Structure, Form, and Architecture: The Synergy

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Lecture - 01
Introduction to Structure, Form, and Architecture

Hello everyone, welcome to the NPTEL online certification course on Structure, Form and Architecture. I am Dr. Shubhajit Sadhukhan, Assistant Professor in the Department of Architecture and Planning, IIT Roorkee. So, I am offering this course with the aim to get some better understanding on the structure form and architecture, which are seem to be very important for specially the students who are pursuing architecture, and even the civil engineers or the architects. Because this lecture will give you some insight on the better understanding of selection of structure real system and then the form selection which will actually support to make our architecture the way we want.

And today this is the lecture number-1. This is Introduction to the Structure, Form and Architecture the synergy. Before I really start this particular lecture, let us jut understand this subject. As this name suggest structure form and architecture it comprises of three different terminology. So, let us understand what we understand by structure.

So, structure has many definitions across different fields. So, pertain into a building design or architecture, structure is basically a combination of different part and parcel they act together to support the system, where the form is the visible outcome of any object. And architecture is basically the process which will include different thinking, creativity and apply with the science and technology to create some outcome, the articulation of space. And the synergy is basically the strong association with all this terminology.

So, in this particular course what we learn? We will learn different type of structure that may be used for the architectural design, different form which can be supported with the structure, and different piece of architecture where we have the application of the structure.

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Let us start with these two photographs, so two buildings. I just placed on the first slide the one is a museum building designed by famous architect Zaha Hadid; the other one is Burj Khalifa - a tall building a very famous building in Dubai. The reason behind putting this two pictures in the first slide to understand the essence of it. The first one the museum we can see this is basically a form which is being created with multiple curves, and being supported with some steel glass and other materials to give a pleasant look. We all appreciate it; there is no doubt on it. The other one is the Burj Khalifa - a tall structure, and it is really fantastic to watch.

But this is the final outcome to bring this into reality there are different processes, so one has to design it, then visualize it, and that has to be supported with the structure. So, can I say that

this is only the form based creation or it is just the imagination rather it is a combination of all this, and that is what this subject is made, but these are all new buildings.

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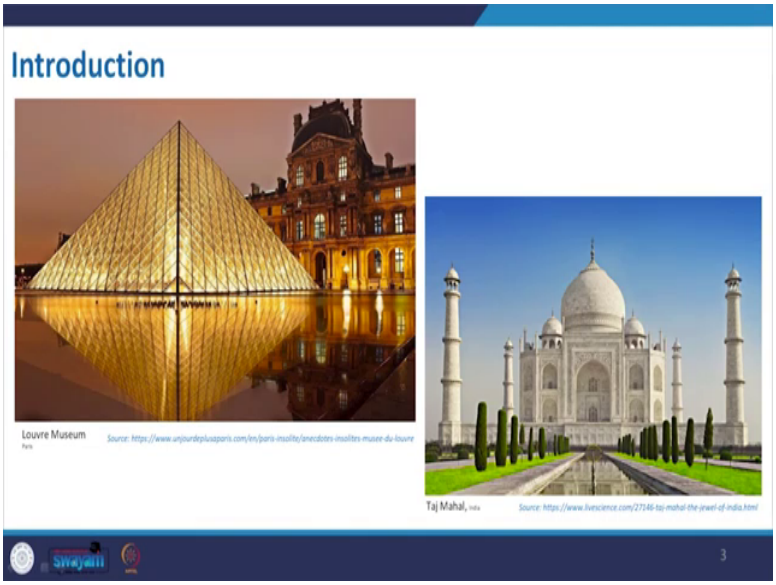

So, let us see this. This is not much new, but again another you know wonderful architecture that we all admire we all you know appreciate one is the Louvre Museum which is basically a transparence you know outlook, and having this pyramid shape. The other one is in India that is Taj Mahal; it was made long back. But with the perfection in the symmetry and as well as the stability still we can enjoy this environment there. So, this is another example.

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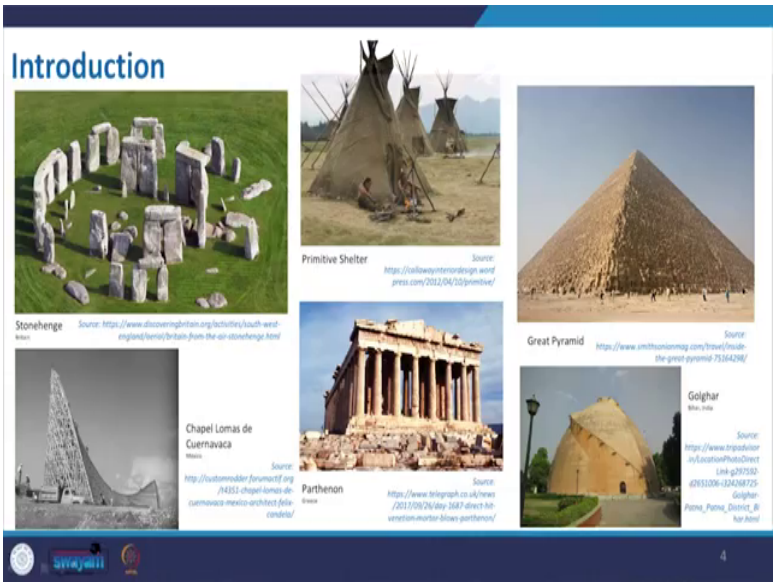

