Structure, Form, and Architecture: The Synergy

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Lecture - 08
Structural Transformation in Architectural History

Hello friends welcome back to the online NPTEL course on Structure, Form and Architecture the Synergy. Today we are in lecture number 8 that is Structural Transformation in Architectural History. As we discussed earlier different role of structured on architecture how it actually help to bring the form and also like bring the quality and concept of that.

But so far whatever we have discussed I have shown some of the you know modern buildings and all, but it is been practice since long like over the time if you see the history of architecture then, we can understand that how that a structural requirement and it needs transformed over the time.

So in this lecture we will basically see those through the ages and we will discuss with respect to the world history of architecture and I will also give you some of the information about what happened that time, like in different phases like starting from prehistory to the your neoclassical modern architecture, what happened in India and how structural form that has changed.

So, in the introduction basically the need for changing something is basically to refine to make it more better and better. So, for example, if I take a cube a solid cube, it is nice object to see with the nice proportion because of all the sides are equal.

But the moment we just create or add or subtract some portion from that that will create some different form, and we create some voidness inside it and make it habitable. So, like that whenever we need something to you know get something from the basic to a new one or modified one which will help us for some of the or to solve some purpose so, we go for it.

So, as true for the structure and your architecture basically the first purpose if we see the primitive age where the you know our did in ancient man so, they were threatened by the other ferocious animals and also with the external environments. So, for that they build shelter.

So earlier what they used to do? They started living in cave, but let me tell you cave is not manmade architecture, it is a natural one ok. So, this is basically the erosion of your rock due to some water flow or the wind flow and people used to you know live there, and then later on they also invent some of the tree house and then slow and slow and now we can see the tall structure like Burj Khalifa or Burj Al Arab.

So, this long journey there are different phases where sometimes structure was so basic and prominence or importance was given to the structural arrangement, sometimes in earlier presentation we have seen, that along with that basic requirement they also ornament it, so, we will go through it.

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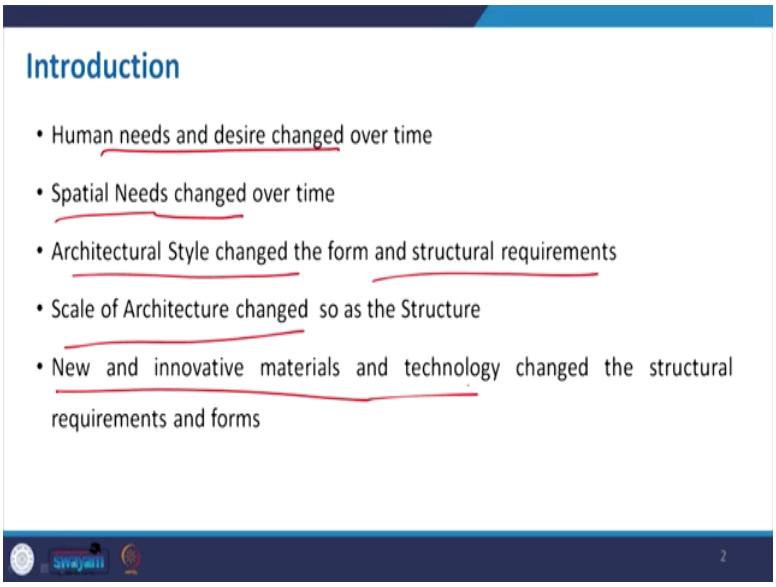

So human needs and desire change over time. First it was a purpose; so the basic one of the basic need is shelter and then when we have it then we want to make it more aesthetically pleasant environment. Even in the cave they painted so, you know this particular idea like decorating the structure making the space more beautiful was there in the history also, but it changed over time.

Earlier there was no that much space constant or maybe for the empires or who were having enough wealth to build mega you know huge gigantic monumental structures, but now it is not really possible because of the land availability or maybe sometimes with some other constraint.

So then were like we invented a different technology, different materials by which we just transform the structural requirement for the modern building. And over the time the spatial

need also change, like earlier it was something like when we considered the cave that has different space requirement and then the modification has been done over the years.

