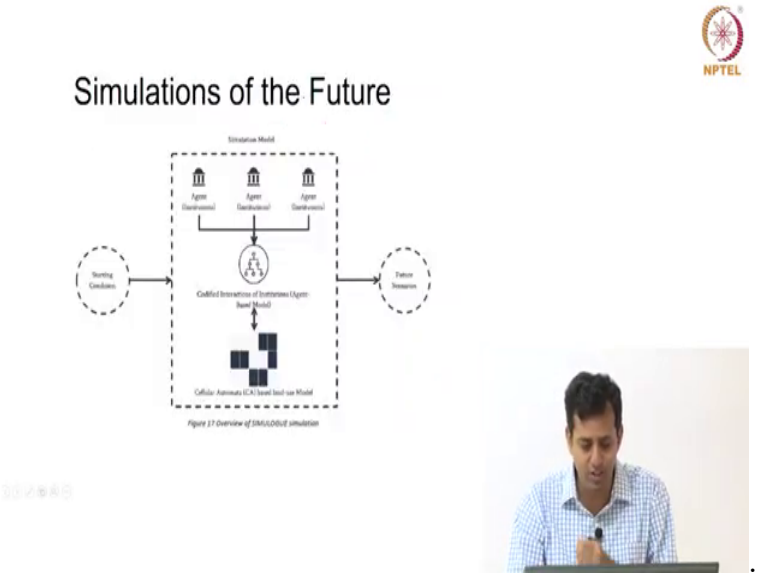

Second and this is sort of a part of a project we are doing currently is, can I start simulating future outcomes to make better decisions on what infrastructure to plan right. So, you know we live in we are now in 2019 about to get to 2020 in Chennai ok. What will Chennai look like in 2030? It is a very difficult question to answer. A lot of people may move into Chennai, people may move out of Chennai right. Certain kinds of facilities maybe get built in Chennai certain kinds of facilities might get raised down in Chennai right.

In the middle people might say let us build a metro rail or something like that right rainfall might be good might be bad. If rainfall is good there if rain fall is better than normal and you actually built a lot they might be a risk of flooding right. So, these so many future possibilities right we could sit for hours and we could list out potential future scenarios right. Some of them might make good scripts for movies right like the day after tomorrow or all of these

kinds of movies right. You guys have not saying that movie some of you have seen it, so you know what I am talking about right.

But what you could do is if you can actually start simulating various futures you can actually start thinking about, hey if these are the kinds of futures I want to get to and these are the kinds of futures I want to avoid. What kind of infrastructure do I need to build today right to get to the futures that I want to? Right so, you know rainfall is going to become the rainfall patterns are going to vary more and more right that seems to be an impact of climate change. I my mind at least there is no doubt that climate change is upon us right, climate patterns are changing and because of that you will have these years where you will have bumper rainfall, you will have years where you will have drought which is now problematic from for me from a water perspective.

Ideally I would like the same amount of rainfall every year right. So, I know exactly how much I can store in my tank right, but if you are going to give me double the amount of rainfall in a particular year I cannot store that much. So, what do I do half of it runs into the sea, the next year I do not have enough rainfall I cannot ask the sea to give that back to me right does it work that way.

So, I have to now figure out so what is the kind of policy that I can put in place today right that might help me stabilize my water infrastructure in the future right. And can I simulate the impacts of that policy right. So, I think all of these urban simulations I think are very important tools for us to understand the future for us to bring in stakeholders and say look you guys want to build more and more houses guess what right.

The problem with building all of these houses is that and building all of these roads is that your creating less surface for the water to percolate down because you are making everything into concrete. Because of which the water is going to flow and you are going to have flooding ok. So, can we look at an alternative building trajectory right can we start not building in the city, but start building more horizontally along the periphery in suburban areas right?

So, and can we bring along potential house owners and builders right and have everyone sort of agree to that strategy because they are all the stakeholders to this. So, simulations I think are a very important part of being working with stakeholders being able to help them understand what are the near term effects and long term effects of you know of developing infrastructure. And by the way these are not these are not done yet right there is still a lot of r and d that is going in right. So, these are all potential projects that you might want to work on right throughout your tenure at IIT and even later ok.

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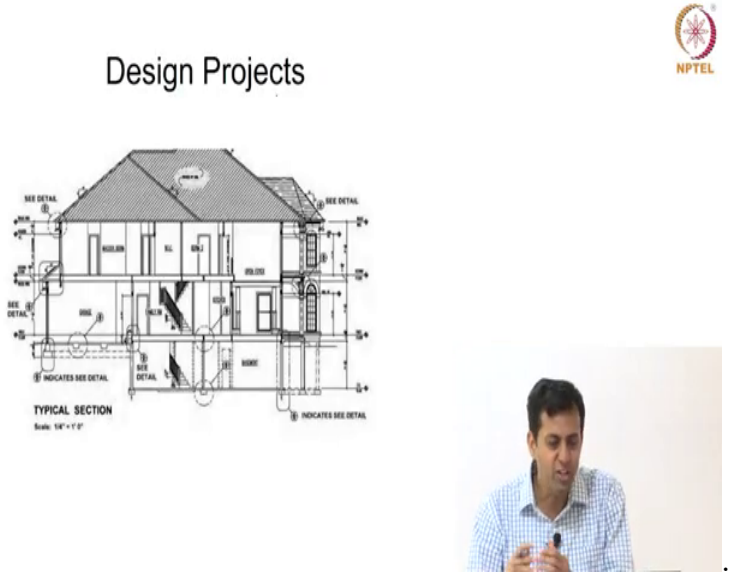

