Structure, Form, and Architecture: The Synergy

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Lecture - 07
Connecting Structure and Architecture - Part II

Hello friends. Welcome back to online course Structure, Form and Architecture, The Synergy. Today, we are in lecture number 7, that is Connecting Architecture and Structure, part II. In part I, we have seen like two different category, right ornamentation of structure and structure as ornament. So, we have also you know discussed different examples like starting from Parthenon to the modern building stock exchange of New York.

So, when we have seen that how a typical beam column structure is giving some ornamentation, some decoration with some you know Doric, Ionic or Corinthian style. Even in the later on stage we have seen some buildings where some other kind of ornamentation being done. In the second category, what we have discussed that is basically the structure act as ornament.

So, structure as ornament was the category and we have discussed few building where we have seen museum, then we also see that dominical structure. So, these are the category. And, I am sure that you have also you know identified some of the building under the category. So, let us move on to other 3 you know which was remaining in that part in this lecture.

So, again to brief about that, so it is basically depending on the architect designer like how he or she will go with the structural architectural and structural outcome. So, depending on that sometimes we have seen the dominance of architecture, the form and sometimes it may be the dominance of structure. And, sometimes it is like something the ignorance of the basic requirement or the structural arrangement which can be a very simplistic solution to that form, but create something different an interesting one.

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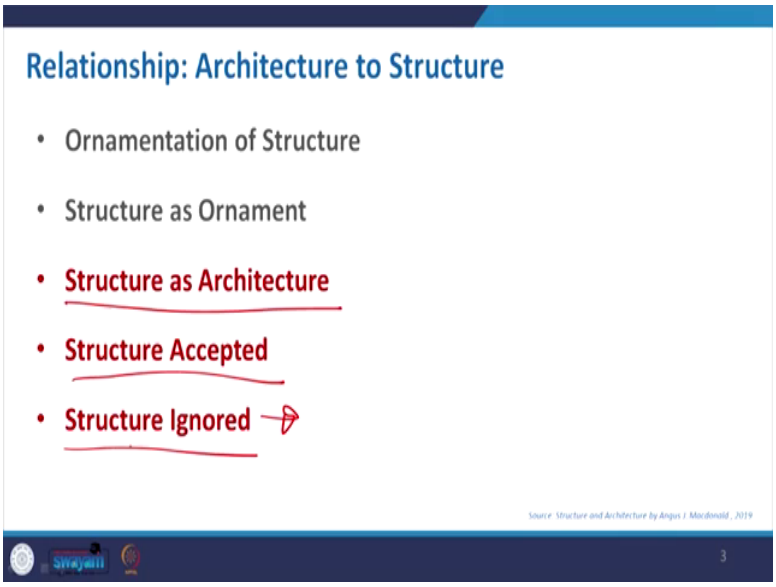

So, here we will discuss about 3 concepts, one is structure as architecture, structure accepted in architecture structure ignored in architecture informative. Again, already I mentioned then also I thought that I should clear it out the when we say structure ignored be sure that there will be no compromisation on the structural safety, stability and other parameters, ok. But when you look into the building we will not really think about the structural arrangement, typical arrangement.

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So, let us move to the category, here the structure as architecture and the cover page itself like this opening slide itself clear everything. So, this is the example of some you know you know arrangement of structural parts, some (Refer Time: 03:41) and other thing was used in this building and finally, the outcome a tower, ok. This tower is having the symmetry, and from a distance is very beautiful when you go have a closer look though it is having some chaos in the visual form, but giving some nice experience.

So, here the structure itself this is a tower simple tower arrangement of you know structural arrangement in order and give you the overall architecture, right. Even if we take the example of like telephone tower, or something like radio tower or something like that which is also looking similar to that not that much esthetically designed or so, but then also sometimes also

we like them, right. So, these are some things were it is basically a structure, but act as architecture.

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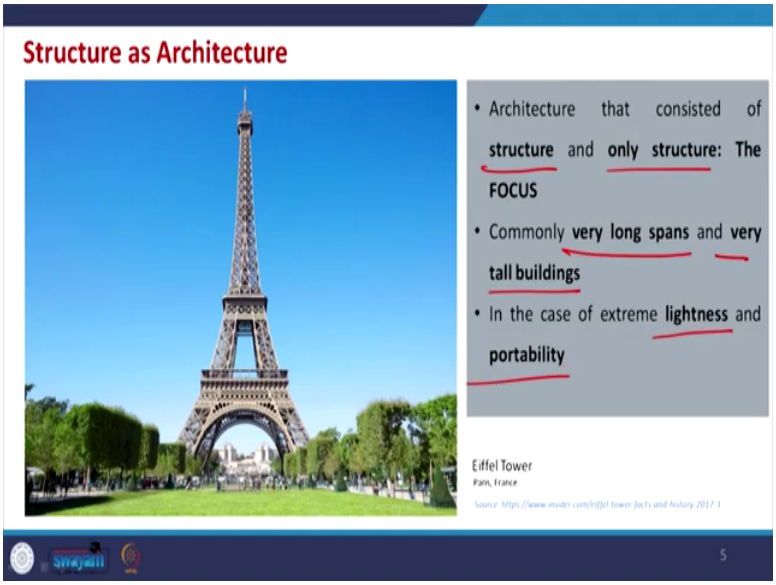

So, this is another picture of the Eiffel Tower. So, where like architecture that consisted of structure and only structure. What exactly it is? It is having some heavy word. The focus is on structure, and the form whatever finally, you know came out for existing building, so that is different, but overall looking at that we give more weightage structure.