Now, not, it is not new in practice even if we go back to the primitive edge from there also like people they invented different type of shelter, different type of structures and form which actually you know make us wonder even at this age. One who is start with the Stonehenge at the long, long back then the primitive silt and the pyramid. We all know in Egypt, there are lots of pyramid, the example the huge mega structures the execution of that with different kind of material form really it is surprising to us. Even that is true for the Parthenon in Greece which is the series of column that is supporting a structure.

And apart from that we can see this is a curve form structure or a design by Felix Candela - the famous architect and structural designer, and in this side the Golghar that is situated in Bihar, and this is basically a structure which is appreciable. But at the same time, if you look at the broad perspective without much not going much detail into the structural components, so these are basically a form. One is a maybe the you know spherical form, one is the

canonical form, somewhere it is a cuboid one, sometimes we use the complex curve with the hyper bola or a parabola, and sometimes it is a pyramid very straight away. So, it has a relation.

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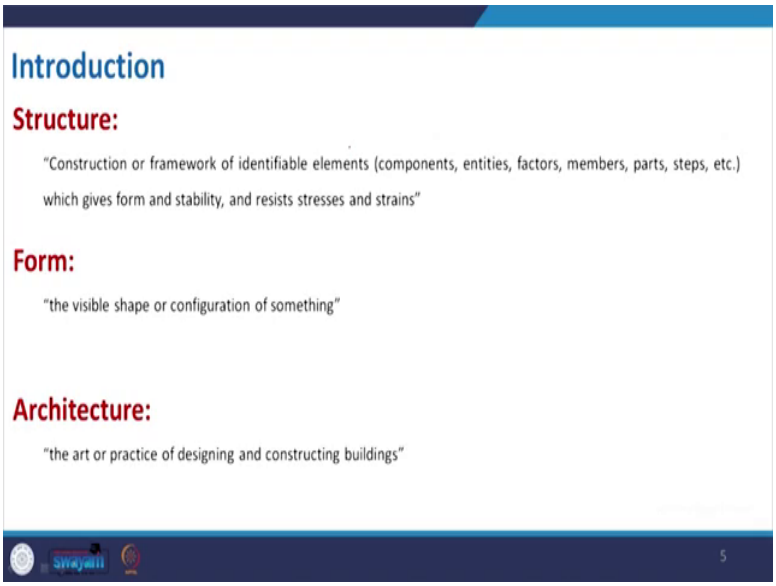

Now, as already I mentioned that if you look into the definitions, it will change in different subject. So, we just strict ourselves to the definition that is applicable for the building design also. So, structure is a constitution or framework of identifiable elements, different components, different you know parts steps which actually need to be figured and need to be combined to act for a purpose and which will make you know your design stable. It will give a form and resist the stress and strain. We will later on we will actually see all those terminology stress-strain in detail though those are very basic, but again we will touch upon that what we understand by stress-strain of a structure.

Then come to the form, the definition of form the visible shape or configuration of something. So, what we can see because of the light and because of other physical parameters, so basically the outcome that is the form. Sometimes it may be spherical; sometime it may be conical; sometimes it is regular 3D shape or sometime it may be a combination. We add some septic form, or some time we go for the additive form to make a composition and give a look to our form. And the architecture I am pretty much sure that you all know different kind of definitions, different definitions of architecture given by different architects and different sources.

So, here it is basically one of the definition; I have taken from dictionary that architecture the art or practice of designing and constructing building. So, sometimes architecture is not limited to building or space creation, sometimes it is also include some other parts. And sometimes also like we create some outdoor architecture it should not be the meaning the you know meaning I just want to convey that it is not always architecture means a closed form enclosure, it maybe something semi open or sometimes even it is of different combination. So, these are the definitions we know.

But looking at the definition, it is not really very clear the association or the synergy that we are talking about, but they are having a relation definitely a form, we say it a stable because of the material used to build it or maybe the structure backup which actually made it stable. In the architecture also sometimes it is just created by the function that we require some space and we just measure that space and we build something some enclosure. But sometimes we can generate with the different form, we just be determined. So, it is a intuitive poses which will help us to create this outcome.