Once you get to that once you have your stakeholders on board, then there is sort of a relatively systematic process that you can follow right. So, first somebody comes in and says were all agreed right. So, this is the kind of infrastructure we want now let me go design it and

this is the kind of blueprint I was referring to right. So, you have now a clear plan right you have dimensions where are some dimensions yeah.

So, you have levels and dimensions and all of that it is very clear right. So, somebody can look at this and say this is the amount of concrete that I need to build this structure right. Because its fully planned out I can go to each and every concrete element I can figure out is it cylindrical is it cuboid, I can use my you know volumetric mensuration formulas that I learnt in 5th standard and figure out exactly how much concrete I need. Then I can start looking at who will supply me that concrete will they give me a discount because I am buying a large amount all of that right. So, you can go in with the detailed design of projects.

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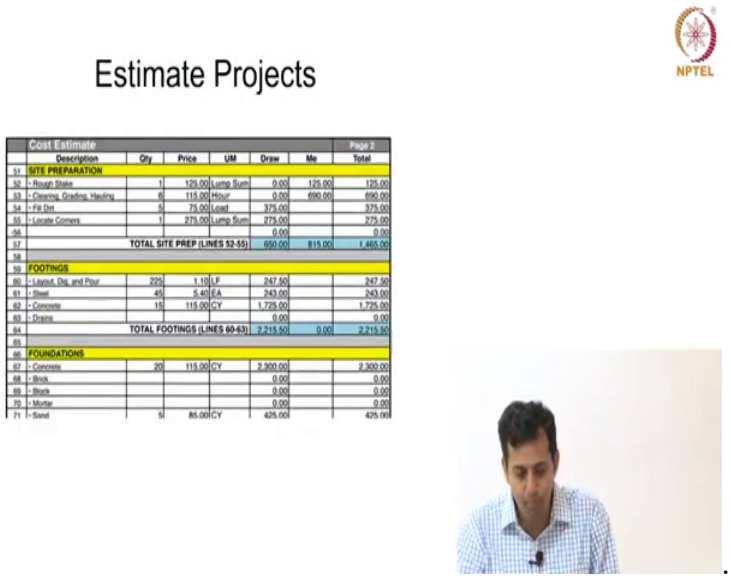

Once you design projects in detail the next step is what we call cost estimation right. So, you designed it somebody has given you this blueprint right. Somebody has given you this design

and say this is what you all you all agreed upon. Then you actually do what we call a quantity take off and you say here are the various items ok, there is some steel there is some concrete there is some drainage ok. In the what we call the footings right there is some sand and mortar at the foundation. So, for each of my elements I have certain what we call items of work each of those items of work I have a quantity.

So, for instance in the foundation concrete is 20 cubic yards right and the price per cubic yard is 115 whatever dollars rupees. I think its dollars is where I picked us out from ok. So, I can actually find out in the footings how much is my concrete going to cost right. So, I can do very systematic cost analysis for every aspect of my work right this particular structure right. So, I am building a metro rail right the metro rail has all of these tall piers on which the metro rail stands on how many of those piers do I have how much cement goes into those piers how much steel goes into those piers what is what are the items what is the quantity and what is the rate right?

Today's market rate what is cement 250 rupees a bag, 300 rupees the bag, 325 rupees are bag similarly steel right per kilogram or per ton what is the amount that they are charging for and I can come up with a very detailed estimate right. And of course, if you are a contractor you will put in your profit etcetera which is all fine ok. So, first stage is once you agree with stakeholders first stage is design from design you come up with these quantity estimates we have a bit of an idea of how much this is going to cost right.

Then you go more or less try to figure out where is this money going to come from do I have it with me, do I have to borrow it right. When contractors come in and bid for your project and voluntarily do it for you. You can compare their cost against this right everyone will have a slightly different cost for you its 115 you know rupees or dollars per cubic yard. Somebody might have a rate discount because he builds a lot right. India cements might give him concrete at a slightly cheaper rate he might say 110 right or plus or minus ray or somebody might say oh the price of concrete is of cement is actually going to go up. So, my concrete price is going to be a bit higher.