So, dominance of structure in that I would rather say and this being normal used when we require to create space either for very long span, very tall buildings and sometimes maybe in order to make your structure light. We can recall the example of some stadium say Olympic stadium in Munich, but we have seen that some tensile fabric structure being used to cover of the you know spectator seating area. So that is basically example of structure, ok. And then

finally, what all outcome comes at the architecture. So, sometimes to make some structure the portable, ok, so it should be with the structure.

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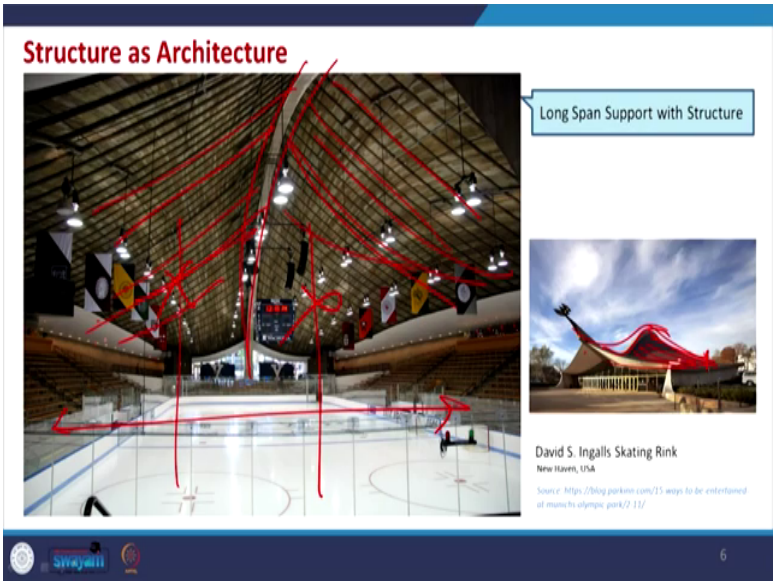

So, let us see some more example. Here it is again ice skating ring where it is so basically the skating ring where hockey being played and again it is in you know in USA. So, the basically if you see this is something like indoor stadium where you need this area column free and for that you need a kind of structure which will support it. We have seen that sales structure could be one of the option to go with where we can create this much of span, column free span which will help to you know make all this activity happen without any disturbance.

So, this is a design where is just structural arrangement. If you see from outside again it is looking like you know fish the overall form, but inside basically it is having a member at the center, this reef which will getting connected from the bottom. So, again it is fixed with the, if

you see in detail so it is fixed with a tensile cabin. So, with everything like every arrangement the purpose is to solve to create the space like column free and for the long span this structure act as architecture.

So, here the structure dominance is being seen if you see all through. So, from both the side at the middle there is a reef and then it is being connected, with a symmetrical design and finally, long span support with structure. So, this is one example of structure as architecture and many new buildings. You know if you search some good indoor buildings, so we will get that this is basically a structure rather than a form. So, whatever the structure being created with the basic form so, that come as a structure as architecture.

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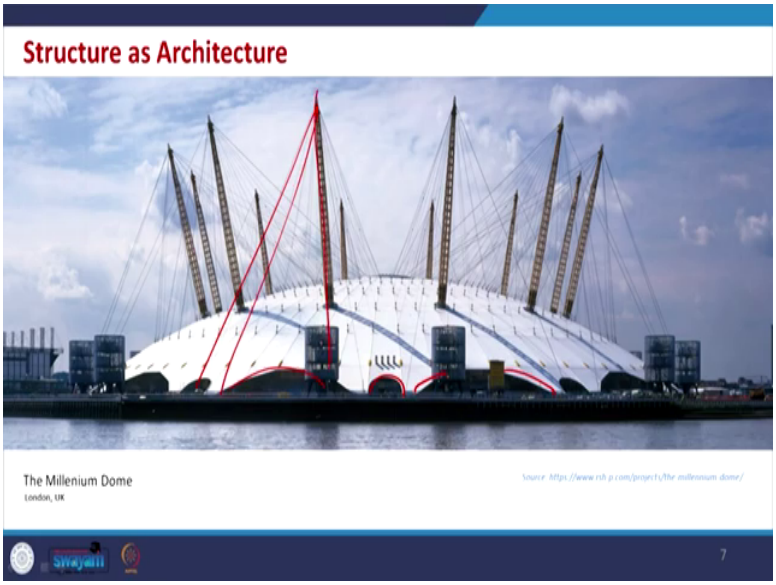

And who does not know this building; this is the millennium dome the very very huge dome being created to for a celebration of the third millennium in London. So, here you see again

that this is tension to tensioned fabric structure. The earlier day we used to talk about that which is being supported with the cable and some vertical post, where you will get this compression in the structure.

