Structure, Form, and Architecture: The Synergy

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Lecture - 02
Relationship of Structure to Architectural Buildings – Part I

Welcome back to the online course Structure, Form and Architecture: The Synergy. This is Lecture number – 2, Relationship of Structure to Architectural Buildings. In lecture number 1, we just started with the introduction where we learnt about different aspect of structural form and its synergy with architecture and we have seen not only in nature, but also in manmade world we have a strong association with the structural form and architectural design.

So, in this lecture, basically this topic is being divided into two lecture, lecture 2 and lecture 3. So, in lecture 2, we will try to understand in detail the relationship of structure with the architectural building.

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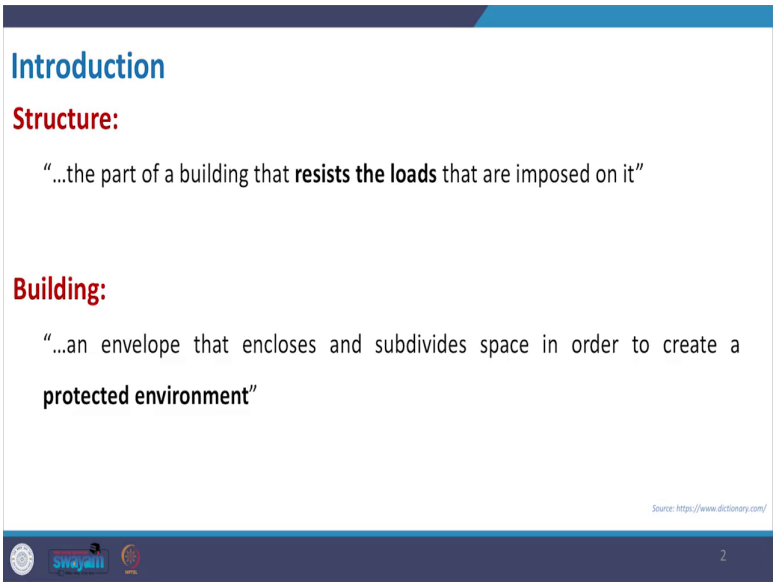

Now, again we just refresh our mind with the definition as I already mentioned that the definition of structure or building or architecture, we will get different kind of definitions from different sources. But to understand in pertinent to the building an architectural design, we just put it like this, the structures the part of building that resist the load that imposed on it.

It is very clear and straight forward answer that suppose a building is a structurally build very strong; that means, the load the external load or the other dead load or live load, we will talk about those different kind of loads in upcoming lectures. But basically we all understand what is load.

So, it is the force on that particular sub surface or the object. So, it should have that I know capacity to resist it from collapse. So, the part of a building that resist the load is basically the

structural element and all together when they actually you know put in a right manner that composition of that element will make the structure of the building.

Now, what is building? Now we learned a definition of architecture where it was said the articulation of space with the help of your the application of technology different you know science into it. Now let us see the definition of building, it is an envelope that encloses and subdivides space in order to create protected environment. Already I mentioned in lecture number one well like in the primitive age people they start building because of you know they had to protect themselves from the external dangerous; it may be from the whether it may be from the other animals.

So, this safety the protection was the need to make something called shelter and this is an envelope that we normally named as building, but in a building it may be a single like lecture room like the room. Now I am standing on it and it may be like a series of rooms put together to fulfill our need. Say for example, if we take example of a residential building. So, we have bedroom, we have drawing room, we have a like toilet then kitchen area. So, basically it is something the division of space for as per our requirement.

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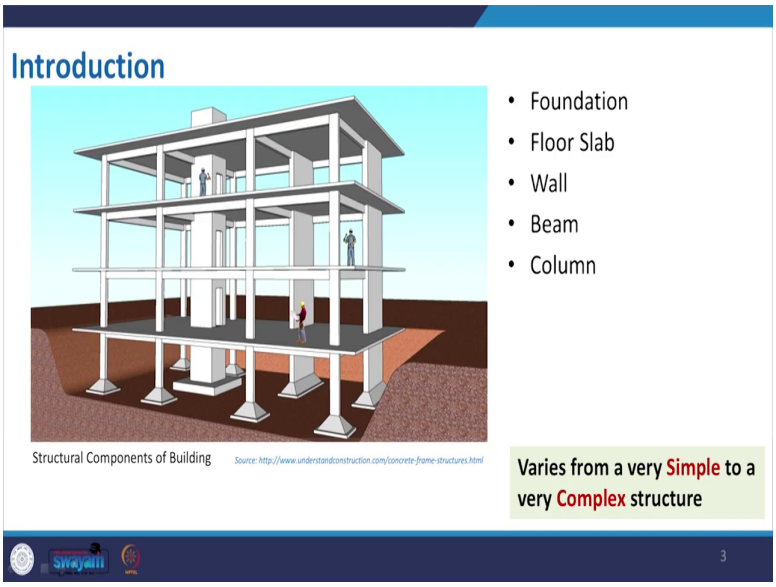

Now, in this particular lecture, we will try to see the close relationship of structural application to the building. Now to start with, this is a very schematic diagram in this slide where it is just you can say the under construction building. So, here different components of a building structures been shown.

So, it start with the foundation that we have you know seen like it is the anchor like the tree, they have the roots to hold it the canopy and the branches like that for a building. So, we need foundation and that should anchor like this will anchor the whole building with the ground. So, that it can stand safely then also it consist of some vertical structure and some horizontal structure

So, vertical means based on its position. So, we can say wall column etcetera and then also to support it like a frame structure, then we also need to put beam adequately to connect them and then to have this space usable so, we have to create different slab.

Now, composition of all these like beam, wall, slab and foundation; they will make the skeleton. Like in the previous lecture, I have shown like one image with a human skeleton and the outer you know surface. So, like that what we see in the building, this is basically the final outcome. But before that inside that there are like a bone like skeleton which will which will be like you know saving the building which will make it shape, will protect the building.

Now, the main fundamental is that whatever the load come on this elements like slab; slab will, then transfer the load to the beam; beam will transfer to the column and finally, it will transfer the load to the foundation and foundation will transfer the load to the ground. So, it is the whole mechanism. We will come into detail when we discuss about different kind of loads and how they act to the building.

But whatever I mentioned in this slide, this is very basic like very simple state forward building where it is just we can say the apartment building, a very simple design and concept. And looking into the picture we hardly get any idea about the material to be used for that or you know the other functions.

So, basically the moment we make it little bit complex like we play with the different concept, different requirement; sometimes we need a convention hall where we cannot put a column in between we have to make it obstruction free then probably the structural composition will change. So, that is why we can say that whatever the you know component of a structure or maybe the parts and parcel of that it will vary to from simple to the complex structure.

