Introduction to Civil Engineering Profession
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Lecture – 12
Analysis & Design

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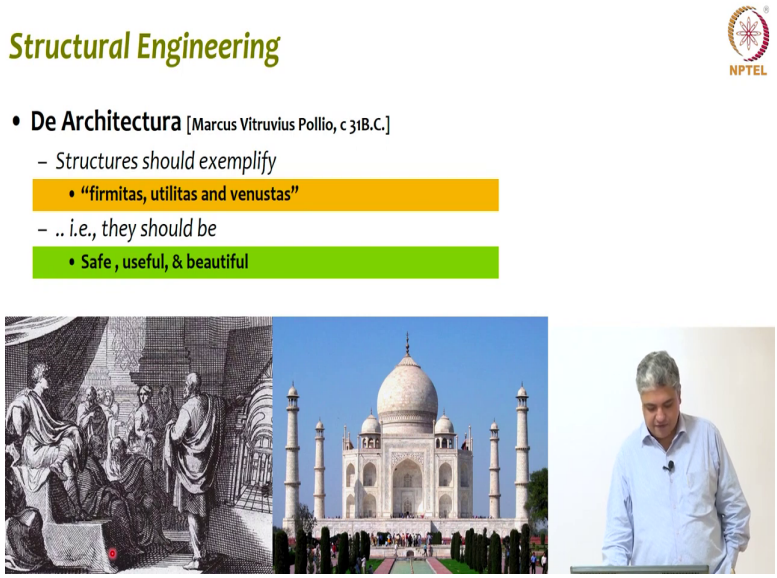

Analysis and Design; and so, we have to build structures which are safe useful beautiful. This is what was told to us thousands of years back.

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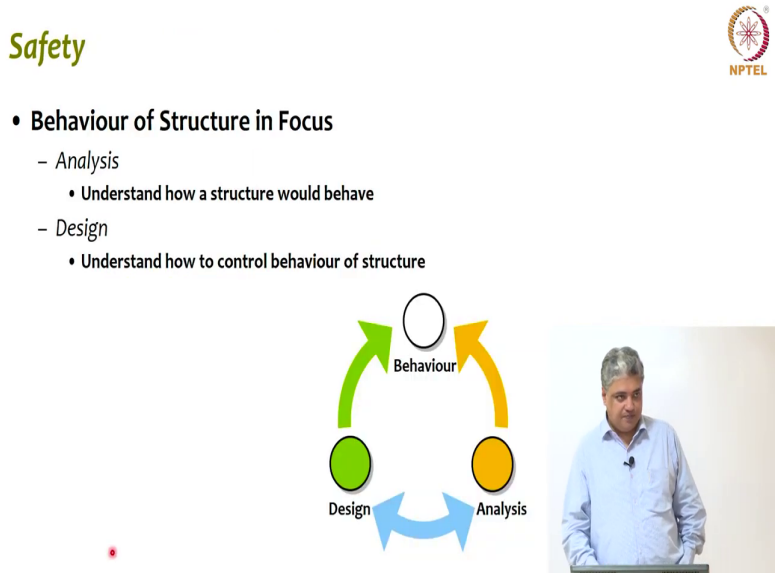

But the question is what is safety and how do you ensure safety right? You have seen some photographs where we have seen structures buildings bridges that have fallen down and that is not safety. So, how do you ensure safety and thus this is where two important tasks are need to be done, need to be carried out by an engineer particularly a structural engineer which are analysis and design.

And what is analysis? It is to understand how a structure is going to behave right and a design is to understand and control that behavior. So, that behavior should be acceptable behavior and that is what you ensure through, your what is called design.