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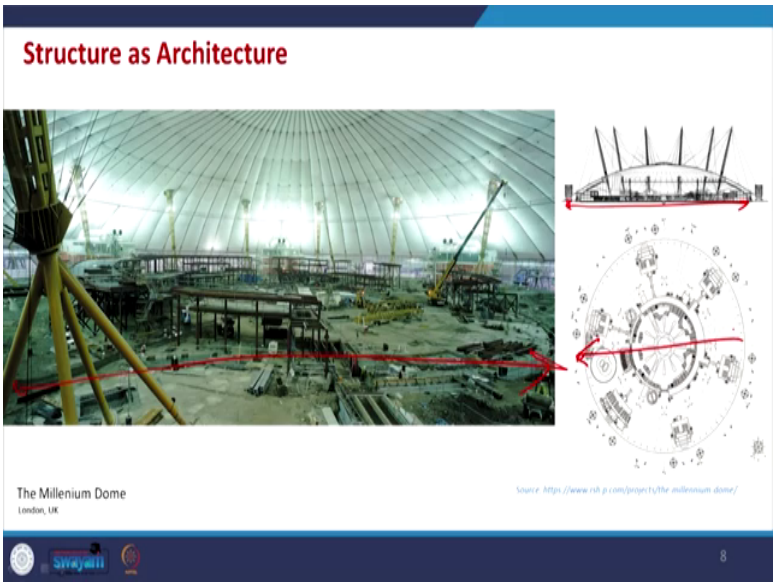

This is the inside during the construction. This is huge dome and the main experience when you see this structure. So, experience is a huge structure, and then the form creation overall it is coming as architecture. This is a schematic section you can imagine the span, again it is for the long span we use to this kind of structure. And, in order to make it stable with the minimal number of you know vertical poles, so reduction in the self weight of the roofing system was required and that is why fabric was used in this case.

So, again this is example where it is being formed as a dome, but definitely it is a structural arrangement that helped us to design such kind of beautiful space. So, for again this is one

example where making space column free was the purpose and the solution with a minimalistic particle support with the tensile cabin and the fabric tension fabric it all the structural arrangement could help us to do that and it is there in front of you.

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Now, come to the high rise building. The moment the high rise building we know came into the picture where we had to create some building tall buildings; so, there main fundamentals to focus on the structure rather than the overall outcome or the form. So, in earlier days the structural you know arrangement of those high rise building was the main concern and there are different parameters to be handled with the structure, ok.

So, while discussing with different kind of loads on building we have discussed that, one is your gravity load, ok. So, all vertical loads like the all say a date load and live load, which is acting towards the ground is one, ok. For any building, so it will have a sale weight, so it is

acting to the gravitation, but along with that there will be some lateral force and when it is high rise building the speed of wind will increase. So, lateral force as a wind load will have some impact on that.

And along with that the seismic one, when there will be a movement of the earth surface, so that will also create some lateral pressure it. Also we discussed about the flood load or the soft soil load, the hydraulic pressure to the building. So, all these lateral load played a very important role and specially for the high rise apart from everything even it is not in earthquake form, so wind is having a problem. So, in order to protect it we must have some adequate structural arrangement.

So, here if you see this is the John Hancock building in Chicago. So, here the trust you structure forms a major component of the visual attraction. So, here if you see the building, so first those majors members you will see that there are some vertical members, and then there are horizontal members along with that this is very interesting to know that there are some cross members. Now, what exactly these are? These are the structural arrangement. Now, why this cross is required we will discuss in detail. But here also I just give you one example.

Say for you just used to stick like this, which has been supported the ground and you just make another stick here, ok. And you fix it very lightly you can tie with some knot, you can take match stick or something and then you try to put the pressure. So, what will you observed? That it will show in this direction, if you put pressure from this it will show in this direction. Now, you just make addition. So, the same frame you take another match stick and connect it diagonally and then try to put the pressure here, you will see the deformation this way will be minimized. And if you add form this direction it will be more. So, this is basically called structural bracing, ok.

Here it is for the lateral force, and placed vertically, but there are examples where you have the bridges, and it is placed horizontally. I will show you some of the pictures during the discussion; on this you know high rise structure or application of this structural bracing. So,

here in this building also you will see that it is basically to resist the lateral load and minimize the sway with the like against the wind pressure. So, overall it is the structural arrangement.

And trussed tube is one of the category where you know we have certain limitation like for traditional concrete frame structure we can go up to say 30, 40, meter height and beyond that we need some more arrangement. So, we go for the trussed, we can go for tubular structure, bundle tube structure. So, we will have detailed discussion on that that how you loop it because with the increase of height you know the load will be more to the building and that is why we have to take care of that.

So, I just give you one small example. Suppose, how load been calculated in a building. So, for this particular slab, so the date load of this will transfer the load in this slab. Now, if you draw this load diagram it will give you something like that, so it is being cumulated. The load here will be just load or column of the upper floor and on, but if you calculate this; that means, the addition of all these floor to this. So, that is why you can see the load transfer to the ground is quite huge and it is like stape of diagram or something. So, here also for high rise building we have to take care of that. So, structure is very important for this and there is some limitation. When we will talk about the evolution of structure system for high rise building then we will get to know different kind of structures to be used for different kind of high, different kind of purpose and span.