So, we segregate the space in different manner, we even we take the example of a residential building, where we have segregated the whole space design space in different you know areas, like we have bedrooms, we have toilets, then kitchen and then dining. So, like that the requirement of the kitchen and everything based on the anthropometry. Anthropometry is basically the dimension that we require to you know do our activity with that.

So, those anthropometry played a crucial role to design those space. So, spatial arrangement and requirement also changed over time. So, we have seen in history that how those monumental structure now become a like human skill structures, so, these are the changes we have seen. Then architectural style also changed and it has influenced from one empire to other empire, based on that it has been followed over that area even it crosses the boundary to spread in you know in a global spectrum and so, as through with the structural requirement because the moment we go for you know huge structure, where like maybe that is not having that much interior space.

So, like with minimalistic interior space we developed like the huge structures. So, that was something else, but that time we should also remember the steel was not there concrete was not invented, so, that is why it is all the stone. So, they made megalithic structure, so we will come to that also.

And now we have invented steel glass so that we can reduce the thickness of the wall and we can do some excellence what was not there in the mind and gradually we are improving on that. And scale of the architecture already I mentioned that from monumental structures now bring down to human structure, sometimes also we followed back the our you know history and we make a structure very huge and spacious.

And most importantly the new and innovative materials and technologies, that changed the everything, the scenario. The time to time we got some good material having good strength and which can be you know easily placed in you know instead of using the traditional brick or

other type of building materials, will really you know giving more strength as well as it will also create the desirable interior space that we normally looking for to maximize it.

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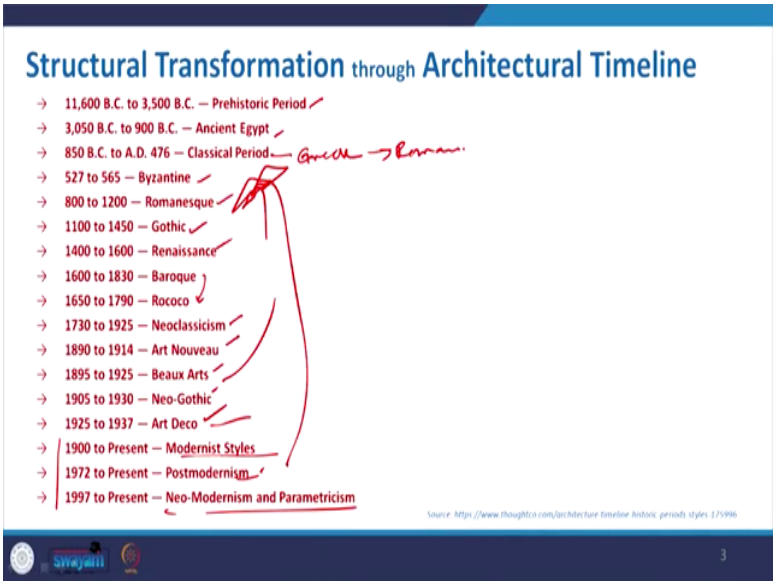

So, let us move to the history and definitely with the time constraint and other you know things, so, it is not possible to give all the examples that we can put it, but definitely here I try to you know summarize it or take some you know very prominent examples. So, I would also request you that you also do this search and also compile some of the more buildings in each of the phases which depicts that you know the architectural style as well as the structure used in it. So, let us move on. So, this is the overall you know timeline and there are some you know maybe in some of the sources they add some other thing deplete architecture or something like that.

So, these are the basic timeline, again it is of the world level. So, starting from the prehistoric then we have the Egyptian architecture and we know the pyramid and other type of you know beautiful piece of architecture at that time, then the classical period is very important where we have these Greek and then after that it is Roman architecture.

So, starting from Parthenon to Pantheon, so style more or less same, but you know the formation and the requirement has changed a bit, then Byzantine, then Romanesque and then Gothic. Gothic architecture is very famous for the ornamentation of structures, the use of some pointed arch. So, we will also get the detail of that.

Then in the Renaissance period again it is evolved then Baroque and Rococo this is basically coming to worsen you know again the decoration and beautification of that.