So, let us understand this with some other slide. So, in this slide, we I just presented one igloo and the other is tepee.

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So, the right hand side picture the tepee is basically a temporary structures. You can see that this is a plot like membrane material which like we can put on a structure temporary made with some you know wooden stick which make, it stable a conical structure. So, there can be a replacement of a tend.

So, the arrangement is very simple and we can easily make it. The other one the igloo, it is again a compressive structure. So, here we will put the compressed eyes and make this form which will protect like the people who are residing inside it. Now just as I mentioned the compressive structure, compressive means if you compress any object say for example, I have this pen right.

So, here if I want just give pressure from both the end. So, what is happening inside it? So, it try to compress, but as because I cannot put in a pressure on this from both the side. So, the

change is not visible to you, but if we perform it with some higher load; then definitely it will collapse after certain time. So, there are structural like which are tensile in nature and all. So, the other side this particular structure canonical structure is well formed and it is protected people for the weather and all.

The concept behind these two is basically the basic purpose to protect from the external environment maybe it is our the extreme cold weather or it may be scorching summer and as of now these two are very simple to construct.

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Now, come to a recent one like this is Burj Al Arab in Dubai. This is really a good architecture and like whenever we see this image or in any video that is showing this building, we really appreciate it and we really want to know more about it from the source.

But if you see the structure that I have shown beside that image, so, it is not that simple that we have seen for the igloo and all. So, here it accounts more than that; more than that I want to mean that its act with the compressive you know load the tensile load along with that there are other several loads that this building should resist. One of that is basically the wind if you see the location of this so; basically wind will play a crucial role. And if you see the height of the building so, at that height also there will be a pressured wind pressure and all.

So, then the structural composition will be different. So, then that should take care of the wind load and other lateral pressure and that is why it is being complexed. So, along with the simple beam column structure, now it need more than that.

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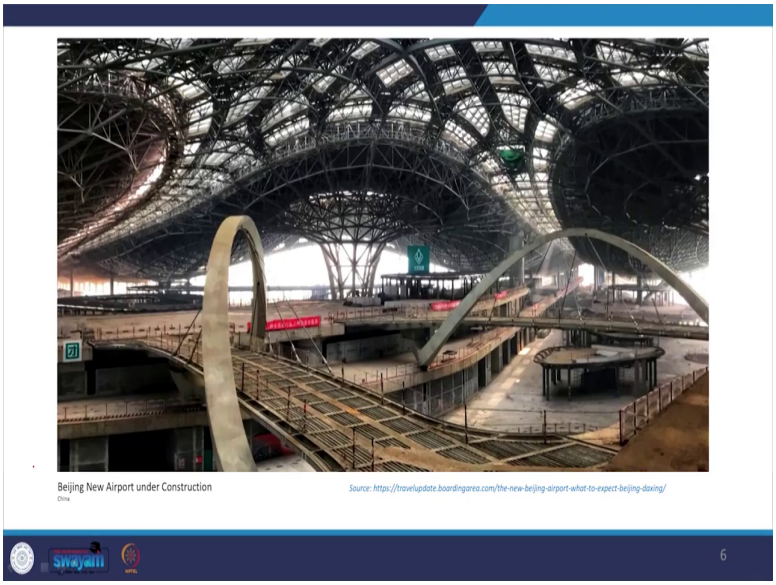

Now, what about this? This is a new Beijing airport in China which will be like which is considered to be the largest airport in the world.

So, see this is under construction photograph. So, looking at this is nowhere matching with the basic concept of the beam column and other structural element is so complex, but it is possible and as because it is possible we can see the image is still like. See those you know different curvature and all and here if you see that not only at the roof. So, they play with different curvature at different axis. So, it is basically creating that particular environment that particular enclosure with some flow.

So, in order to make it happen so, we have to design the structure accordingly. Now we have two way, one we restrict our self with a very straightforward composition and compromise our concept we cannot go beyond that, but this is the time where we should go what we want and we support it with different you know structural advancement and we apply the technology to make it happen.

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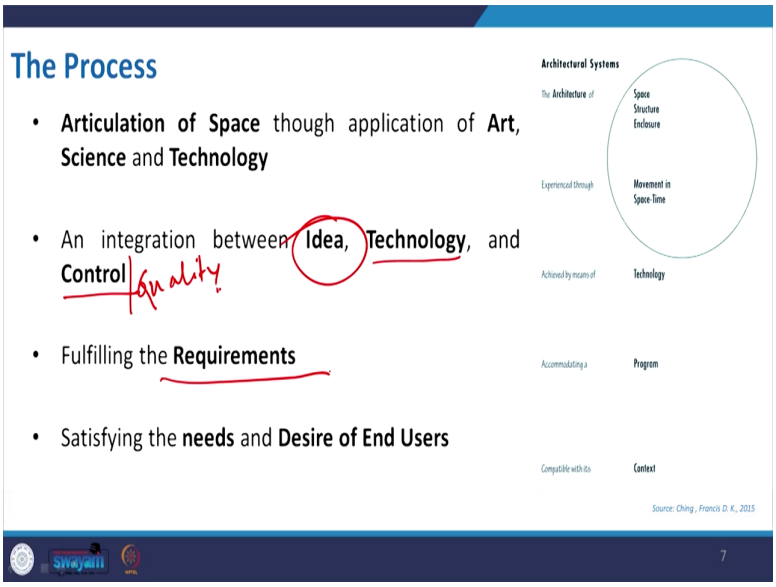

So, this is the repeat slide that already I presented you know in my last lecture, lecture number 1, but just I have a recap to it. So, in this process, we create the space, we articulate the space as per our need, we sub divide the space as per our requirement and definitely there we put our idea. So, this is very important here, the idea and then the technology definitely the new technology will help us to make it more and more you know desirable and the control on the quality and we have to fulfill the requirements.

So, these are very key parameters which with which will go for what.