So, here with this example the intention to show you that for in the modern building also the structural arrangement just bring like this structure as architecture in this category.

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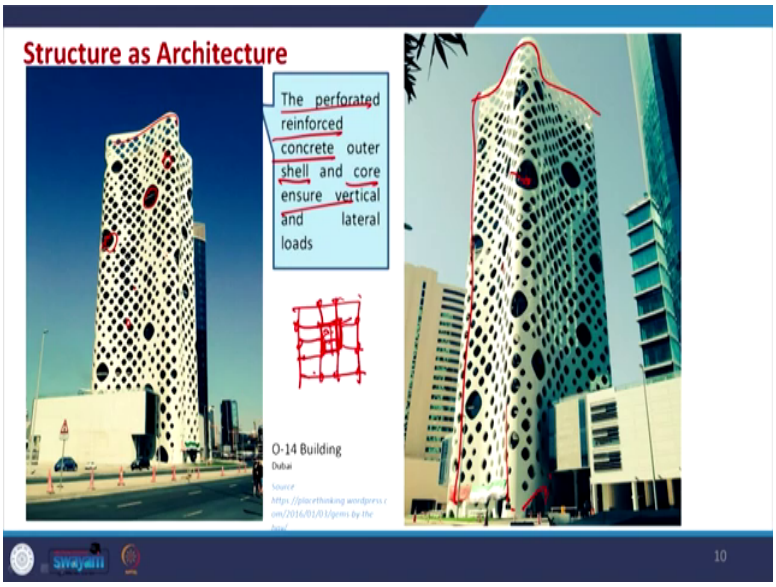

Here, it is another O-14 building in Dubai, looking very organic. So, what exactly it is? This surface is made of concrete; rather it is having some perforation. It is also having a core. Now, what is core? So, in a building in a high rise building many a cases you know we design a core, and which essentially you know serve all these services like the vertical circulation.

The other thing along with that and normally we use some you know very you know strengthy material some shear walls or something which will support the other you know external surfaces; so, where you can reduce the thickness of the column or something. So, we will discuss. And so, normally this core concept will come into picture when you discussed about we will discuss about your high rise building.

But, here it is something where different perforation of different size creating some kind of you know rapping to the building, but here this is again a structure. So, this along with the

core, the perforated reinforced concrete outer shell and core, ensure the vertical and lateral loads. So, here it is a form, being created with some structural material with the core, connecting it and overall it is representing the architectures. We heard also it is one example of structure as architecture and this is from like Dubai, O-14 building.

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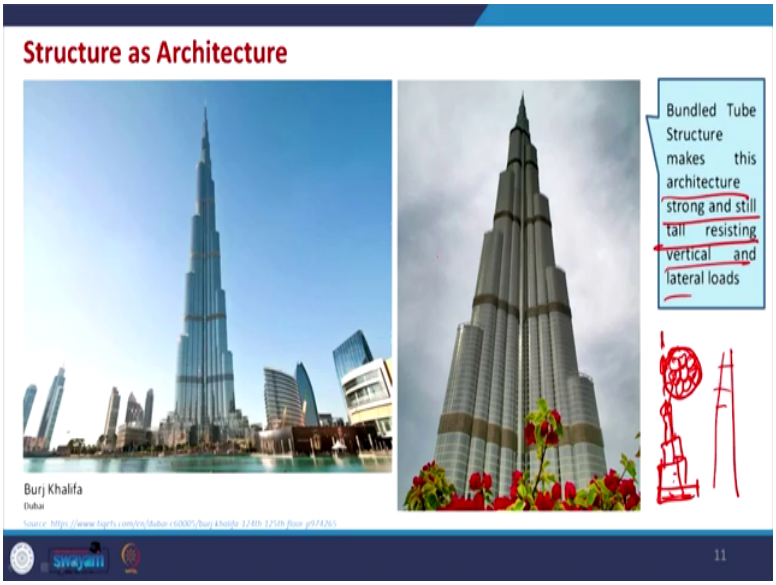

Again, this is from Dubai, what is called Burj Khalifa. So, for the tallest structure and there are many structures are coming up which is living you know higher than this one, but this is a completed building. So, here if you see this is basically this is followed a bundled tube structure, ok.

So, for example, in gloss you have some tube, right. So, you place them together, ok. So, the strength of that to you know resist, the lateral load will be much more higher. And again if you observe it carefully all the high rise building nowadays being made with the increase of

height they reduce the cross section area in order to reduce the lateral load of the wind and this is something where it is a very staggered. So, with the increase of flow there is some drop and some of the towers just you know drop at that time and it will not continue.

So, overall the creation here is basically the structural arrangement. The way we put, want to create a stable structure, so we should go with something, stay and then you know reduce the weight and then finally, whatever the outcome is in front of you high rise building, the tallest building as of now in the world. So, here it is another example of structure as architecture.

So, bundled tube structure makes this architecture strong and still tall resisting vertical and lateral loads. So, lateral loads normally it is very very very important for the high rise. We will also discuss that when we discuss different you know mechanism how to reduce the load, what should be the exact structural arrangement to overcome that window.