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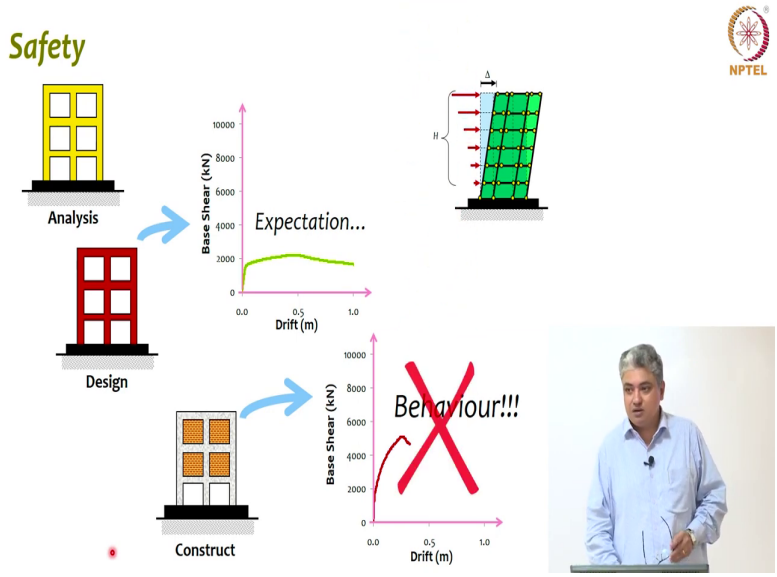

And we will see little more very quickly just to give you an example; all of you have seen you know simple buildings being constructed wherever you have lived, grown up you must have seen.

So, and these are these nice buildings with columns and beams and slabs what we saw just couple of slides back. So, in that the analysis and the design often is done with only for the frames that is the columns the beams and so on so forth. But suddenly when we construct, we put these infill walls; the walls that you see the brick walls. So, what it does to the structure is, it changes the structure and it changes its behavior.

So, what do you expect while you analyze and design the structure is not what you get after the structure is constructed and that is not acceptable.

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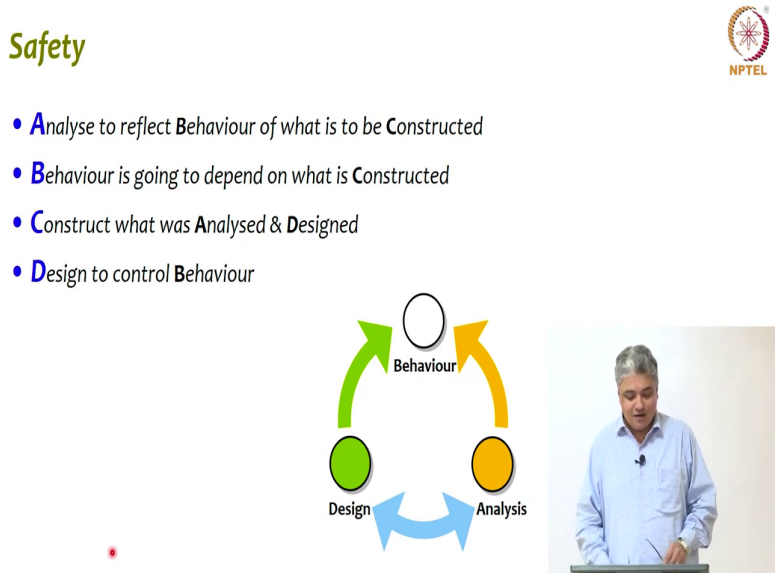

So, this is what I call ABCD of engineering or ABCD of structural engineering is, you need to analyze to reflect the purpose of analysis to understand and reflect the behavior of the structure that you are going to construct. And behavior is going to depend on what you construct right. So, you are supposed to construct only what you have analyzed and you have designed for.