And then you know in the 18 16th century 17th century that time Neoclassicism then Art Nouveau then your Neo Gothic those are the you know new type of form that has come, but followed some of the earlier you know concept and the order architectural order and the rhythm. And then when we take the Art Deco and the Beaux movement during this you know 1920 and that particular phase, so, system has changed the modernism is getting to start at that time.

So in modern style the you know we go for the minimalistic structure so, those are actually possible with some invention of you know steel and other things. So, after the industrial revolution, so, the structural requirement and their you know used in building thus changed the scenario. Then the post modernism we have seen some beautiful buildings at that time even including your you know Sydney Opera House and those kind of structure.

And then the Neo Modernism and Parametric architecture this is nowadays in practice, and if you want to see that all these things like for modern to the new postmodern and the parametric architecture these all are practice even some of the buildings we again look back to the you know earlier classical order in the architecture.

But these are the architectural form so, our focus will not really discuss the contemporary architecture and their transition, we will also try to focus on the structural changes how it has changed.

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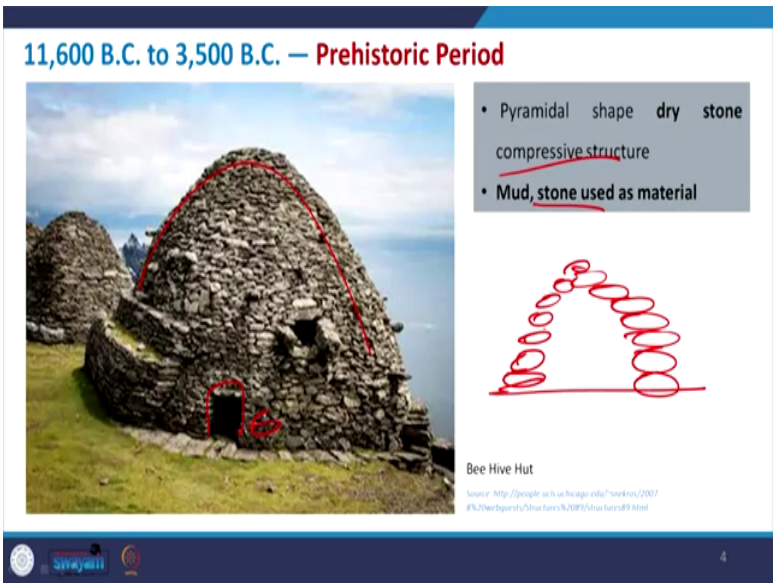

So, in the prehistoric period that we can get some bee hive kind of structure which is basically a dry stone comprehensive structure. So put stone after another so that will make this structure. So, it is similar to the construction of igloo, so where no mortar being used so just the self weight being transferred through this particular arrangement. And here sometimes we also used mud or sometimes most of the cases stone was used, so that was something like having small opening to just act as a door. So, this is something really interesting at that time, and this is basically a comprehensive dominical structure so, where we just stack stone after one after another to form it.

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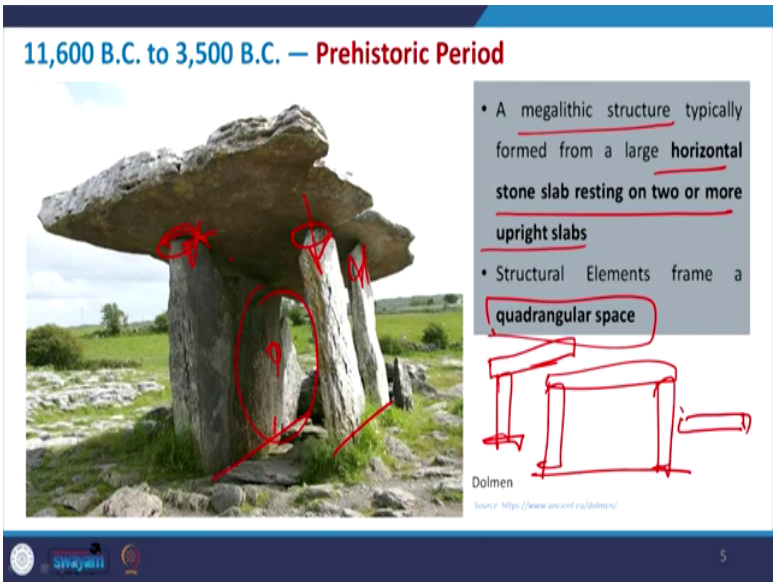

This is another example of dolmen. So this is basically the megalithic structure. So, megalithic structure is basically where you know horizontal you know slab is resting on the upstanding slab. So, if you take a particular slab like stone slab and then you make it you know upright in this position and you put another one again no mortar being used. So, you can see that how it is resting there.