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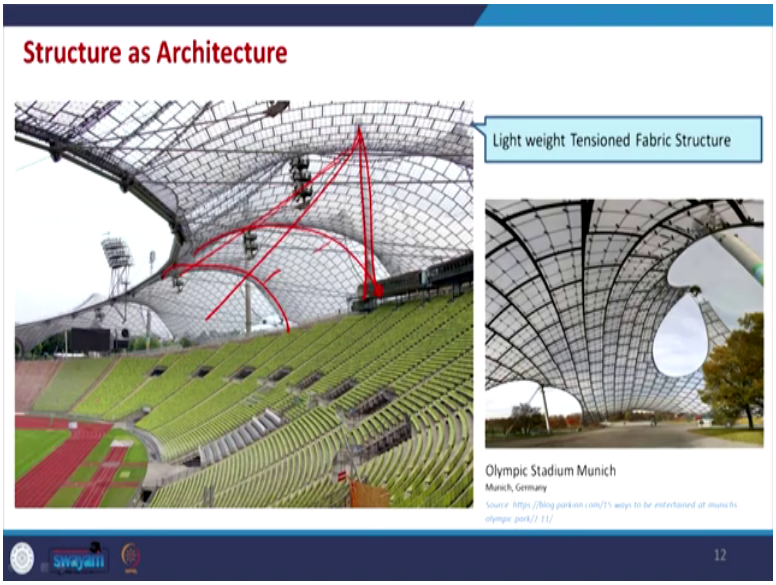

Yes. So, as we at the beginning of this we discussed that this structure as architecture, we can give take example from where we have to create long span and we have discussed like millennium dome and then the other one your skating ring. And, then sometimes for tall structure, then we discussed about Burj Kalifa then John Hancock building and then also discussed about the O-14 building.

Here it is basically for making your structure light. So, then the solution is you can go with the tension fabric structure. You know earlier lecture we have discussed so many, one example from your Arizona State University Campus that you know sky song structure. But here also it is just the arrangement of the vertical post. If you can see through in detail, so these are you know tension, given tension, these are all tension fabric which is tide up with the cable to that post which is fixed outside, so that all spectators can get some uninterrupted view of the activity. Whatever the games are played in the middle so they can enjoy at the fullest; so, this is also required. So, it is basically a structure arrangement structure itself whatever the structure you made with minimalistic form creation and all that acts as a architecture.

Now, come to this structure accepted. Now, definitely here just I would like to say what exactly it is structure accepted or structure ignored. We cannot ignore structure. We have to have accept the structure, otherwise how our building will be stable. But here the concept is where whatever the structure in form creation being there we accept it, we do not try to deviate it from that, and we just try to put in order so that it will not really you know disturb for the creation of the form that we wanted, right. Now, how it is different from other category, that categories that we have discussed? Here whatever the structure says will follow with that, ok, but along with that the form to be created.

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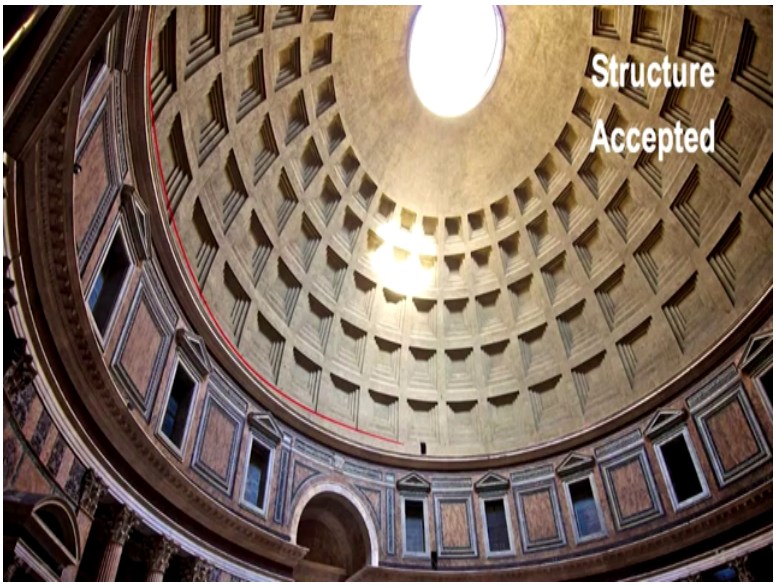

So, see for example, here in this example this cover photo is you all know I guess this is the Pantheon in Rome which is having the huge hemispherical, domical roof structure on top. But, how it is being supported? Let us see.