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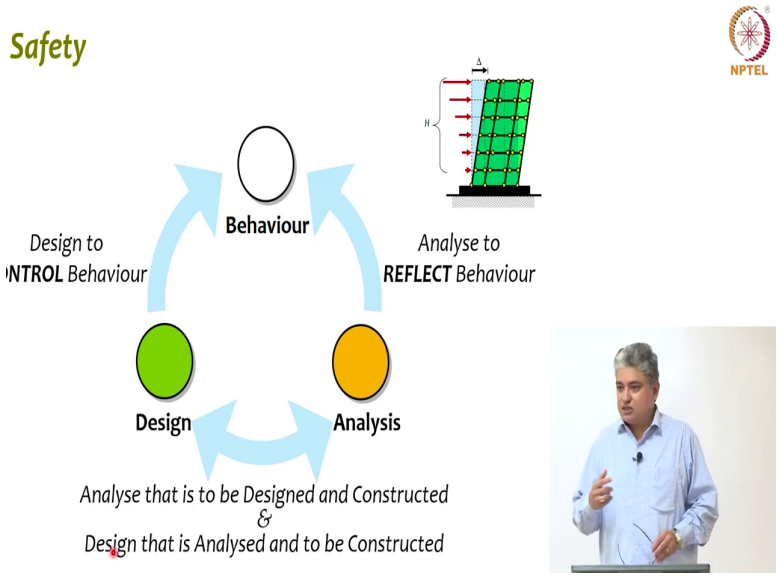

And essentially through design, you control the behavior of the structure. So, that the behavior is acceptable right. This process is very important and it is not a you know, it is an iterative process that you have to undertake to ensure safety.

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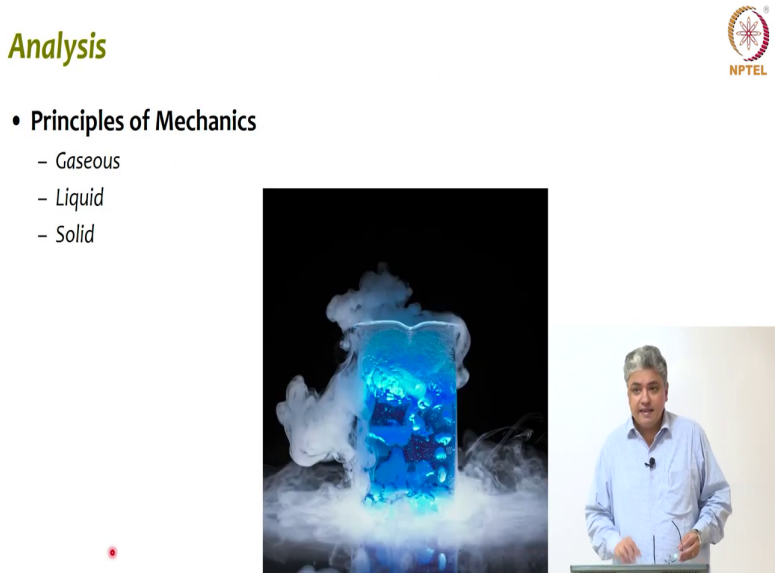

In this process when you saw when you talk about analysis and design how do you do that? Obviously, we use principles of mechanics and without going into the details of it and there are whole lot of courses that you are going to take to understand each one of these. So, we have mechanics for gases liquids and solids and pit packed. You know to our large extent in structural engineering we use solid mechanics and structural mechanics to understand to undertake do analysis and to control behavior a through design.

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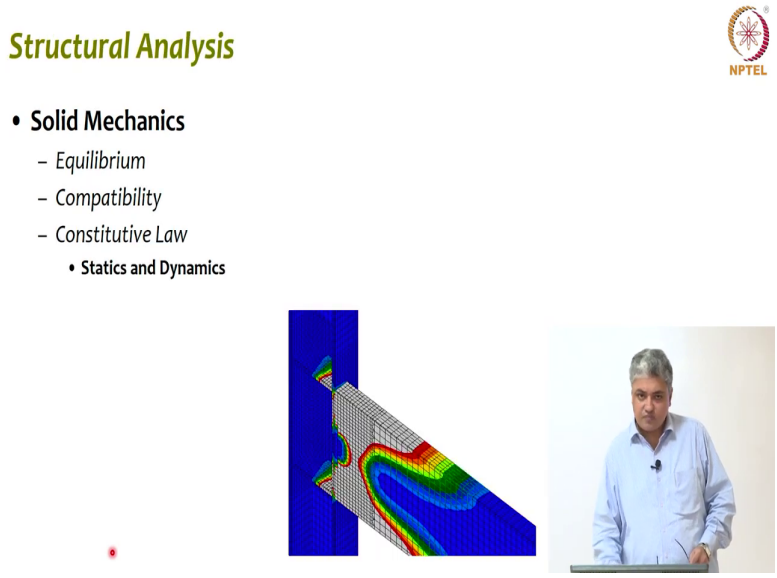

And in this, the fundamentals are the three pillars are equilibrium of forces or stresses compatibility of deformations of strains and of course, constitutive laws or which is you know how materials behave. And behavior is not just under for the given loads, the behavior under statics and dynamic conditions. So, what are these?