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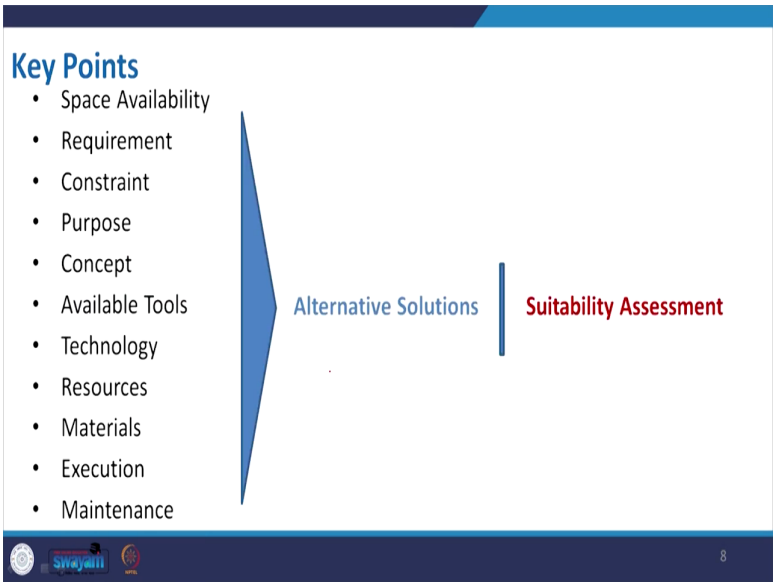

And these are the key points where also we mentioned about the concept. So, the moment we get a requirement that we need this much of space, this type of space then we start generating different concept.

How we can make it you know you know purposeful? How can make it different from existing one? So, that it will make a contrast to the existing buildings and all and all will appreciate. So, to bring that wow factor into our building so, we should really play hard in concept stage.

And then definitely the other points to be maintained where we should also look into the space available, the resource available technology available the materials. Another important thing which will change, many decision even sometimes because of the materials we cannot

select a structure because a material is not available at that particular site or location, then the execution. So, when we execute well then that will give the result that we actually want.

So, before we move to the next slide, let us understand the simplicity and complexity. So, you all can see that I have a paper plain paper piece of paper and this is very simple right I can use it for writing something what is.

If I fold it so, I can make aeroplane out of it. So, with the plain concept plain blank paper, we can create many thing, but just think about the structural point of view. So, if I try to hold this paper, it is not possible because of the self weight and all, but I just fold it.

Now, it is standing right. So, this type of structure will discuss in that particular section when we discuss about different type of structure that we can use in our architectural field. So, this is folded plate and if you make it like that trial and error you can get something like that. So, here it is a letter you can say m or w, but you know frankly speaking it can also carry a load. Suppose this paper if I want to put this charger or like the changers slide changer, it cannot hold the load; I am scared that it may fall but with this it may act as a stand without any external support.

So, so this is the beauty like with the plain paper, with the plain kind of slab you convert it to the you know folded plate slab can you know solve many purpose. So, we will discuss in detail. So, let us move on to the next slide. So, in this lecture, we primarily focus on the concept.

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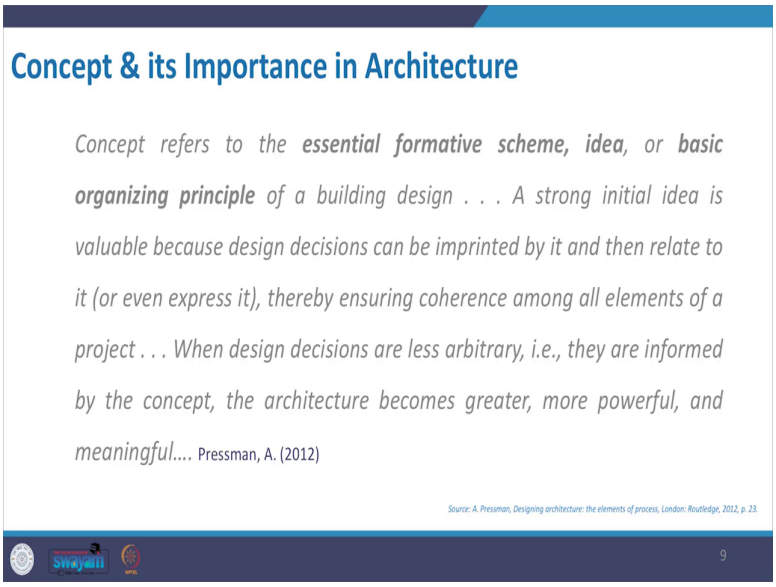

So, what pressman says about the concept? Concept refers to the essential formative scheme idea or basic organizing principle of a building design. A strong initial idea is valuable because that will be implemented, that requires the cause that requires the other energy manpower everything.

So, that is very vital thereby ensuring coherence among the all elements like all elements means the space available the structure to be used; everything is related with the concept.

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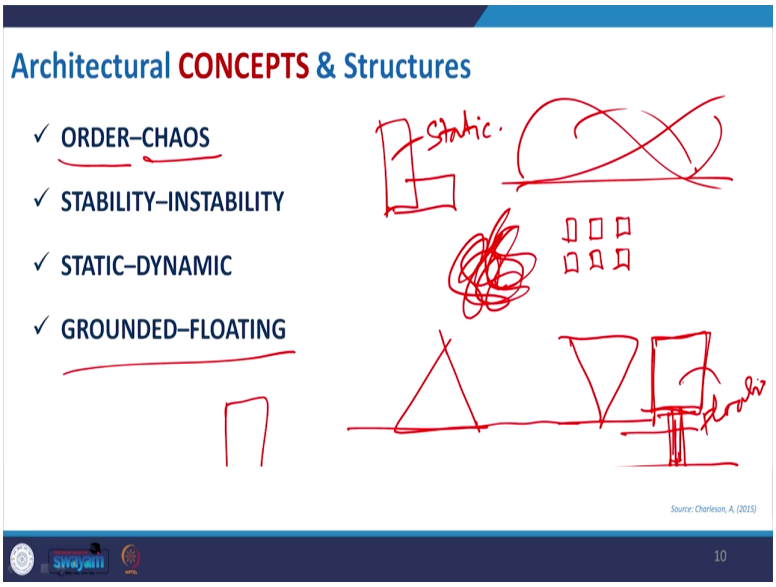

So, for that based on a book authored by Charleson that structure as architecture. So, concept and structure has a relation and broadly, we can classify that concept in four pairs. So, one is order versus chaos, stability versus instability, static versus dynamic, grounded versus floating.

So, looking at the terms we can get some idea what exactly they mean. So, when we called something in order, say everything is order so; that means, it is very simple straightforward well chaos is scramble like this is something I draw. It may be an abstract art, but it is creating a chaos where I just make this arrangement. So, we can say that they are in order and they are making a like you know three column two row composition array.

The stability and instability, stability means say for example, this is a you know elevation from a site of a pyramid and if you just this is the ground. So, we can say that this structure

this form is very stable whereas, if I make it inverted so, it assume to be very much instable, but that is not the challenge.

Because also like we can make it happen, there are buildings which is having. Static means is very straightforward where we have a composition like this and dynamic relate to the flow which will change or give a motion when you look into the building. So, we will have some curvature and other thing.