So, it is giving some form of stability and because of the self weight and the position so, it is again making like the structure stable. So, it is the horizontal stone slab resting on two or more upright slab so, this is a megalithic structure.

And it create a quadrangular shape. So, basically this is the integral space, so, it is it was helpful that time to protect ourselves from the external externalities or protect from the other

animals. This is another example of the same where multiple such megalithic structure is formed this temple kind of structures.

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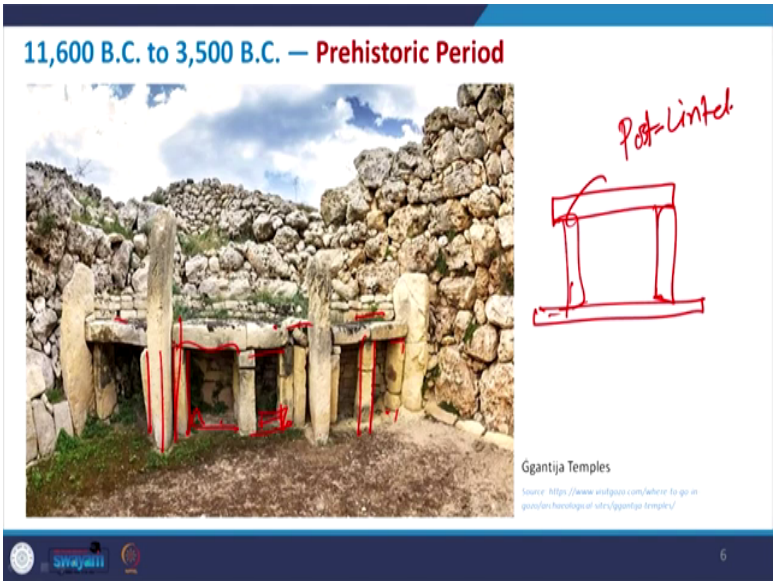

So, here you can see that the interior space subject to like with respect to the you know solid structure is very less. As because there was no specific idea like how much is optimal you know area to be given for the structure and how to do it, remember there also it is again putting stone one after another to create this space. So, that was the idea and from here itself the idea came that is basically like giving us stability to structure where horizontal member will be resting on the vertical member and then we later on name it post lintel or post beam structure that we will see in the next phase.

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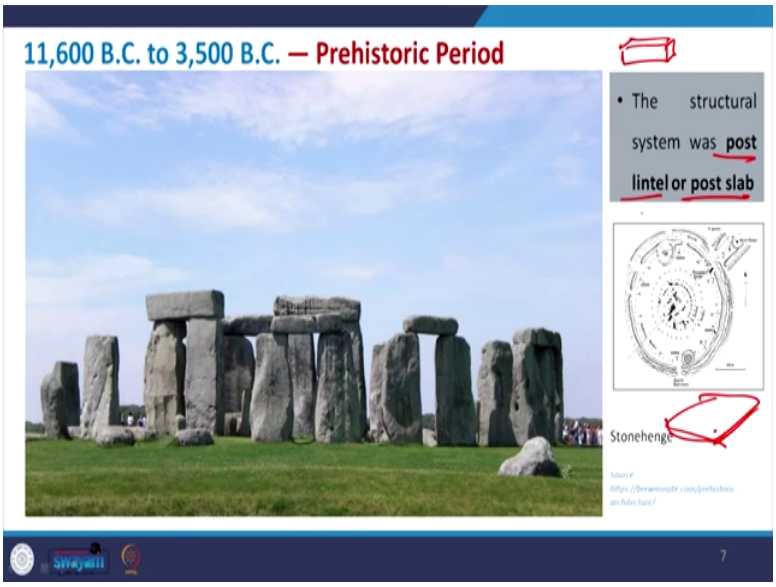

So, this is again pre historic example and this is the Stonehenge following the same you know same kind of arrangement of structure post lintel or post slab. So, depending on the span or the area of the stone we used either we call it slab when it has a considerable you know area, length and width, and when it is just you know just like a piece of like beam so, then we go for this post lintel structure.