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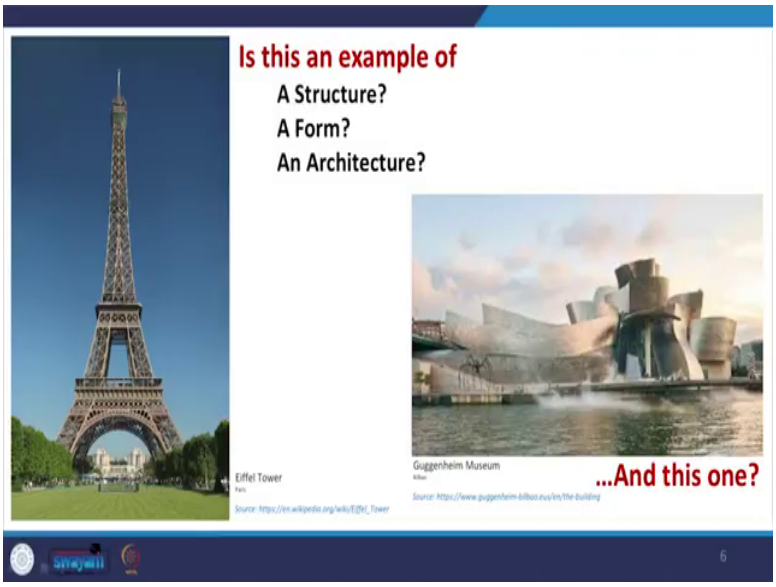

Now, here I place two photographs again and taken from two you know different wonder piece of architecture one is Eiffel Tower in Paris, the other one is the Guggenheim Museum in Bilbao. So, my question to all of you looking at this photograph the first what comes in your mind is this is an example of a structure, or a form, or an architecture? Already though I mentioned that I have taken these examples from great architecture, but still the option is on.

So, some of you may say that Eiffel Tower is a kind of latest structure is made of steel and is a creation is a structure. And I can debate on that that maybe it is a just a form that is being created with the perfect symmetry with some scale and proportion. And as because it has some utility spaces, so we can also say it is architecture. So, if I get a definition in this case, all definition all answers will have the you know right sense. So, we cannot really distinguish.

Now, come to the other one the Guggenheim Museum is a very complex design and developed on the mathematical calculation, and all different surfaces, different curvature, the application of material. So, it is something a form which actually they pick some transition and create this beautiful piece of architecture. So, again we cannot define these two photographs with a single answer, we cannot discuss other two answers from this.

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Now, this is a simple photograph that depicts all like. What comes first, structure, should we start our design with the structure keeping in mind, or should we start just the form? So, it is very tough question. Yeah, to me, it is very tough because you know when for a student of architecture when we give this subject, any design assignment, and ask them to design it, so we give them some requirements. So, whether they will first start with creating the you know

form of that or they have something in their mind about the structure they can use, so it difficult task for them.

But definitely we cannot neglect one for the sake of the other one. So, we have to give the equal emphasis to both of them the form creation as well as the structure probable structure that can be you know considered for making that form. So, we need to think this simultaneously. So, for making it very comprehensive, very stable and you know great outcome that we want from the design, so we need to think both. The form that can be taken off the structure that can be you know helpful to create that form as well as overall it will give the architecture that we want.

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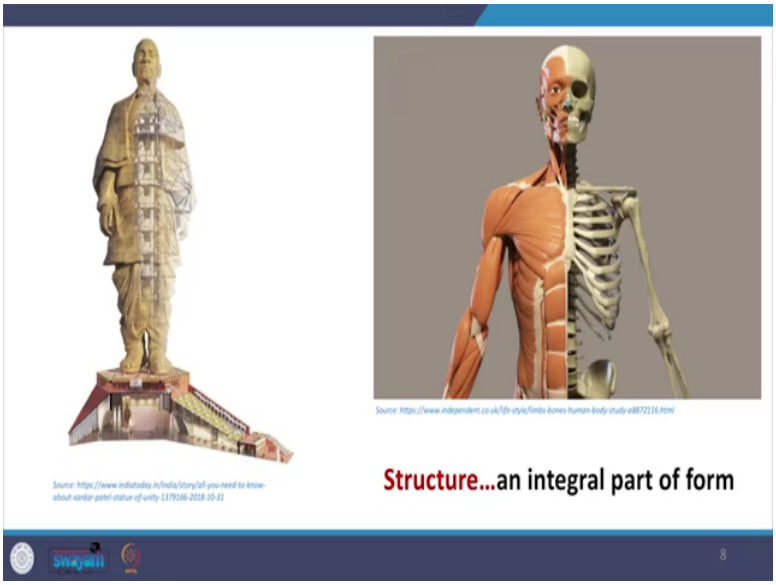

Now, the next slide, this slide is basically a representation like again a then continuation of which comes first. So, it is very difficult to say that time. But in this picture if you see this

skeleton and the mask that creates the beautiful human like us. So, always if we appreciate the outlook is basically what we see, we can appreciate the human looking good and all. But at the back it is being supported with the skeleton the bone and also that is being will structured. So, that is another important thing though we have different parts of the skeleton different components, but if they are not tied up in a right manner, so we cannot function, so we cannot appreciate.