Then grounded and floating, grounded means it has a feeling that it is anchored with the ground whereas, floating means it seems to be plotted, but exactly it is not the real case, but visually we will see. Suppose a building which is having a mass heavier and you know, it is just stand on a very simple you know and very narrow structural element below. So, this is seems to be floating. So, this is overall idea that we can say.

So, let us just understand through different case study.

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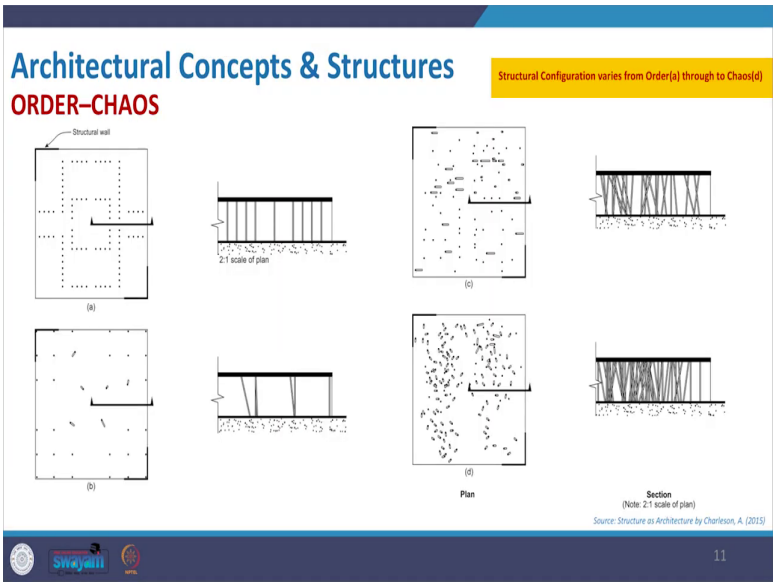

So, this is again a nice example given in the book structure as architecture. So, here the you know the concept of a making architecture like form your order to chaos, how its going to change. So, in this is the plan where you can say that these are dots are all column and they are placed in order. So, creating a very order from architecture and then when you start rotating it to the b. So, it is moving to the chaos and finally, when you make it very random, then it is making this picture right.

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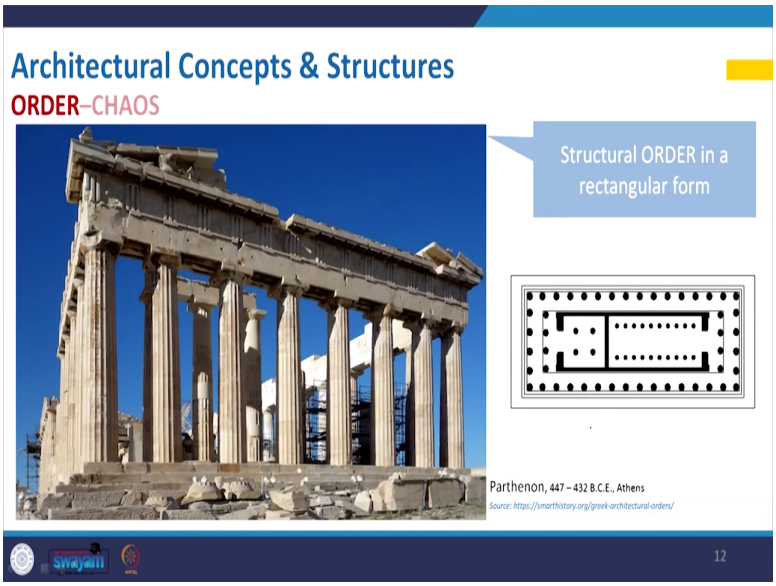

So, this is the conceptual image. Now we will get this one. So, this is a another example of order which is a Parthenon form history Athens. So, if you seen the plan so, external and internal columns they are placed in order and finally, this is the outcome where all verticals columns are placed in order with a equal distance and also. It is giving a feeling of order and we appreciate it so, this type of building.

So, this is one example from the history.

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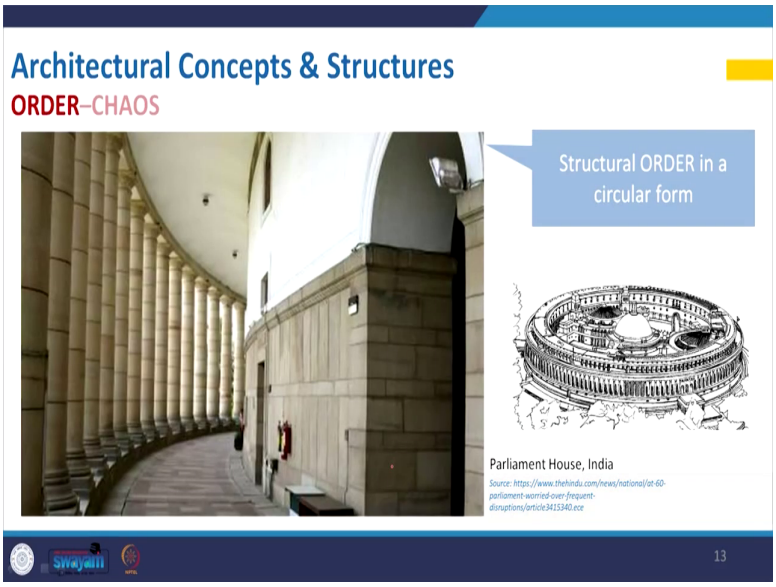

So, let us get some more example and this is from India, our Parliament House. So, here the corridor and these columns ok. The earlier was like that order form we got in a rectangular form, but here we are getting it for the oval form. So, in this corridor the vertical, they are placed in order and creating another aesthetic. So, we appreciate this kind of structure not only in parliament building, there are many such buildings where we have this kind of columns you know placed in a you know elliptical form or in a circular form. So, this is another example of order.

Now, let us move to the chaos.

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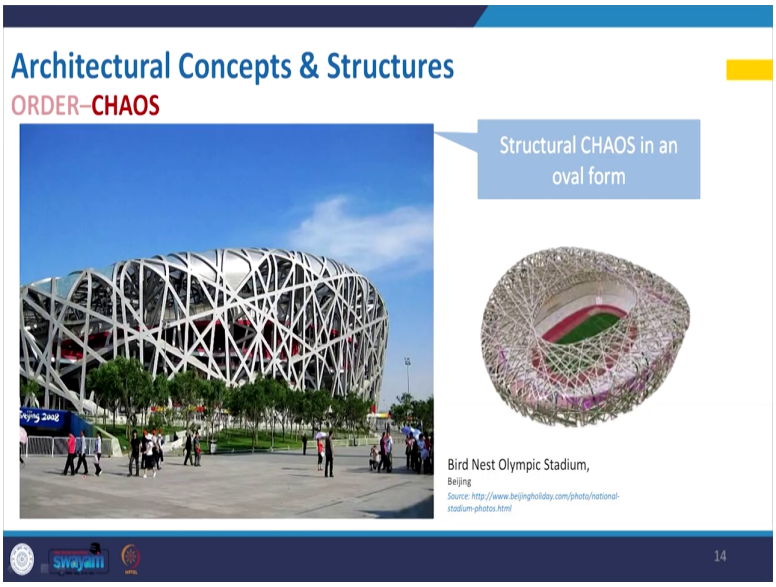

And here like before I say anything looking to picture, you can understand the chaos. So, basically if you see this is the Bird Nest Olympic Stadium in Beijing, China. So, in this is another fantastic creation where the concept is been taken from the nature the bird nest and the members are placed randomly not in particular order.