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So, this is again one example from the pre historic period and now we move on to the Egypt. Egypt again they create the you know beautiful architecture with the symmetry and the stability. So, pyramid is considered to be one of the most stable structure because of it is you know larger base and then when its go up it merge to a point. So, again for the winter condition and other lateral forces this kind of shape is very useful.

So, that is why now also in the building modern building high rise building as we go up we give you know conical or paramedical shape at the top in order to reduce or the resist again the lateral wind load. But again it is a monumental scale structure is being very used and stone as material. So, the using stone as a material is basically giving good strength and all together it will like one after another it will also give a megalithic structure so, that it was stable.

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Not only pyramid even that period in Egypt they have also constructed other structure where they have used the timber beam and then this is monolithic stone masonry. So, you can get this particular wall. So, a piece of you know stone they are they have used, then the columns made by single rock.

So, that is another important issue so, that is basically from the single rock they cut and they give some kind of you know Ornamentation to it, they paint those structures. So, in Egypt this is famous that they always about the Egyptian you know painting on the wall and the columns.

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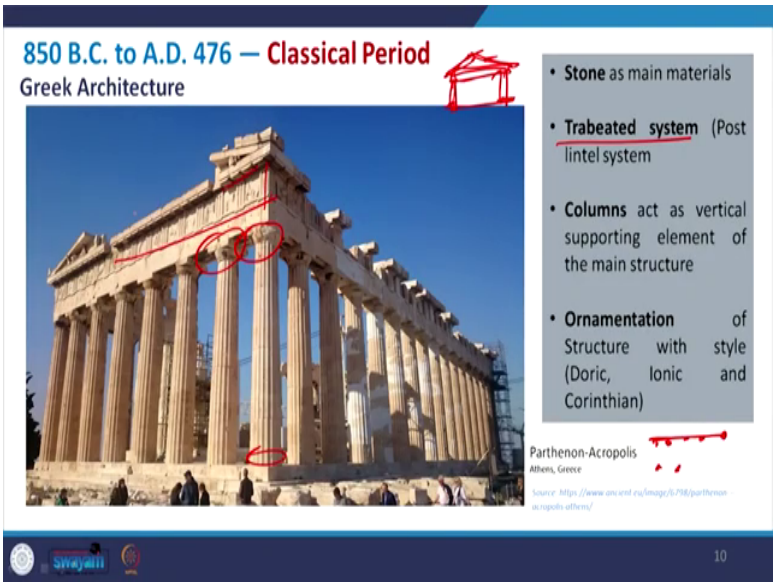

And overall the concept is again remains same in this era also, this is post lintel or post slab where, your horizontal slab is resting on the vertical columns. Now come to the classical period there we start with a Greek architecture and this is the example Parthenon which almost in you know many of the cases we repeat this particular example because of its multiple you know characteristics. Here again it is as already we discussed about this, you know Parthenon that it is basically a structural you know dictation is there to create these forms.

So, basically in a rectangular form multiple columns are placed and then they are connected with lintel or beam, and basically what it gives? It is the trabeated system, where you know you have this horizontal beam on this column and then you can create these kind of you know triangular members to support it to create the roof system.

And the most important thing here, it is not simple like post beam structure or very you know rough finish, so enough decoration has been made and the Doric architectural style been used in this structure. So, you can see the capital of these columns and already we discussed this in the last lecture that how this Ornamentation has been done in this particular period.

Even in the lintel or beam also Ornamentation has been done. So, basic idea is your post like lintel structure, but with some Ornamentation. And this has been carried forward to the Roman architecture and there like structure system again, your post slab or post lintel, but here in this case column arranged circular or rectangular.