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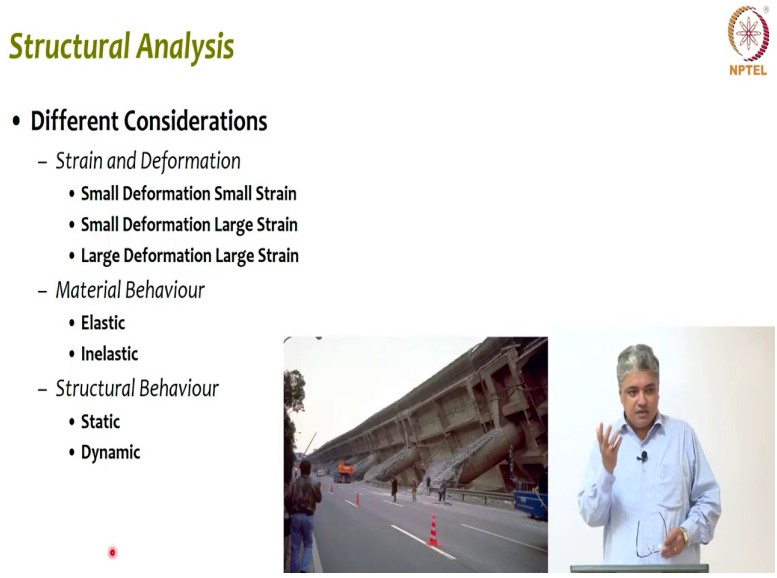

So, we saw the stress strain curve, any general material you have that. So, we can say that the deformations of the strains are small or they can be large right. When we saw the stress strain curve of the of that steel mild steel, we saw it was more or less linear up to a certain extent and then it became non-linear.

So, it remains elastic up to a certain limit or it can be inelastic. And similarly statics is where you have a load applied on the structure in a nice way. For instance, if you look at this table this table is carrying the load of this monitor and the computer and it is sitting there right. It is not changing, but sometimes you have loads which vary with time and that induces additional response in the structure which is time dependent right.

So, those kind of situations are known as dynamic situations. For instance, you have a very splendid chimney and you have a wind blowing a state. So, you will suddenly see that the

chimney is swinging swaying a little bit back and forth back and forth that is kind of a dynamic response. Similarly you see you are there will you will see a lot of videos about building shaking during earthquakes right that is another example of a dynamic.

So, when you do analysis in design, you have to there are many considerations and these are the considerations that you will be you will have to learn and understand how to use them. And only then you will be able to understand and capture how structures are going to behave and that is part of your curriculum here right. So, you are going to learn that.

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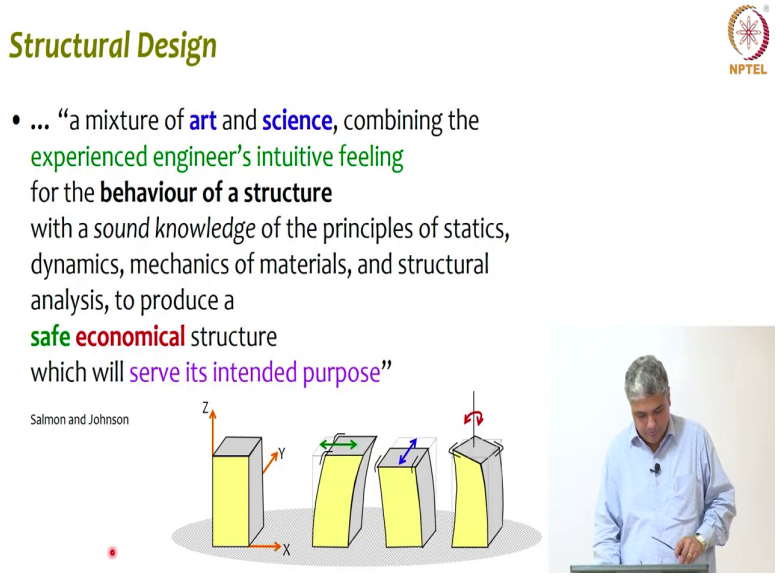