So, it create some chaos, but overall outcome definitely we appreciate. So, it is not only like we should always create our architecture or design in order, but sometimes perfect execution of chaos will also create some greater you know experience.

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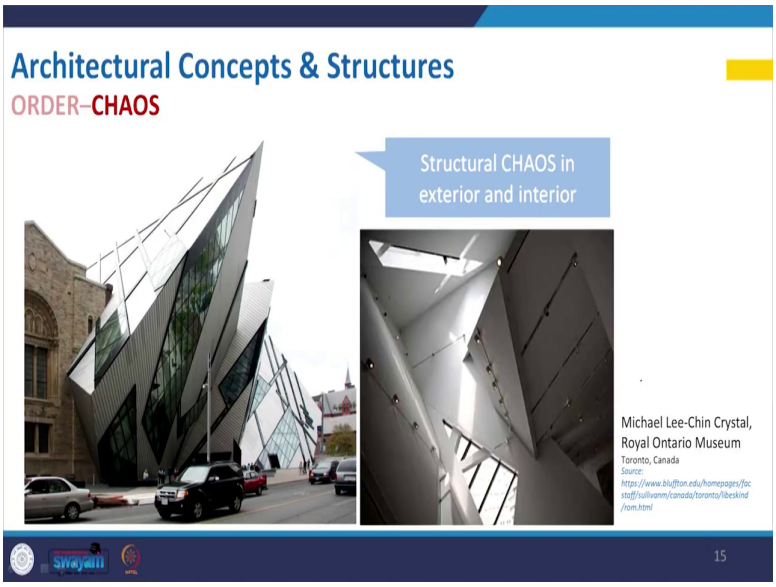

This is another example where this is Royal Ontario Museum. So, here you can see that none of the surface are very straightforward or in order. So, in from external, it is something like a looking at like some concept who are pursuing architecture. They must have heard about deconstructionism. So, it is a deconstruction concept has been played.

And surfaces are just you know tangled with each other and this is from the interior; even interior, we cannot get a smooth you know surface not smooth in sense of the material. I say that when you just move your eyes through those lines so, it is creating some chaos. So, this is another piece of you know architectural example where structural are met in such manner which is getting chaos.

The basic concept was to make it like this and the structure that support it and final result that we all see in this picture.

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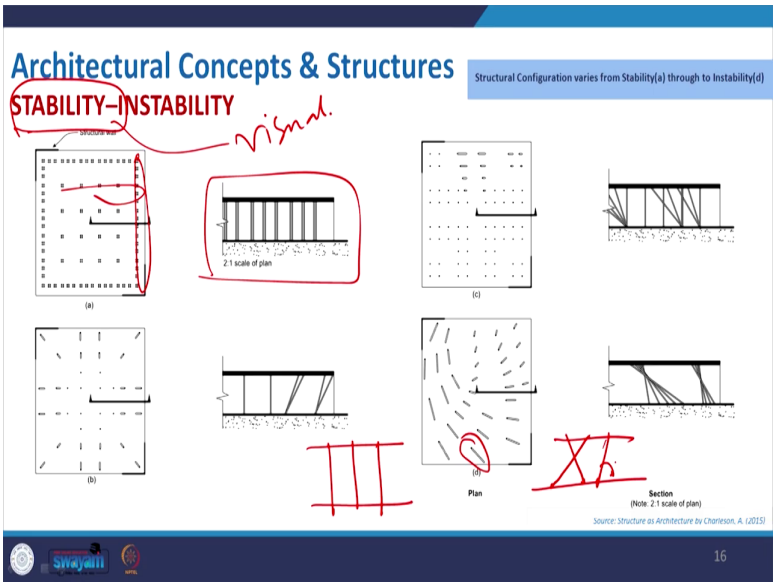

Now move to the next concept that is the stability and instability versus you know, in this stability; it is not basically in point of the structural stability ok. So, let us clear this stability is basically visual stability.

So, looking at the building, we will say it is showing the stability or it is not showing the stability because a building looking instable in this aspect. We will not mean that structure is very poor and it may fall anytime. So, in this visual stability if you see again this is the picture from the same book, the reference is given here.

So, here if you see that it is a proper arrangement in order so, external columns and internal columns and they make it very stable form. Now if you move through this a, b, c and d; in d where these are placed. These are not regular column, these are some other members; columns are placed in a slant.

So, basically if we just try to draw so, this is one slab and this is another slab, we can connect it with this straight column. And in the instable form that we create intentionally something like that where we will feel that these particular column may fall.

So, it is showing up you know visual instability to it. So, let us clear this idea with some of the examples.

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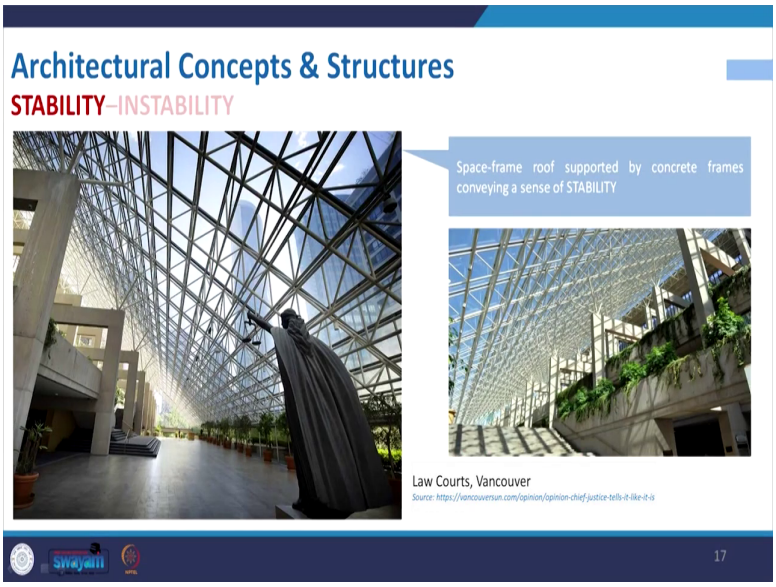

This is the Law courts in Vancouver, the structure is very massive. But still as because we have these you know concrete support where you can see those a space frame are being supported.