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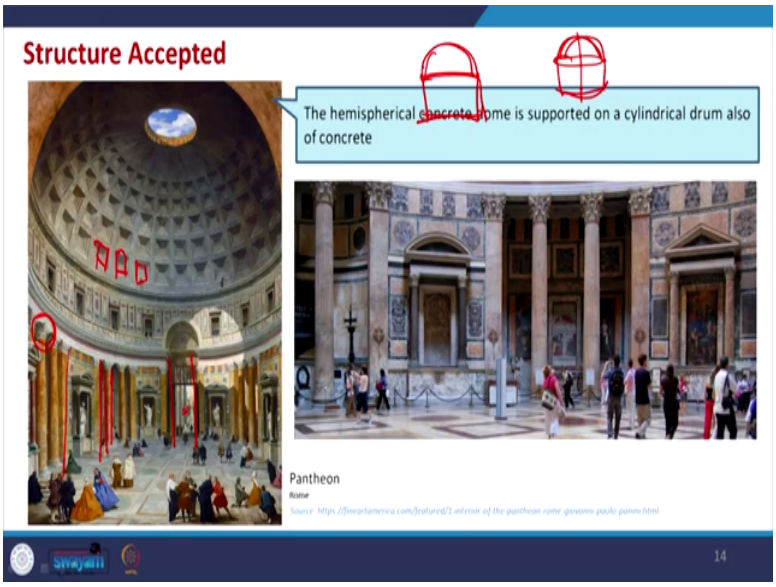

So, this is a painting I have taken Pantheon. So, here you see that this is a basically you know dome which is placed on a cylinder; so, very simplistic form creation. But it could be very simple like a dome is being created and the cylinder. So, competition if you see, you know in the first year when you start learning graphics or discreted geometry, so there we try to figure it out the composition with spear, with cylinder.

So, this is a simplistic form of this structure, but now how beautifully is being placed. So, there is some void being created, some entrance somewhere this is used of some you know Corinthian column, and then solid white, solid white, all this creation even the some you know curvings in the roof top. Overall it is giving something beyond your cylinder and your hemispherical dome structure. You can see in detail, so how these being created.

So, here the structure says it is a cylinder heavy mass at the top at that time definitely we did not have the technology to reduce the thickness of the structure, steel was not there. So, on that it is basically a load bearing comprehensive structures, so all loads being carried by the wall and the support, but then also it is being created in the sense where whatever the structure is coming it is accepted that is considered, that is visible, but with some modification that is being placed to create this nice ambience.

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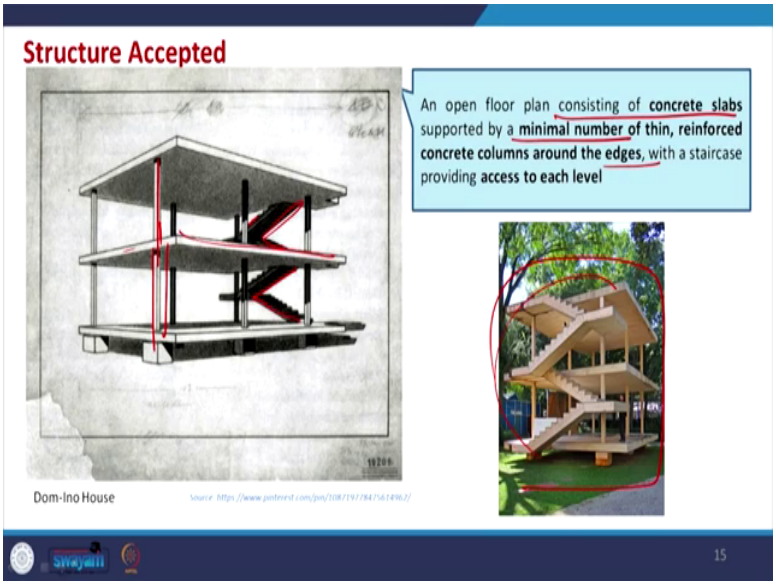

This is the simplest one, proposed by Le Corbusier that Dom-Ino house with basically simple your column and then you have slab and in order to access you have staircase, simplistic. So, here it is just the structure. No final you know any ornamentation to it, nothing added extra to it, so an open floor plan consisting of concrete slab supported with the minimum number of thin reinforce concrete. So, here it is very important to note that at times when in history

where there was some crisis then also the shelter was required, so with a minimalistic form you can go with that.

So, here whatever the structure comes accept it; we do not need any alternation and many a building very simple building in the history and in the recent time also when we go for the mass housing, low cost affordable housing will still follow this kind of you know minimalistic form where whatever the structure will come with little modification in that we bring that. So, structure accept it in form making is one example there I put it.

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This is New York Chrysler building. Here also it is a beautiful example of the steel structure, but here it is not exposed. Overall creation if you see that it is giving a nice form, but all these are made with the structural things. So, here the structure is accepted as it goes up, up and

then we just accept that. We do not try to deviate it much form the form creation for the form creation. So, this is another modern example in this.

So, basically to summarize this particular category. So, whatever the structure comes in that process we accept it, it may be exposed it may be hidden, but we do not divide like we do not really deviate from whatever the structure says to solve the problem.