Coming to design, I mean there are a lot of ways design can be defined, but I find this particular thing extremely elaborate and very well written. It says is a mixture of art and science combining the experienced engineers intuitive feeling for the behavior of a structure. Once again the focus is on behavior of a structure.

With a sound knowledge of the principles of statics, dynamics, mechanics of materials, structural analysis to produce safe economical structure, which will serve its intended purpose; it is pretty elaborate. So, it talks about everything, but most surprisingly, it starts with this phrase. It is a mixture of art and science and this is what I have been trying to impress upon you that structural engineering is not just dry engineering, it is it is about arts, it is about creativity and so on. So, well then we will see.

Experienced engineers intuitive feeling, how do you become experienced engineer? How do you become experienced in something? Forget engineer only by practice, there is no shortcut to this right. You want to be a good singer, you have to practice every morning; you want to be a good football player, you have to practice.

So, you have to be a good engineer, you have to practice what you have been taught in every class right. Please take it; there is no shortcut. So, you have to work hard and you have work sincerely, work diligently and you will be successful in your life, but for that you have to put in that effort that is the first thing. And what is it that you are going to work for to acquire sound knowledge to acquire sound knowledge.

Not just today this is start, tomorrow in that subject that is taught and all you have to take it beyond that to acquire sound knowledge of principles of all these all these all this and this is where you will see your whole curriculum. Today if you go back and look into your curriculum, you will see all these items placed one after another semester after semester right. Such that by the end of your 4 years, you will not become an experienced engineer, but you will become an engineer.

And then you will have to start practicing and then slowly with your every project every work that you do with years of experience put in, then you become that. The other important words are safe economical structure right. Safety is of paramount importance, you cannot compromise on safety just for the sake of economy; that is another point I want to make right.

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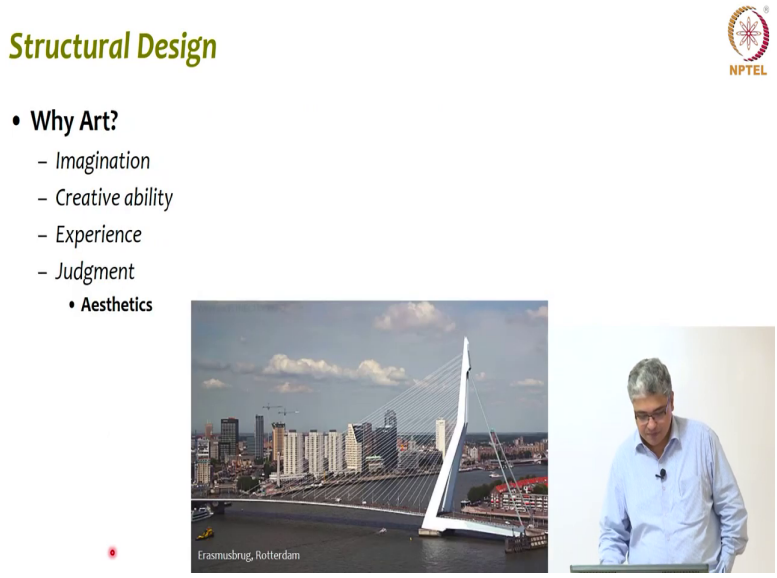

And the structure of course, has to serve its intended purpose and with we always build a structure with a purpose. So, right that is what we started our whole discussion about.