Here also you can see this is supported. So, while walking like while walking with this space, you will feel a stability that this whole roof will not fall over you. So, you feel very secure and then you can say this structure is made very stable. So, space frame roof supported by concrete frames, conveying sense of stability ok.

So, it is stable structural stable and visually also we feel it very stable, but if you remove this and it is it is having just some slant you know random members, so, probably will be scared.

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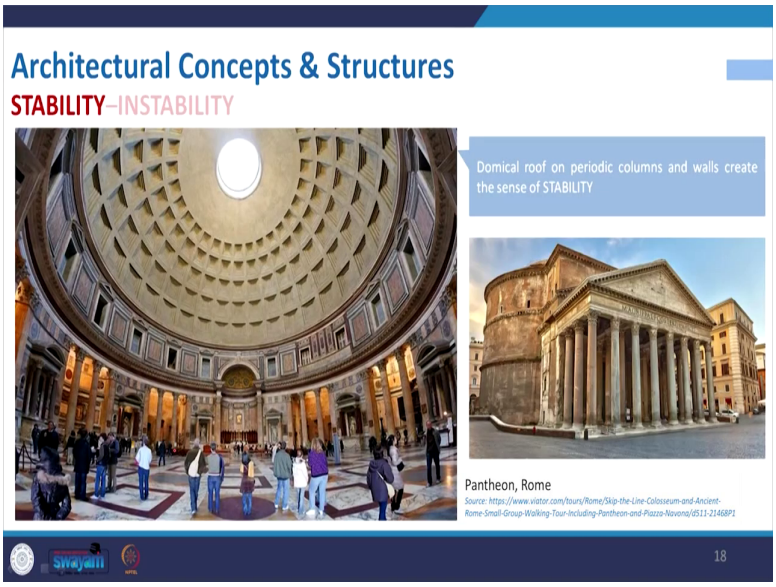

This is one example of another you know in the category of stability from the history example, the Parthenon the Pantheon sorry the Pantheon Rome.

So, here you see that you know huge dome domical structure as a roof, but this place is it feels very secured because of those members. So, if you see that the whole domical structure being placed over different wall component and the column so that this give a sense for stability.

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Now, move onto the instability. Forum Barcelona Solar Plant looking at the structure itself, it is very looking very dangerous, but structurally it is strong stable. But visually, it is looking very instable because of some of irregular piers support this whole pergola is being placed.

So, if you stand here and look into this structure probably we will feel it very instable.

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Take this example the reactive, you can also search of this building which is being created by two artist and this is a experience balancing self weight. So, this is having a pivot point. So, these two people moving from different place and all it will have this inclination and all. So, it is a perfect example of a visual instability of a building, but again this is a stable structure. So, structure is made accordingly. So, along the concept it is made.

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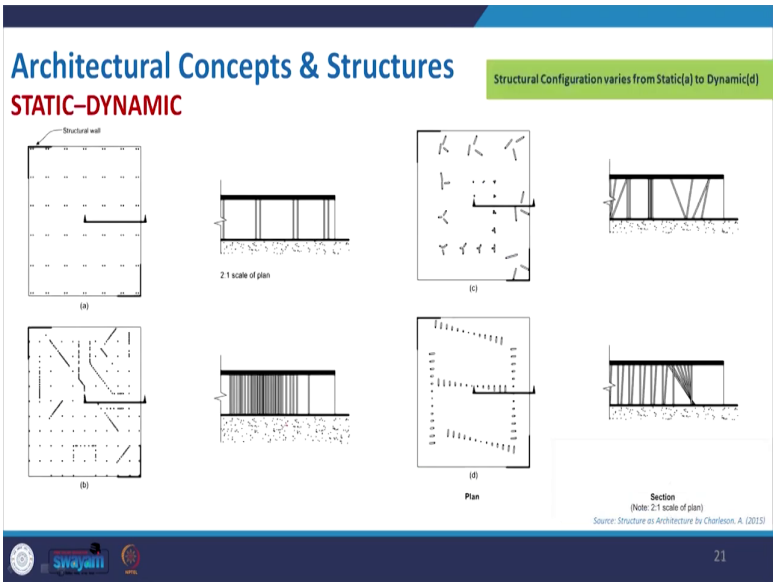

Now, move to the third concept that is static versus dynamic. Static means we will not have any you know flow. So, here also it is a regular arrangement of column pair wise column. So, it is giving a static you know sense whereas, you placed it in order or you just change the scale from small or something like that or maybe you create something in you know you know dynamic in order.

So, it create a visual dynamism in your architectural form. So, again let us clear with some of the example.

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So, this is one example of a Hotel Hyatt Regency from Kolkata, here the structure. So, it is very straightforward and static. So, horizontal and vertical you know in combination to that and it is giving a very static you know image when you look into this.

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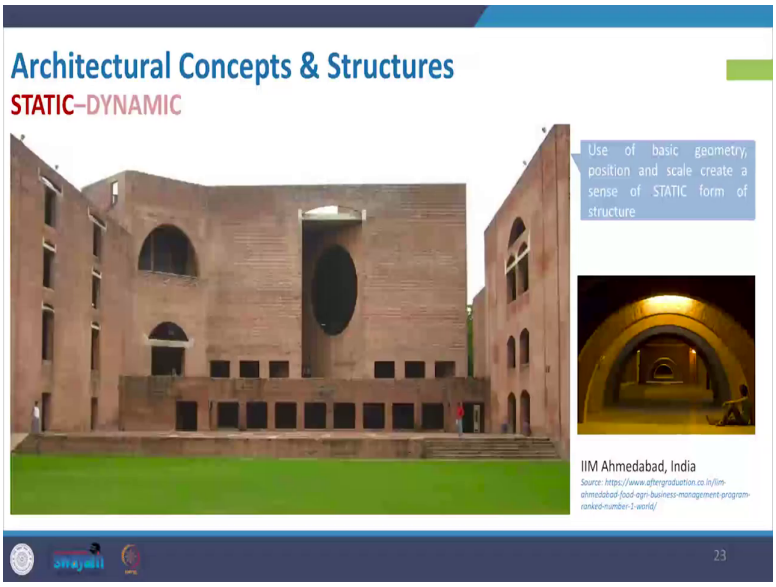

Move to the next example this is from Ahmedabad. So, here also the heavy structure, the exposed brick work then you know very straight form is giving a sense of staticness. Even the inside like it is a series of you know semicircular arch, it is also creating a very static environment.