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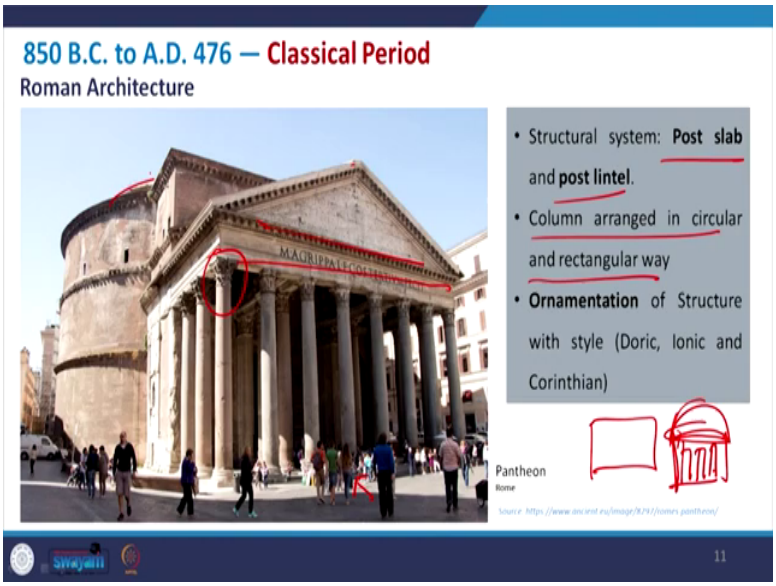

In Greek most of the cases is the rectangular form, but here in this we also discuss this example in the last class that it is like hemispherical dome based on a cylindrical form. So, giving more stability to that and also create those you know we accept this structure in

architecture and here in the entrance portion so, they have used the column, but here the Corinthian style is used where the capital is giving a you know ornamentation aligned with the you know organic thing like leaves and other you know living elements. And again the structure is pretty similar to the Parthenon at this front portion and the back portion is a huge dome. So, this is basically again following under the category where it is being used with your stone as a material.

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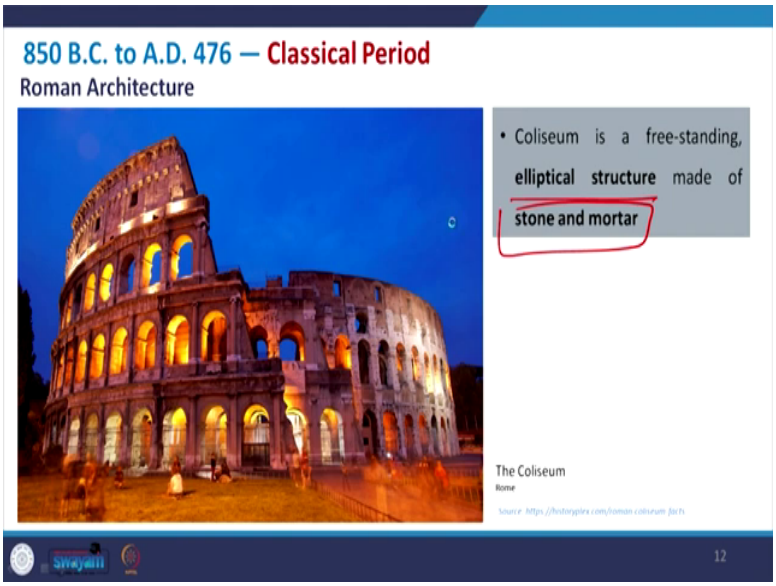

Now this is another example from the Roman architecture the Coliseum, so here this beautiful arena is being made and give a elliptical structure and here stone and mortar being used, even that is used in this case also.