So, you can see it is a simple, we had to build a bridge. They had to build a bridge over this river and looking at the skyline of the city, they are decided to build a structure of bridge which looks like a beautiful small springing up from the river right. It serves the purpose, but you they add creativity to it and that is what is possible in structural engineering.

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Science, you have to really understand what is going on inside because if you do not your structures will show you will surprise you surprise you in a very bad way.

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So, that is why they say structural design right. This is this was a simple bridge; this was a simple bridge and they kept on adding things over and above that and then finally, look at this beauty beautiful structure that you have.

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So, that is why we said on the first day that the 5 tenets of structural engineering is not just safety functionality aesthetics, but also durability.

And economy right you cannot, if I want to have a small a shelter, I will not go and build a pyramid today with a small chamber in it right. It has to be fast, it has to be durable, it has to be economic also in addition to being safe and functionally correct.

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So, what are the things that a structural engineer has to do? Very quickly I will not go through this, I am sure there are other you know occasions where you have been told about how civil engineering project goes, but the basic components if I look at it, it is if there is a design process. And then there is a administrative work including contracting and so on so forth.

And then the structure has to be constructed or the system has to be constructed. So, there is fabrication and construction, but there is one more important thing, which we often means is operation and maintenance and maintenance. We are very bad at maintenance, trust me. We have to develop that culture also we build lot of good structures and then we do not, we think once it is done. It is our job is over our job is not over, we have to continue to monitor it and do maintenance and operation.

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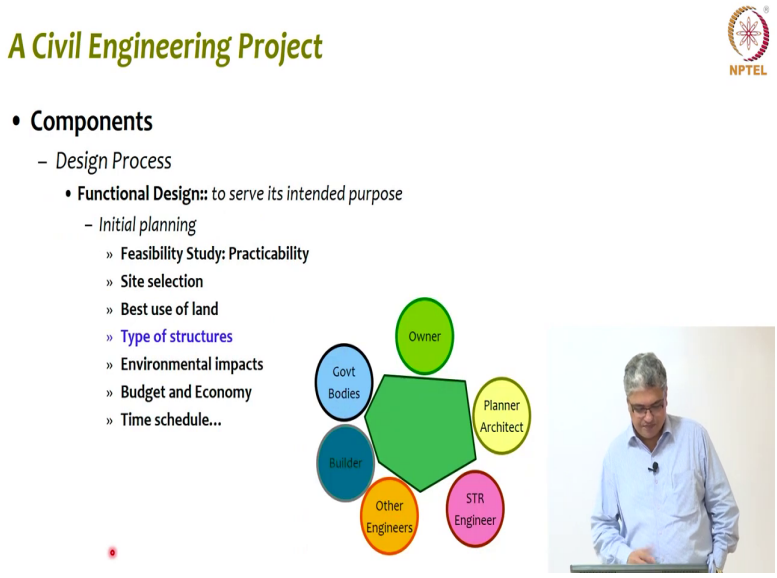

Very quickly, this whole design process actually has two major parts. One is the functional design and this is where the whole feasibility study is done. Today, you will hear lot of these you know feasibility study is an important aspect you need to get so many clearances and so on so forth right. But one of the important part of that whole study is what kind of structure to build I need to build a bridge, what kind of a bridge of what material of what system I need to build a structure a building, what is the kind of building, what structural system do I use, what material do I use.

So, all these decision making has to happen here and they often say that if you make if you do not put in enough thought enough thinking into this process, then by the time you start executing the project you will find that there are lot of difficulties right. So, this is an important step and this is where lot of players come into the picture. And as you can see of

course, you will have the owner, you will have the planner or the architect; you have other engineers government bodies and so on so forth.

And you also have the structural engineer and the civil engineer right, he or she has to start participating from this stage. It is not that let them all do everything; we will come at the end because your input is also very critical in shaping the project in the first place.