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Now, come to dynamic, this is a building design by a Zaha Hadid. So, here you can see that the building is creating a flow. So, everywhere if you see that it is showing a wave or even it is clear in this picture.

So, it is not very static. So, basically if you look into this building, your eye will actually take that root or make this transition. So, this is another nice example where it is showing the visual dynamism of the building and this is being supported with that particular type of structure.

So, it is not straight forward beam column structure. So, for that we need different kind of structural element and that is why this subject is important to know because if we do not have

the knowledge of the structure that can make this or which kind of structure is really fruitful to that, then probably we cannot create this kind of dynamic architecture.

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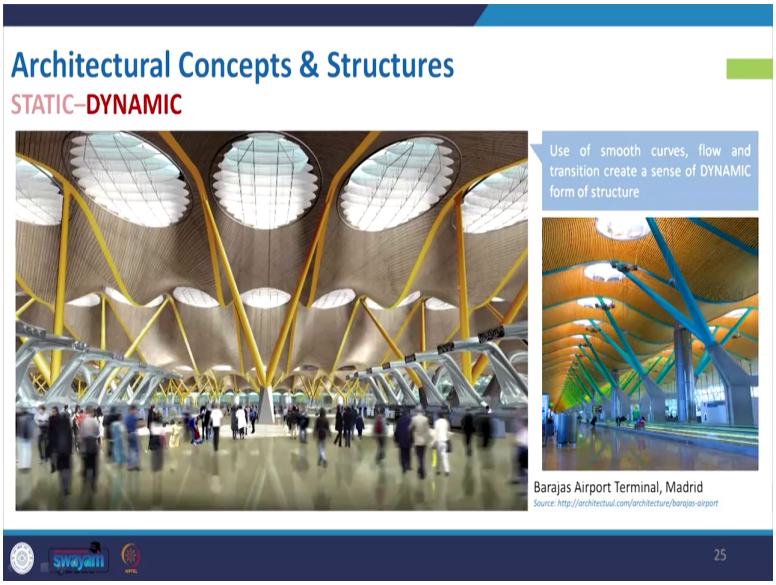

So, take another example of dynamic architecture. This is a Madrid Airport where this is the terminal building where the roof structure again creating a flow and creating a dynamic sense everywhere. Though the structure is very light and it has to be light because if you see that this pan is quite huge, we cannot have more obstruction.

So, again this structure is giving a sense of dynamic visual dynamism to the building and the structured being made with that with the proper you know roofing and the light weight structure at the roof supported by the adequate structural members.

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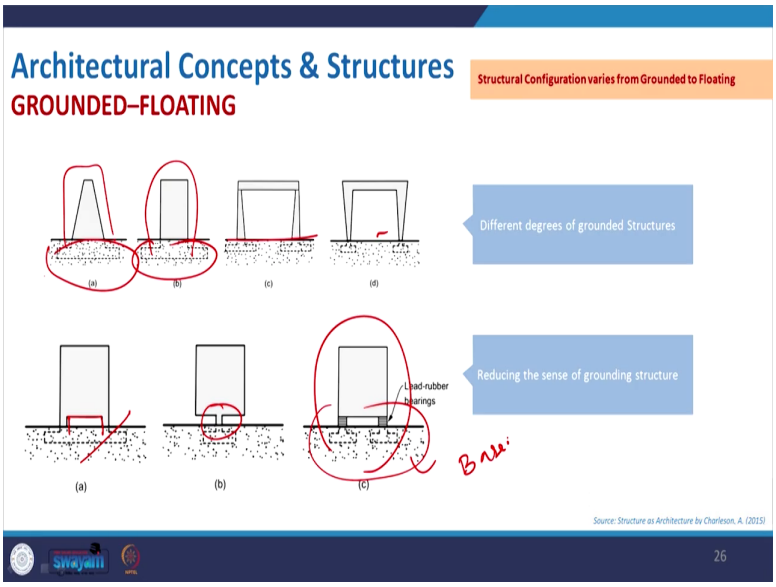

And this is the you know the fourth one and the last component under the concept category.

So, here if you see the grounded; that means, if you see this part this is dotted the foundation, then the superstructure; it is something like that. It is having a you know connection straight way with the ground. So, it maybe a portal, but when we talk about the floating so, the reduction or in the you know surface at the bottom to the ground; it is creating a sense of you know floating.

Here also the I have I have already drawn this kind of picture where it is the heavy mud is you know standing on a shallow structural member and sometimes also you can have these lead rubber bearings where you know this kind of structure we use for the earthquake prone area

where you know base isolation technique or something of that nature being used to make your building protected.

So, these are the concepts. So, let us clear our concept with the some of the thing.

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So, here the building is again a curve, but the interesting part is that it is grounded at different discrete place. So, so that we can see that it is anchored. So, otherwise it may flow out or something. So, this is perfectly grounded. This is the Rolex is the learning Centre in Switzerland.

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Now, this example is a very famous example in the field of architecture, the Glass House. So, here it is the placed very simplistic architecture with you know you know glass and the other transparent material and it is perfectly grounded to the lawn. So, this is another example of grounded you know visually grounded architecture.

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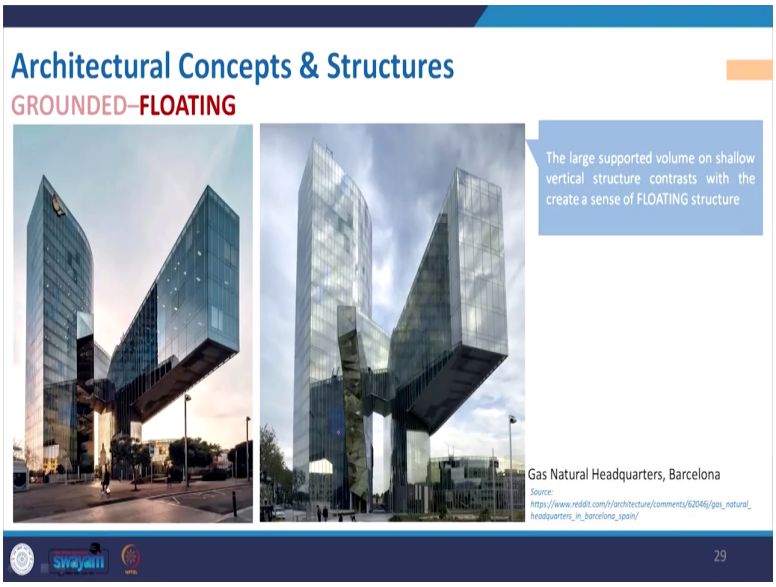

Now, come to the floating this is Gas Natural Headquarters in Barcelona. If you see this particular cantilever ok, normally you know in a building we have some cantilever 1 meter, 1.5 meter and in some special building, we have 2 to 3 meter. And then we are very scared that how to make it, it make collapse or something without any support. But this is being created and visually building is stable definitely that was taken care of, but this heavy mass with a shallow vertical structure create a sense of floating.