And that is so true even the recently build the statue of unity, it is a huge structure, so the outcome is looking as its sculpture, but if you see the construction. So, it is made of different structural element that are combined together to give this stability. And end result you can all see this you know really a great structure or you can say this sculpture or the form, or even the space created once I did the architecture.

So, looking at this two slide what we can understand as of now that we cannot think structure and form separately. So, structure is an integral part of the form. And we should keep this in our mind when we take up any design, so that form the day 1, we can actually start thinking of the probable structure that can be used for the design, but definitely we cannot fit everything everywhere. So, based on requirement, we will fix it.

I give you another example. Say for example, I have this pen it is a very simple design, but it is not that much simple. So, basically the result we are getting from the refill. So, in this the refill is a very tiny thing. And if you just give a try to use that refill to write, we will not be comfortable, but when we use the body of this pen maybe of plastic or maybe of metal to give the grip. So, one thing is your basically the anthropometry and the ergonomics which will help us to make the grip, this is one point. But at the same time this body will make it more stable, so that you can use it very comfortably. So, like that in each of our creation to give a you know solid or maybe a stable you know outcome, so we have to think about the structure how we can fit it.

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Now, this is one example from a Beijing China, so that was built recently the Bird Nest Olympic stadium. So, this is again another example of a structure which is inspired by the nest. So, here we can say the form was taken; the initiation is just a bird nest. But the execution the proper alignment of the beam and column, it is very important here. It is not so much regular that we will often see in our building, you know regular buildings. So, this, this is another example where you know the form is predominant then the structure, but again to make it happen to get this failing that we can resemble is with the bird nest that has to be supported to the right type of structure.

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Now, go back to the next go to the next one. So, this is another example of the form. So, this is a photograph of TWA Terminal, and this is basically the main terminal building. So, looking at this picture who are actually you know have studied the contemporary architecture and I am sure that they know this building, and this form creation is like to inspired by a bird. So, it has a relation with the airport, so rather the aeroplane. So, they both are flying or with that concept, it is developed.

But the roof structure, if you see that is very important to think about the type of structure to be used. And who are having experience of you know the airport any you know international airport or a you know standard big airports, so we need some huge span whether it maybe a example of our Delhi airport or maybe the Kolkata airport or any airport if you visit, so we need that span, so that people can move easily. So, to get that span we need some kind of

structure which is not regular beam and column maybe. So, how to select that one is another challenge.

Again if you think of a form like here they have use the form of a bird, so the challenge will be even more to how to implement it. So, again it can say we can say that this also this represent that the structure is an integral part of form, and we all now come to a point where like we get those examples and we can correlate it with this.

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Now, next two slide, this one and the next one, we will see some of the forms which is already present in the nature. And next slide we will see some form which is basically the man made. And the structural form that we really aspire we really you know appreciate those things, one is the cave and it is maybe the you know the first shelter of that particular

primitive age, what which was created naturally and the form it is making stable, so that people they can feel some safety out of the externalities and all. And this was very useful.

Now, to address this, I just want to extend it, basically like why should we create the form, why should we create the architecture, the basic need of architecture or a space as we consider that the shelter is one of the basic needs of you know survival. So, basically if there is no need, there is no invention, no design.

Now, for the shelter the purpose, if we go back to the history, so in order to save like our primitive age you know ancestor, they actually had to you know save themselves from the externalities from the other animals and all, so that is why shelter was much needed. Though it was a tree house or the cave, or later on they invented many other things to you know get survived from the externalities, so that was the need. So, that creates the requirement to create the space the enclosure which will be safe. But at the same time if that cave not that much stable and can cause some of the other problems to the in habitats, so purpose is not solved, so that is why the stability and the safety. So, these two terminologies, we will use later on quite frequently to define the structural need.

The other one is a bird nest again is a fantastic creation, and it is really need some perfection. So, if you see in due course of time, I will show you this particular nest in detail like how they have made and it has a purpose to lay their eggs, and then how they make it very safe from other you know external externalities, other you know dangerous this birds. And in this particular form it is basically amaze looking form, you know very close picture it is just a zigzag of some of the fibers and all, but overall it is creating that particular sense and a good architecture that we can always inspire. And from that now it is this kind of nest being use or we can see it in our interior as a means of your lighting or something.

The other one is the honeycomb. This is another beautiful piece of creation where like the bees, they made this hexagonal shape and it is so accurately done. So, this is a form and in order to stabilize it how they have you know made it, we will also discuss it in due course of time this kind of structure. So, in the lecture profile like you know number of lectures, the one

such topic will be of the architecture and you know structure created by different animals and birds.