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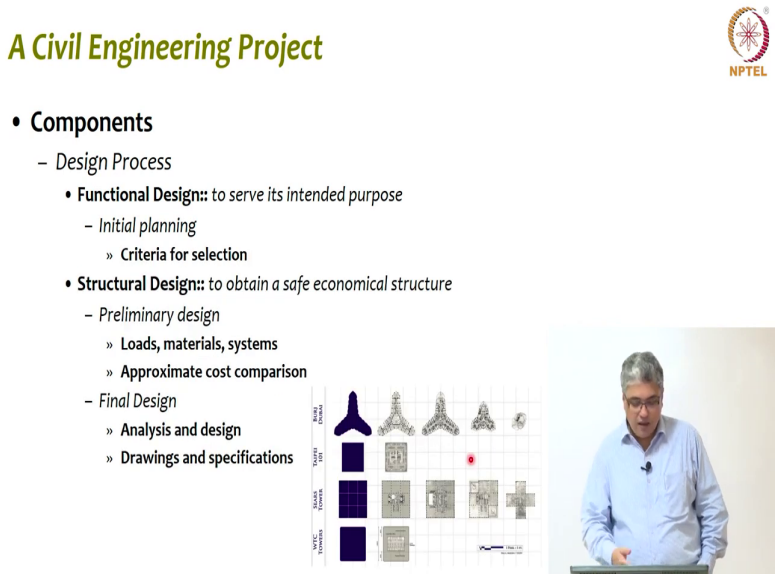

And then once that is done then of course, you will have the structural design and in that also it is not a one step process, it is an iterative process where you first do a preliminary design you understand systems and so on so forth. And then an important task that is to be done is cost comparison; because you have to do it economic way right. And this is where again structural engineer comes in and plays a very very crucial role, plays a crucial role in doing this

and finally, once everything is kind of frozen. Then you go and do your final analysis and then finally, drawings and specifications.

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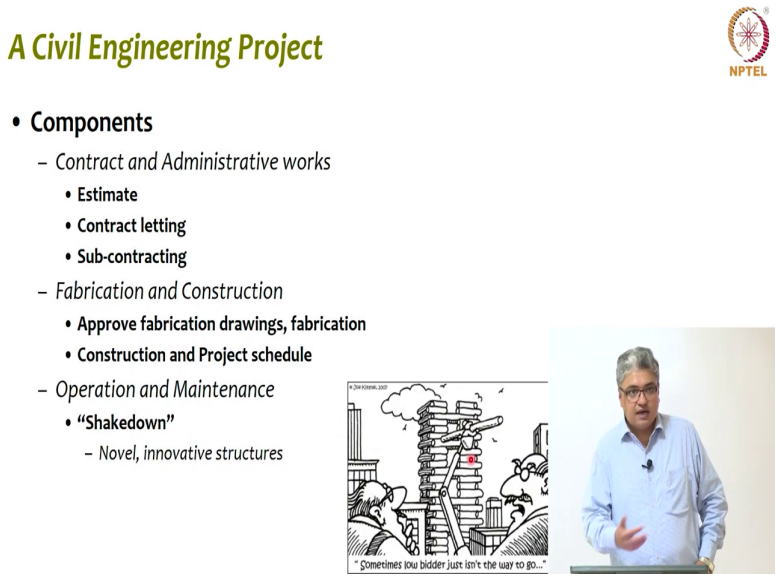

Right that is not all; in the administrative work also contracting, estimation and approving of fabrication drawings actually supervising construction; everything is our important activities where a structural engineer has to play a role, including what we are talking about in terms of operation and maintenance and so on so forth.