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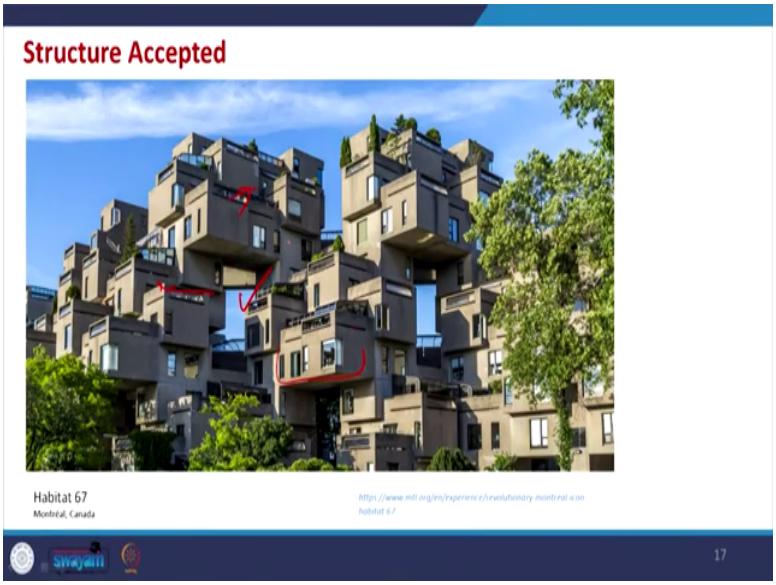

Again, this is form Habitat 67. Nice arrangement of your you know some cubicle arrangement here like your rectangular block being places different housing unit the purpose was to give the nice view to all of the you know resident in that. So, here also like to maintain the stability whatever the arrangement, whatever the arrangement one after another to be placed it was maintained.

So, again this could be one example under the structure accepted and you will also find more and share with me like which can be you know incorporated in this category. So, we can enhance this particular database in this to come.

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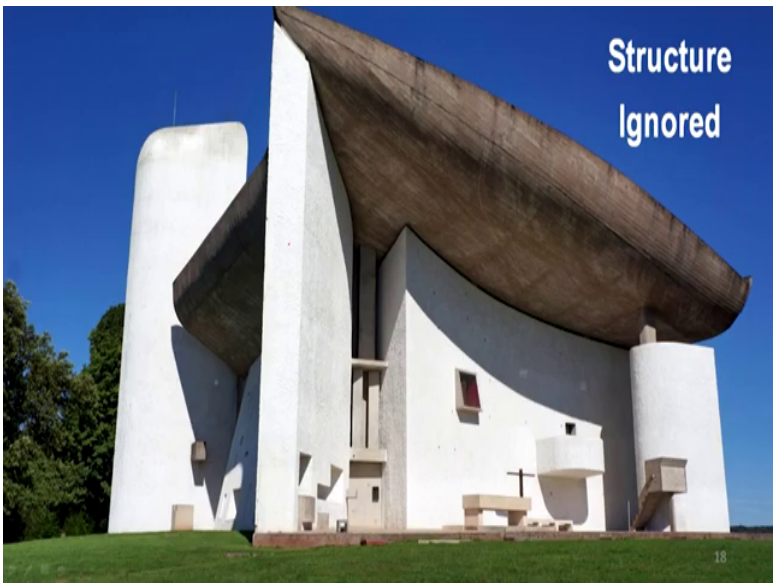

Now, this is the last, but not the least under 5 different category where we get connected with structure architecture, then architecture structure something in that manner and where structure ignored. And again I am saying that this ignored is not leading to the compromisation to the structural requirement we do not compromise because after all your outcome whatever the architecture will bring into the real world that should be stable, ok. And people they can experience it like without fear, so that should be safe also.

But in order to give some organic form or something which is unorthodox, so there sometimes we ignore the typical structure that could come, we just ignore that. So, basically

here structure ignored is in form making and not considering to give of aesthetically aesthetic forms to your architecture.

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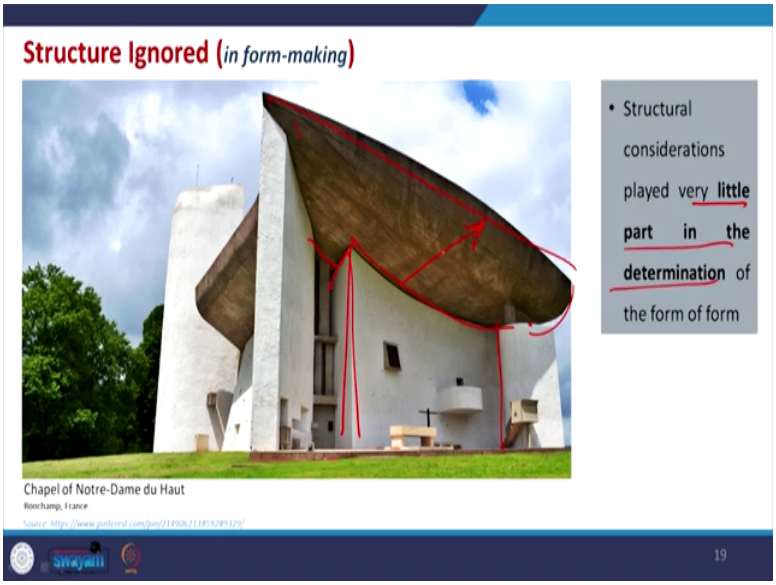

So, this is a creation. Here in Ronchamp France this is the Chapel of Notre-Dame. So, here if you see the structural considerations played very little part, very little part in determination of the form.