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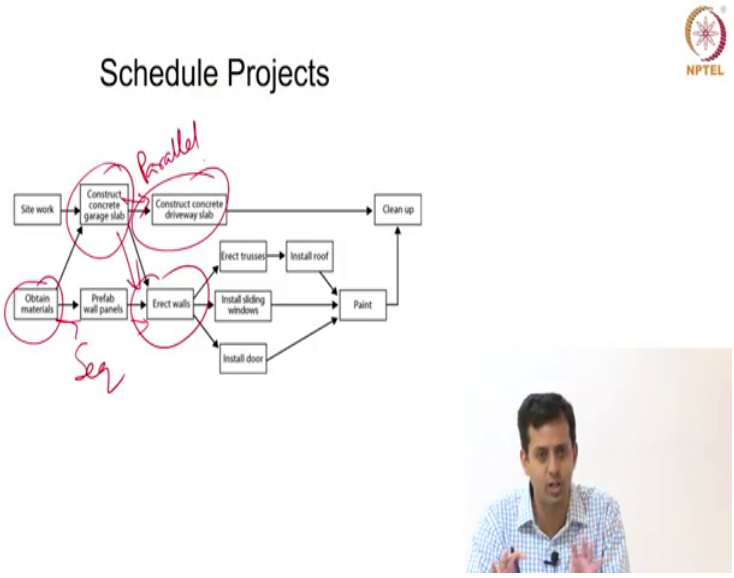

So, there is always be fluctuations right, but at least you can compare somebody is bid with what you come up with and sort of see this is about in the right ballpark. So, this is step 2 estimate once you have estimated you have selected a contractor etcetera you got to schedule the project you got a plan it what comes first, I got to obtain materials then I have got to construct the garage slab, then I construct the driveway ah. After I construct the slab I can erect the walls see some of these things happen in sequence, some of these things happen in parallel ok.

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So, this is sequential this parallel right. So, there are very many ways in which I can sequence a project right. So, I got to think carefully do all of this sequencing etcetera. And once I have done all of that my final task is to actually monitor. The construction of that asset before I hand it over to somebody to operate and run and live and use and whatever right and today monitoring of course, you got to be at the site to monitor right. So, that is why we have a person with a hard hat etcetera, but today is monitoring what does this person have in his hand right. Its some kind of a tablet right it could be an iPad it could be some other it could be some other model.

But he has a tablet right because a lot of this is now digital right. So, a lot of digital information so he for instance has a drawing of exactly the area that he is standing in or maybe even better a three dimensional image of what that area should look like. Looks at the image looks outside and says or he says hang on a second there should be an opening there and that

there is an opening here in this drawing, but there is no opening there right. And so he reports an error and you correct. So, at any given point of time you got to monitor. You cannot just say here is a design thank you, bye bye I will come back in 1 year and I want to see that finished structure does not happen that way right.

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You have got to monitor that the work is being done as per the plan. And today's monitoring is starting to become more and more automated, more and more digital along with these kinds of tools ok. So, once you done that you can actually hand over the project for operation right. So, in some sense and this brings me to the end of today's presentation and not a minute too soon its exactly 11:15, but essentially what I wanted to do is to give you an overview of infrastructure and construction project management right.

On the one hand you can simplify it and say ok, I have got to come up with the design I got to then come up with cause I have to schedule you it and I have to then construct it and monitor it. But there is also a lot of other stuff right that goes and you have got to sort of first convince people that this is feasible you got to do detailed design you have got to find a contractor there are stakeholders everywhere who will come in who will start protesting. And by the way there is no such thing as all the protests are done right. Imagine you are building a water treatment plant somewhere or wastewater treatment plant like what I showed you right. Initially some people might come in and they might protest all of that you might satisfy them.

And then when you are constructing people in the neighbourhood might come up and say you hang on a second I did not realize this plant was going to be so close to where I live. And I do not want to live next to a water treatment plant I completely agree that we need wastewater treatment plants in the city, but not next to my house right. So, not in my backyard right NIMBY there is an acronym right I do not know if you guys have heard this. NIMBY stands for Not In My Back Yard right; essentially says I want this, but please do it somewhere else not here ok.

And this protest might come very very late right after you have awarded the contract after you have bought the materials after you start up the foundation people might start protesting. So, there is no such thing as check the box my stakeholders of all disappeared. So, this whole stakeholder management piece right is a very very important piece in the whole infrastructure project management in addition to the engineering design the costing all of that. And while we will teach you a lot of the engineering design piece the stakeholder management piece requires a bunch of other skills. It is not enough if you are good at mathematics unfortunately right you cannot deal with stakeholders that way right.

You need to be good at you need to have great interpersonal skills you need to have sort of charismatic leadership you might need to have a really good understanding of legal issues, the law. When you can apply the law? When you cannot? So, what; that means, for people like you in the room who might want to look at a career in infrastructure going forward is your

civil engineering fundamentals are important right. But beyond that, you almost also have to skill yourself in economics, law, management sociology all of these right.

And they are really successful infrastructure managers are the ones who are multidisciplinary right. We have all of these either they have studied it or they have an aptitude for it or they read about it you choose the way you want to go right. But if we remember the beginning we said India's infrastructure is not as great as it needs to be. We need to build infrastructure we need to surmount all of these challenges technical, non technical and you guys will have to develop a varied skill set to do that.