Now, again the example of the spider wave, so it is strong enough for them to you know you know stay or use that as their habitat. So, this is we can relate with some of the cabled structure and also, we get inspired by that. And we can create some kind of structure with the roof like rope, and we make it. The human skeleton already have depicted it with the picture that this is the backbone. So, everything we do even today I am standing, I am delivering the lecture. So, basically it is supported by the structure. So, along with this skeleton like all the bones and with the you know mass, it actually formed and make it make me able to speak.

The other one if the other example, so if there also we can create it has a relation with the golden mean ratio I guess many of you know this ratio where it is basically a form like where its create some of the involute and it is a really beautiful creation. So, these are very few of them that I could able to put it in the slide, but there are many. So, basic idea of putting this to get habituated with a form that is already there in the nature and their structure, so that we just modify a little bit we can take inspiration from this example and we create our solution keeping all these in the mind. But based on the requirement definitely things is going to be change.

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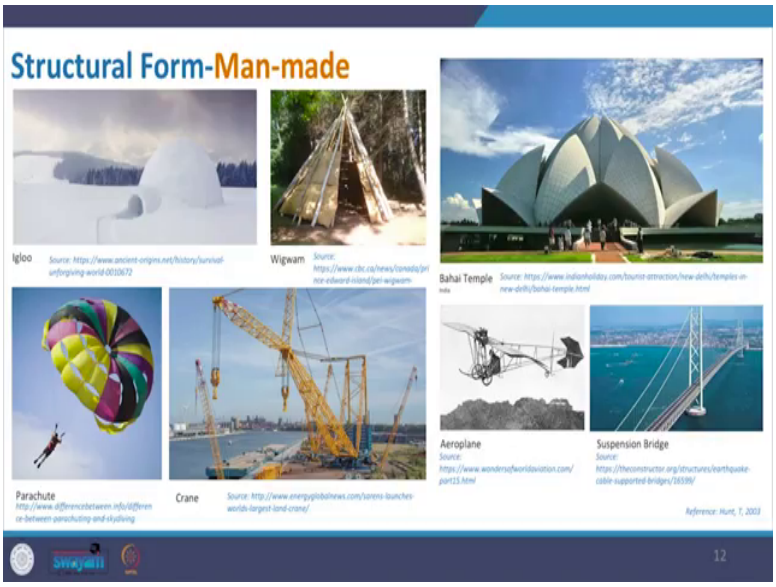

Now, these are some of the man-made structural form where Igloo is another structure which is being made in you know, in case to get the comfort from the outside like to save our self inside and get the comfort from other externalities outside in that. So, Wigwam is another structures very simple structure that also help to get protect it from the external thing.

Then even we create something like you know your kite or maybe the aeroplane or the parachute, the acts with something with the air. So, like sometimes we had this term call aerodynamics, and this is the principle why are all this flies and other thing. So, this is another helpful tool or the term that help us to decide upon the selecting some kind of structure for taking into consideration this aerodynamic properties.

Again we create the cranes which is another you know supporting system, I would say to create the beautiful piece of architecture that really helps with the you know levers and other

thing this crane is created, so that it can help us to build the structure the wave we want and at with time.

And know another invention that is the first aeroplane that is again acts with a aerodynamics and all. And we can see the example of the corner that is a suspension bridge, and we really appreciate and there are lots of suspension bridge across the globe which really you know because really think about how it is so much architecturally pleasant and strictly looking great as well as it stable. So, how these are acting why it is being made with the suspension cable or is making a tensile structure. So, we will discuss this kind of you know structural form being used for different purposes during the course. And the courses design in such a manner that we will design each component different type of structure and form to create this.

And last, but not the least in this slide is the example of a cell structure which is situated in you know India, Bahai temple. And this is another example where like it is a meditation you know hall being created where like this cell structure is help and how it is creating the form of a lotus and sometimes we also refer it as a lotus temple. So, we will see this thing how it really acts.

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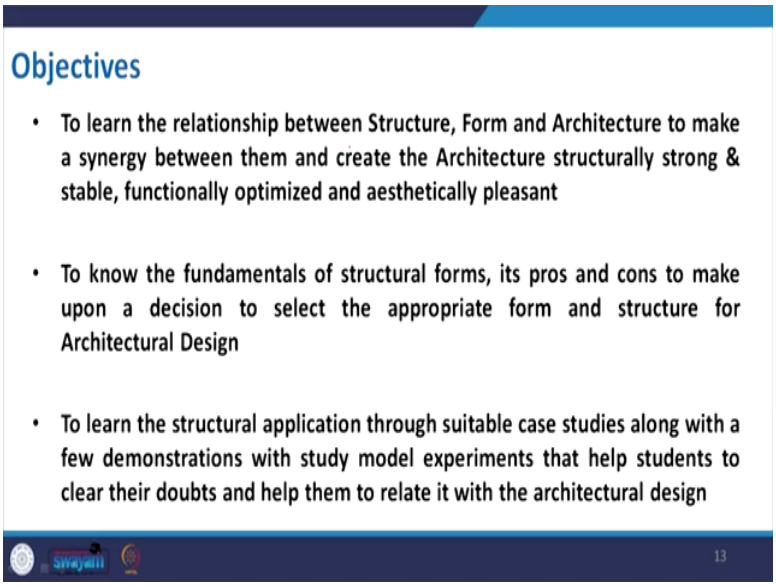