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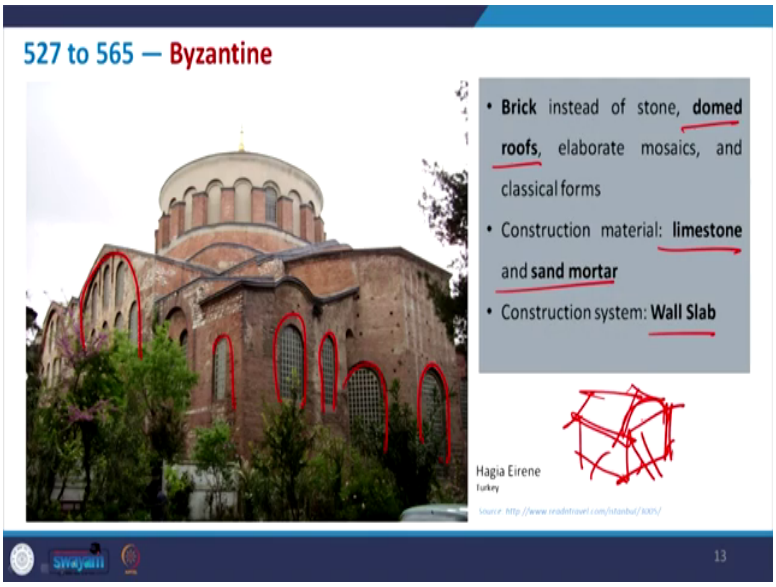

Now, come to the Byzantine where like stone is being replaced with some brick instead of stone and then dome roof like in even in Pantheon in Rome we have seen that. So, it is being used and here along with that you can see that you know arch use of arches in for the window being used, even for the structure these huge you know the roof. So, again the pitch roof has come into the picture and construction material basically limestone and sand mortar and construction system is wall slab.

So instead of column, so, it is basically the load bearing structure that is being constructed. So, wall is being formed so, that give envelope and on top of it either it is pitch roof or the dome roof. So, there is a transformation that we can see earlier it was post lintel kind of structure where you get more void through the structural arrangement itself, but here it is something where we go for wall and slab.

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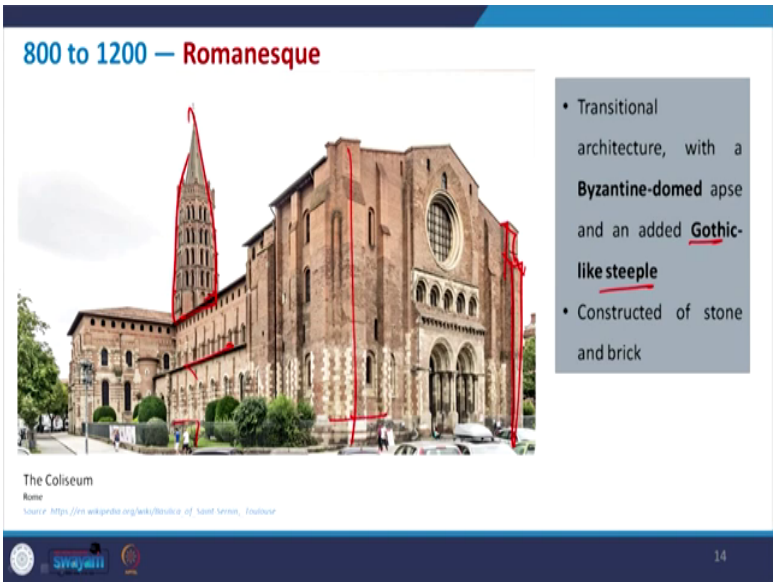

Now, the Romanesque is again the addition to the by Byzantine dome that is your Gothic like steeple. So, this you know structure being added to it and definitely, if you see again the scale has a little change in that even like the scale has little reduced here and along with that they also creates some additional support to this. So, basically again here the stone and the brick being used and again it is like your load bearing structure that was constructed during this phase.