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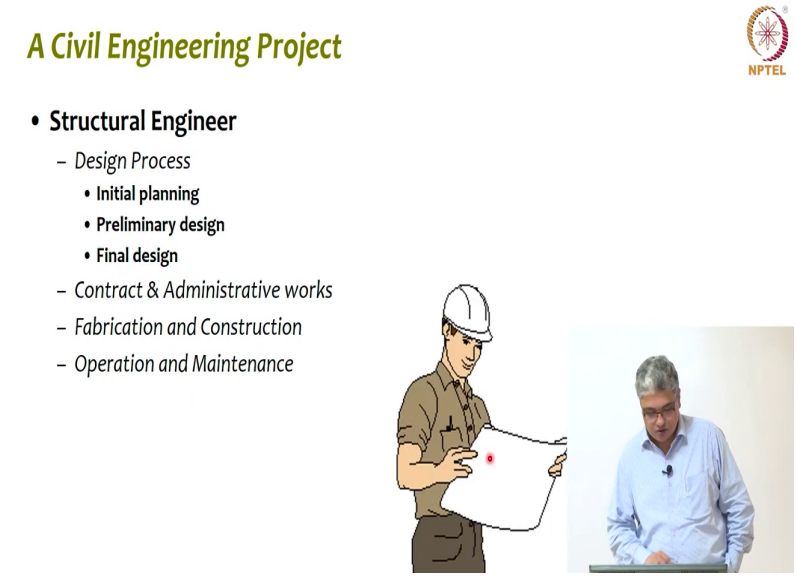

So, a structural engineer takes part in each and every activity that you see in a whole project a civil engineering project right.

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And therefore, the responsibilities are very high for a structural engineer or a civil engineer. So, to speak first of all you have to be technically competent right, you have to know what you are doing, that this is true for any trait; any trait you take this is true.

At the same time, you need to develop administrative skills also because, it is not just you one man cannot build you know make a whole project such a big project. So, you have to work with people and you have to manage people also right. You have to understand economics of project and you have to interact with people and you have to understand social aspirations and so on so forth. What the community wants from you right and so on and so on and so on so on. There is whole lot of responsibilities and duties that a structural engineer has to play in a successful completion of a project right.

So, you have to develop in calculate all these qualities in you if you want to be a successful engineer, if you want to be a successful structural engineer. And if you do that, if you manage to get all these qualities, it is needless to say that often you will find yourself being the team leader of such a big project. Because a team leader is one who has who understands each one of these items and who has capability to hand capabilities to handle each one of these items right.

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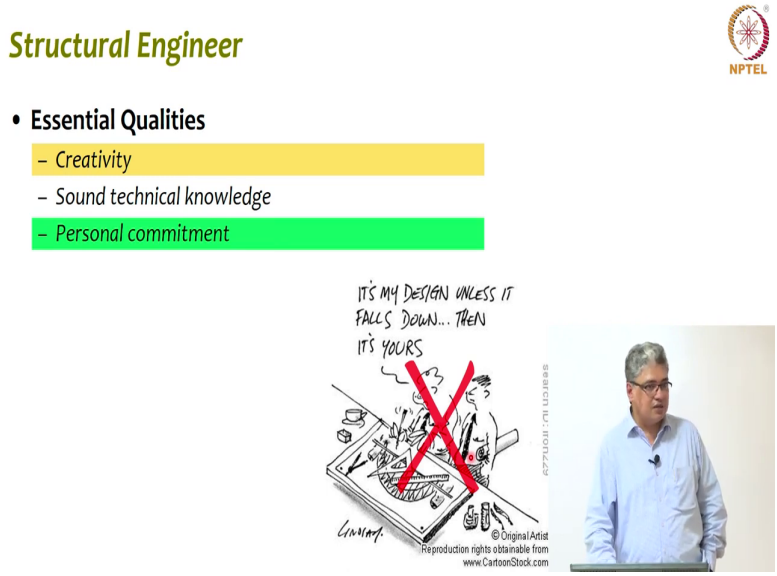

So, that is very important and that is why say that you have to be open to ideas and have new ideas do not they you know be scared to try new things. We saw the mixing and matching of different systems, different materials right. Somebody had to take that call some day that ok; let us do it this way. People have done, this people have done this can we mix both of them together right that is creativity. Of course, sound taken in the technical knowledge and

personal commitment. I like this cartoon and I show this cartoon, but just to say this is not the right, this is this does not reflect a good professional engineer right.

So, this is not the right thing to do and we will not do it. We will take responsibilities of our actions, we will be committed to our work and we will do good work. That is the commitment that all of us will make towards us over selves.

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I will stop here; I said this will be a very brief one as usual I have taken photographs and all from the internet and I am grateful to all the original contributors. If you want the links, I will give you all the links.