Now, moving on to the objectives. Now, to be specific the main objective of this course is to learn the relationship between structure form and architecture to make a synergy between them, a proper synergy can only work and create the its architecture structurally strong and stable, functionally optimized and historically pleasant.

So, if I make a structure very strong enough and stable enough, but hardly we have a any place to live in, that means, our purpose to create that space is not fulfilled. So, probably our selection of that structure or element is not appropriate. So, we have to also satisfy the function or the requirement of creating architecture, and after all the last but not the least is to look it very impressive aesthetically pleasant, so that everyone looking at the building appreciate they enjoy that particular creation,they appreciate, they give a value to it.

The other objective is to do the fundamentals of the structural forms. So, here we will not really go into detail of the mathematical calculation of those structural things, but main idea is to understand their behavior their fundamentals and their pros and cons to use for a certain things. So, it will help us to make a decision to select the appropriate form and structure for our architectural design, specially for the students who are just started the architectural design maybe in the second year or maybe the in second semester of first year, this course will really help them. Because when they start the architectural design at the same time this course will give some input from the structural point of view the structural form that they can use to you know improve their design solution,they will not stuck into that.

And again to learn the structural application through suitable case studies, it is very example there are successful stories. So, we will explore that. And what is my idea I will also present you some of the you know model and we will do some small experiment to believe in that particular property how it is going to help to our requirement, and it will definitely clear the doubts that we had normally in our student's days also we face that problem. So, it will clear the doubts of those things and help them to relate it with the architectural design.

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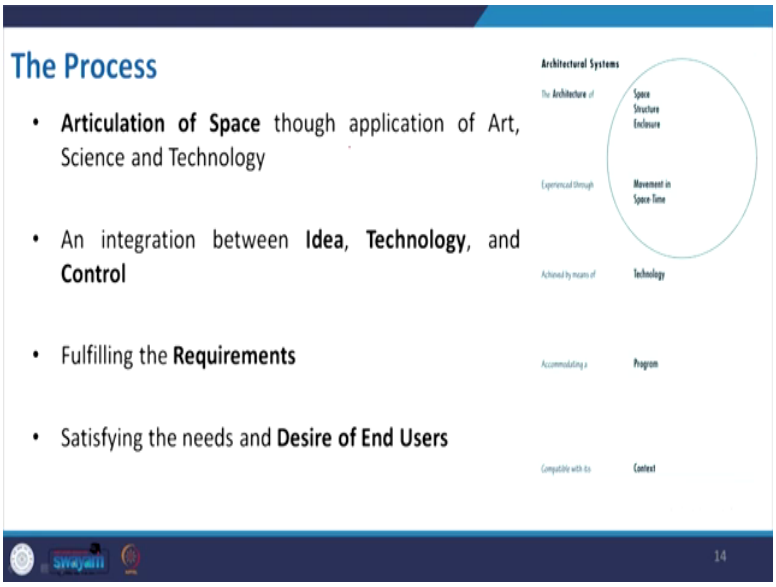

Now, come to the process like architecture is basically the articulation of space through application of art, science and technology. So, we all agree that first we have to be very much imaginative, and we have that creativity to create something really appreciable, and then we have to make it real with the application of science and technology. This process also includes an integration between idea, first idea should be there to create something innovate innovative, then the technology and the control. The control is very important where we manage it, and then definitely the one of that process enclose the fulfilling of the requirements.

So, if we fail to fulfill the requirements, may be the solution will not be appreciate. Satisfaction satisfying the needs and the desire of the end user the how the way who are using it who are actually you know experiencing it, how well we can satisfy them to that. So, this is

the process of these in a summarized way where like as like when like we go to an architect for the design.

So, basically it is between your user design and developer, developer maybe the builder in this context to have a design solution. So, always there is a process ok. And feedback like user the client come to an architect, so say the requirements I have want to do this and I have this much of fund or something. So, architect will design something.