See in this example like this huge mass being created, and this roof yes because now the material is available we can think of reducing the thickness of the structure, we can go for a cantilever of a desired lane with due consideration of structure requirement to support it. So, then this is one example where structure is being ignored in form making.

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This is another example designed by Zaha Hadid, Riverside Museum Glasgow. So, here also if you see this is basically the form the plan if you see that is some matching with the site, and as well as the weight. So, wherein in the section if you see, that it is having some irregular roofing system, so which is not very simplistic structure. But here whatever is required to make this form to match with the environment and the concept of the designer, so we will go with that and accordingly will select some structure to make this.

So, here also the structure the typical structure that could come is ignored and then this is placed like we just the form creation, and this is a very beautiful example under this category structure ignored.

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This is from Singapore. Here also if you see this is a form of flower, so again it is sales structure being used here, but definitely to make these it is elevated, supported with some you know like thick and thin vertical support. So, overall this creation is something where we cannot really think about the structure. Looking at the building it is basically the form that comes first in our mind.

And here we again this can come in structure ignored where it could be supported in a different manner or we can minimalize the application of the structure, we can also go for some cost saving, but anyway here the main focus was to make your architecture little bit organic and here that is why the structure is ignored in form making.

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And this is the last example under this category. This is again a form of Nautilus. So, this is a resort in Mexico where you can see these form. So, looking at this we cannot really give what exactly the structure. So, as it is definitely a sale structure kind of thing and as because it is derived from a nature you see the interior everything every space creation is the form, the architectural form or the organic form that comes first to create this. So, structure again ignored in for making definitely in order to make it stable whatever required was considered in that.

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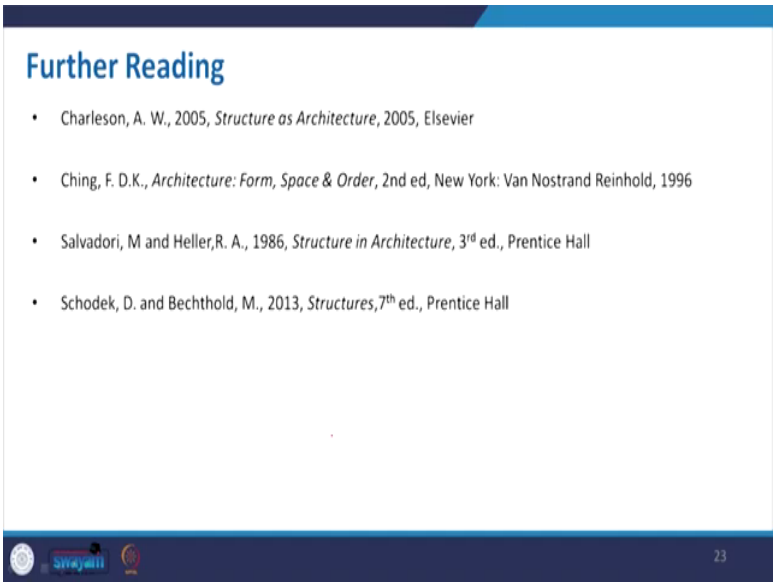

So, these are the further reading, already I have given in the earlier slide. So, if we want to summarize it in today's lecture what we learned the first example, the first category was about structure as architecture. We have taken example of Eiffel Tower or some high rise building where we have seen in Burj Khalifa where basically it is the structural arrangement to protect your a building from your gravity or lateral load all impose load on it and finally, the outcome is really a form. So, structure act as architecture.

In the second category, where we also discussed about accept structure. So, structure accepted there means whatever the form like in order to make the structure, make the architecture whatever the structural requirement requirements come into picture we fit it, we do not actually deviate it from that, but in order to give the completeness we give some you know

other you know arrangement of that. But definitely over all looking at that they will maintain a balance between whatever the structure is required you can say that it is adequate.

But in the last category the structure ignored in form making where the form was given impresses and for that the typical or optimal use of structural require like arrangement and requirements was not followed being ignored to give this particular form. But again this ignorance will not having any relation with the compromisation of the structural stability steepness and safety.

So, that overall ambience in all these examples we see that there are something which is predominating. So, we have seen different dominance either sometimes in architectural form, sometimes with the structure, sometimes the combination of both and sometimes the total ignorance of structure in form making, and it is a free flow design of by the architects. So, these are different kind of thing where we have like discussed so far in two lectures and this is very you know important two lectures.

And what I suggest you all that you I could like could add more pictures or more examples to it, but intentionally I just explained of different variety taking from different era different examples. So, I would suggest that you also do this exercise and you just try to figure out some of the buildings from the country from, the overall you know you know across the globe and you try to feed out to give this building is basically can come into this category.

So, there may be some cases of same building can come under two category, but there will be something called predominance, looking at this as first instance which one will be the you know in your mind, so that you can put that building in the category. And with that we just discussed about different form either with the concept of architectures structure relationship, quality structural relationship. Here it is basically connecting both we discussed about that.

Now, the next lecture will be very much interesting that is structural transformation in architectural history that starting from the primitive ways Stonehenge tree house and now the

modern install structure, how it transform, ok. So, we will discuss that in the upcoming lectures on the structure transformation in history and till then have a nice time.

Thank you.