So, that is the overall idea to pick up these example. So, this is giving a visual sense that this heavy mass this particular wing of the building is floating. Now move to the next one.

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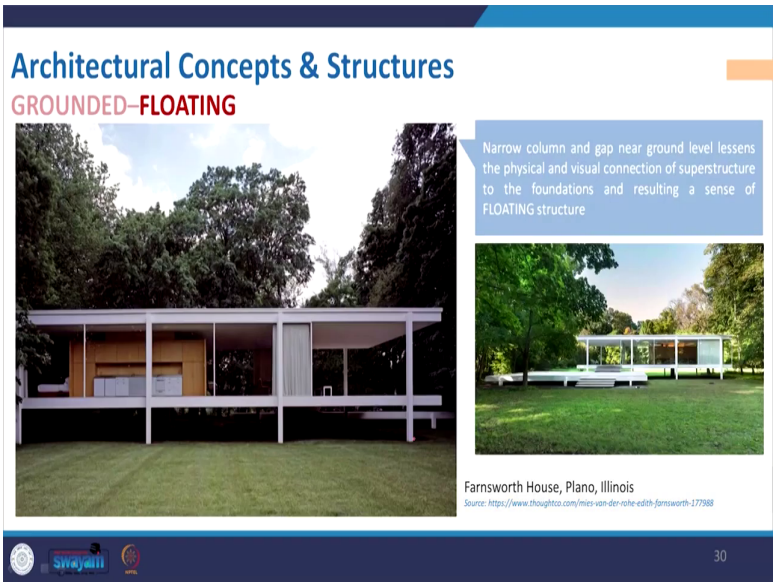

So, this is similar to the glass house building, but here the difference as we can see from the concept we have seen somewhere if you reduce the connection with the ground of the superstructure that is also giving a sense of floating. Here you can easily see those gaps. So, this is your ground level and there is a enough gap to it.

So, this building with this you know minimal support with the narrow columns. It is showing a sense of floating. So, this is the example of floating.

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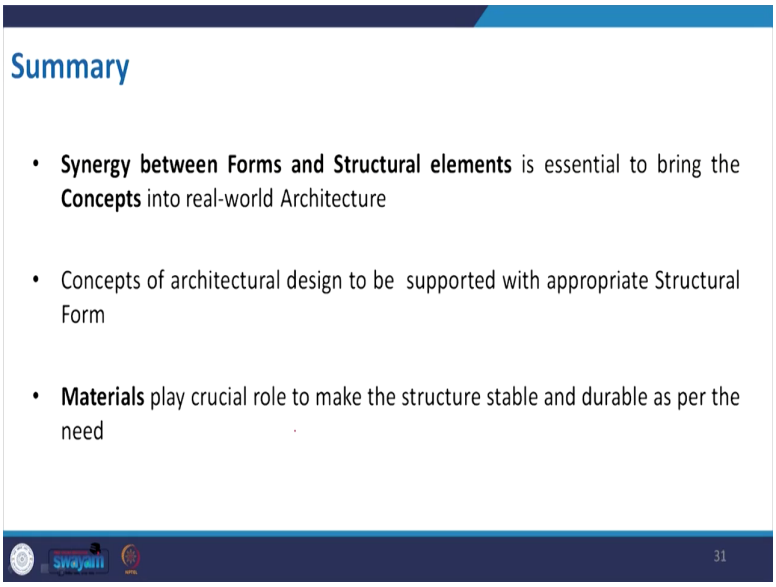

So, all this examples we have seen that is basically the concept. So, concept was created to make a dynamic and you know and you know as per that accordingly like one has to select that appropriate structure that can fulfill that concept.

So, if you summarize this particular lecture so, synergy between forms and structural element is essential to bring the concepts into real world architecture. So, as already I mentioned if we dream of something to be very dynamic, having large span, having very light weight structure; so, we have to select the suitable structure for it.

If we go very traditionally conventional manner with a very limited structural form very straightforward beam column so, may be many of our concept will be compromised. Then concept of architectural design to be supported with the appropriate structural form that I already mentioned and in order to achieve that, one has to know the type of structure to be

used and in order to make that structure. we also should know the material to be selected for making these structure because each material will have different property in terms of resistance strength. So, we should also have clear idea and that is why in the whole course we will have some lectures on materials.

So, different kind of materials that will give a visual look is a one area, but also considering the structure and strength. So, that has different properties. So, when you see a building so, we see the building material, we see different components of the building door windows etcetera. So, like that each components of a structure like though it is material or the form or different property.

We will discuss in detail in coming lectures and these are the further reading already I have mentioned these are few important books.

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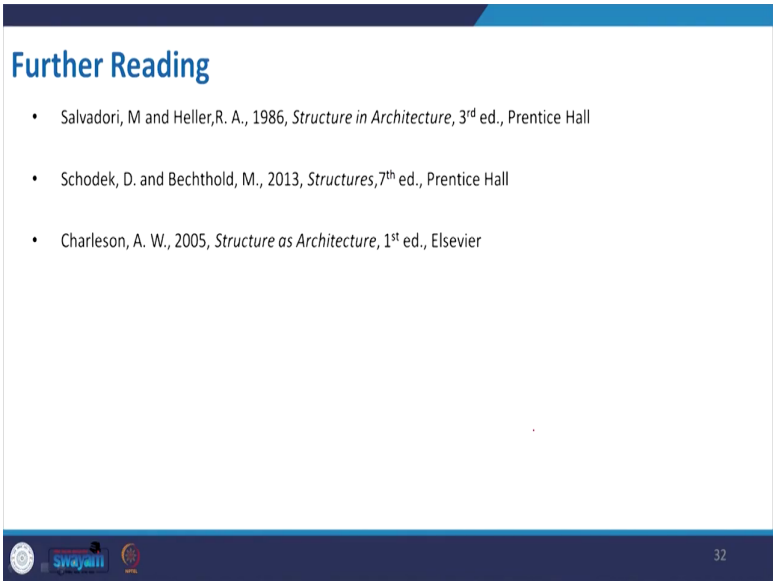

You can go through and you get a more examples in the next lecture, we will discuss in lecture 3. The part 2 of this where, we will discuss about the different architectural qualities and the supporting structure relationship.

Thank you for taking part in this.