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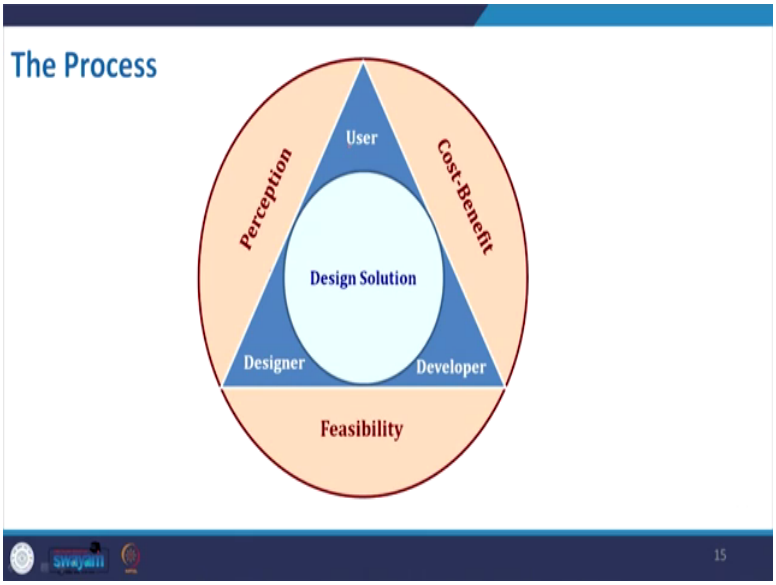

And then it will have a cross checking and feasibility and cost benefit. So, basically it is optimizing everything, so fulfilling all needs, so that the final outcome will be as desired. And during that particular designer, it includes good architect structural designer, many other designer, many other engineers, so that it can be done in a comprehensive manner and give the outcome.

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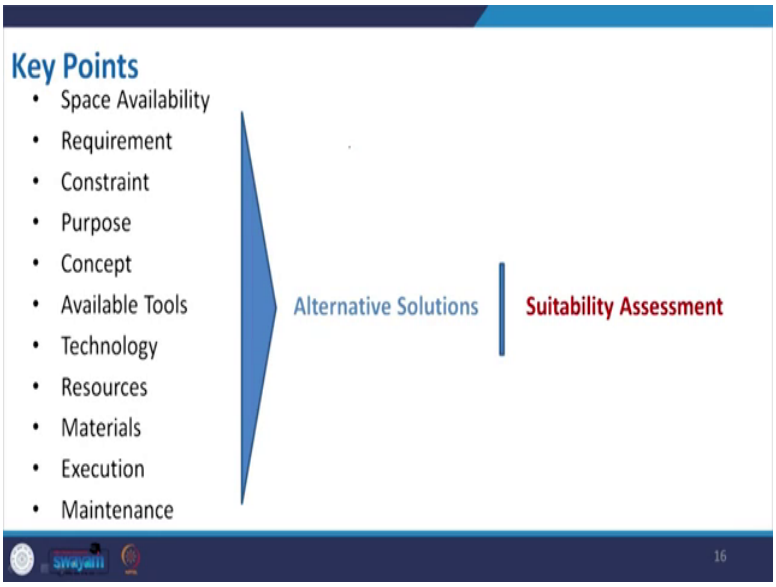

Some key points that I just want to highlight in this lecture and definitely we will go into detail in our coming lecture. So, key points that we have to decide upon the structural form and all, the space that is available, the requirements given by the client, the constant different constant may happen that your structure to be built in earthquake prone area or in the flood (Refer Time: 33:00) area, then what is the purpose of the structure that is whether it is a like huge activity hall or the you know you need to make it for a huge convention hall or it is just for a small residential building, the concept that idea that create the form and all, the available tools that will make this design.

The technology definitely day-to-day the technology there is a huge improvement, so how we can integrate that with our design process then different resources along with the manpower and other resources, so that we can optimize. At the same time sometimes we although see the economic viability, then the materials to be used how this can support the form and the

esthetics that we were looking for execution. So, after all everything we have and finally if we fail to execute in a proper manner, so that we will not really give us the required or desired outcome and the maintenance.

So, based on that definitely during the process, we make different solutions alternative solutions, and we go for a suitability assessment to pick a the best one that can fit.

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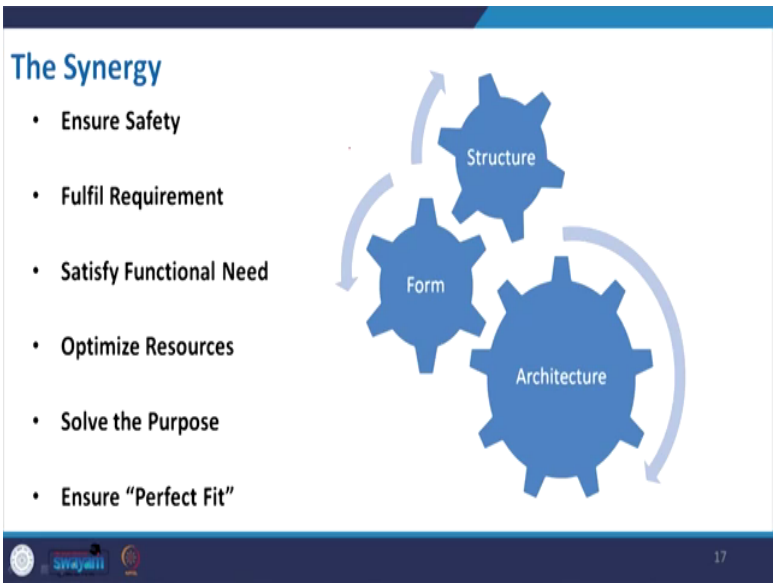

So, now we are almost you know into conclude this particular lecture. So, the synergy we talked about among form structure and architecture there are different objective definitely. So, this synergy, proper synergy will ensure the safety of the user, fulfill the requirement very obvious, satisfy the functional need. So, one of the primary you know points that we have to look into and the optimize the resources, resources as I already mentioned it may be the material, it may be the you know cost, it may be other manpower etcetera, solve the purpose.

So, as purpose was one of the you know like initiation to create something new, so anyhow this synergy should solve the purpose what we actually desired, and then the ensure the perfect fit. So, taking the best synergy, best alternative to have the desired result.

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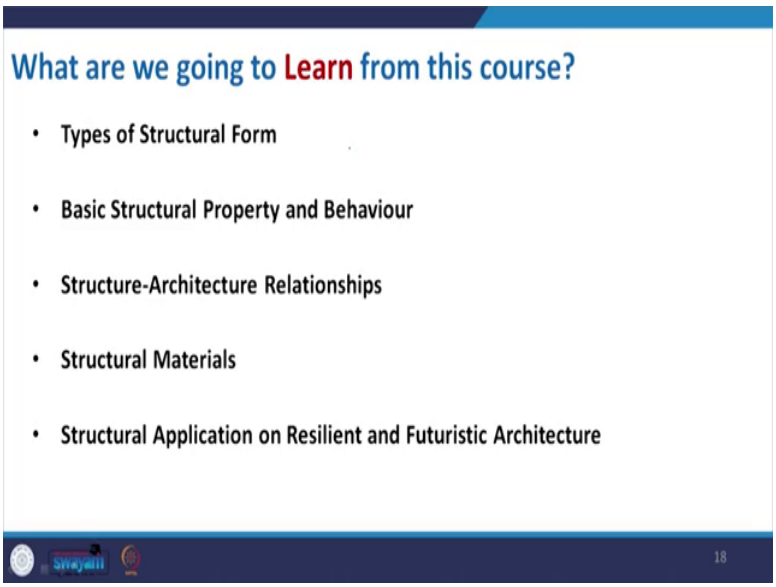

So, basically now coming to this slide what are we going to learn from this course. In this course, we will learn the types of structural form, define forms, basic structural property and behavior of them to know where they can be you know applied and where not, structure architecture relationship how they are being related from the past to the recent time, different structural materials that are very helpful to create different kind of you know wonders in architectural field, this structural application on resilient and futuristic architecture.

So, resilient and futuristic architecture what we are talking about this is the need of the hour where we have to make our thing resilient with the you know natural disaster or manmade

disaster. So, how we can do it with the case study. Next lecture we will focus on relationship of structure to the architecture buildings as of like this is our focus to related with the buildings. So, I think this will help you a lot.

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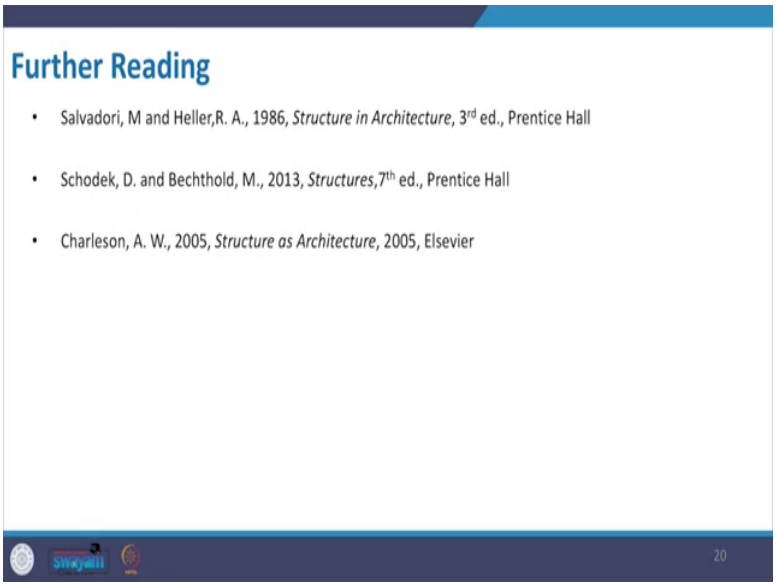

And this is the reference you can go for the further reading.

Again I would like to thank you.