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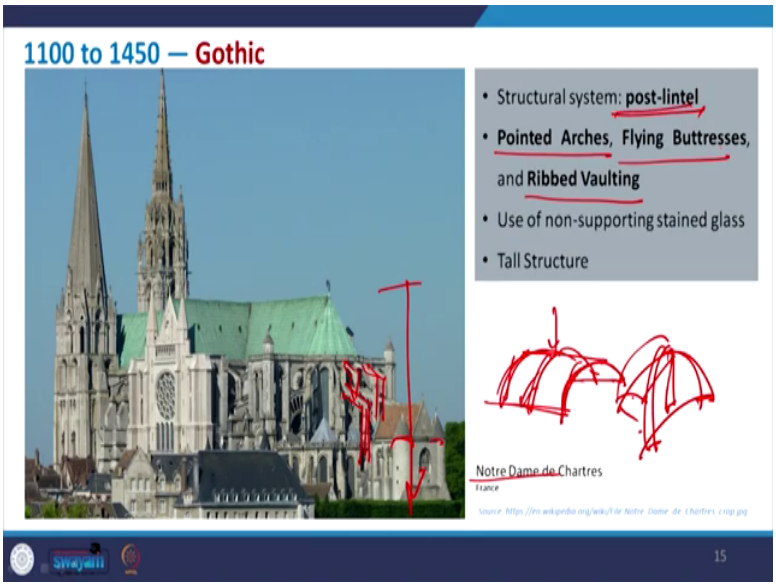

Now come to Gothic, Gothic era is specially known for its ornamentation of structures. So, basically here you see the basic structural is again your post lintel and post slab also and then you can see that pointed arches then flying buttresses and ripped vaulting these are features of this.

So, what is the flying buttresses here? So, you can see here that it is giving another support lateral support to the main structure, and when it is talking about the vault, ribbed vault is basically you know sometimes it may be like it is again a comprehensive structure which will transfer the load through the structure on the you know on its support. And then sometimes it may be like the ripped one where like, we create a frame of the vault and then we cover it up. So, from interior you can see all these buildings and this is the Notre Dame in France, where

we can see this piece roof along with these buttresses and then inside it also you get some cylindrical form and the vault, use of vault.

So gradually like in order to support the tall structure and also create the interior space more interior space to make this space like column free to have the assembly in a beautiful way. So, development of this kind of comprehensive structure ok, were ripped vault and other lateral force at lateral resistance being provided by flying buttresses these are you know some of the addition to that. So, shifting from simple point lintel to adding all this is one of the feature in this period.

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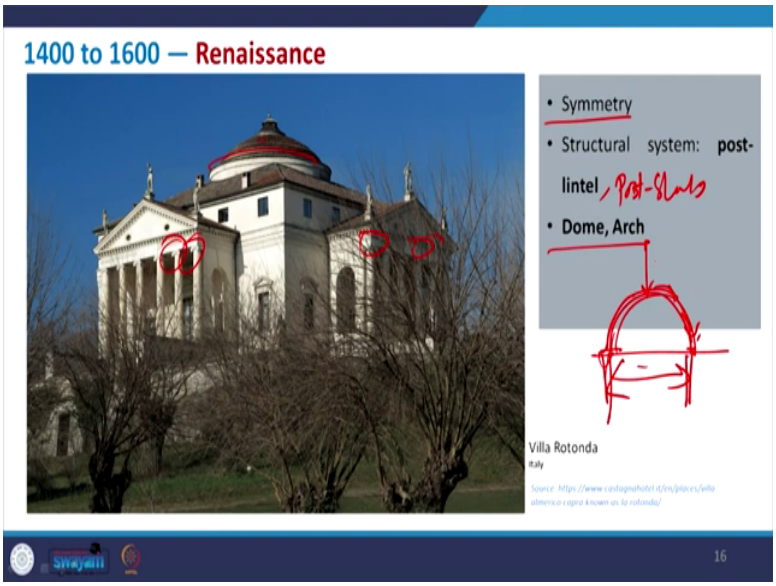

Come to the Renaissance period here with the symmetry played a role and almost you can see those style like, here also ionic column being used and it is similar to the Roman and all, but

again it is your post lintel and your post slab structure, along with that the central dome arches being used.

So again the you know for the arch when you discuss during the property of the arch, then also like with this symmetrical arrangement it will easily transfer the load to the support. So, we can create some you know span with this kind of structure. So, as to with the dome and again like if you take the example of India, from India then Golconda fort in Bijapur, they also have like it also has a huge dome; so, that is being practiced to create the structure.

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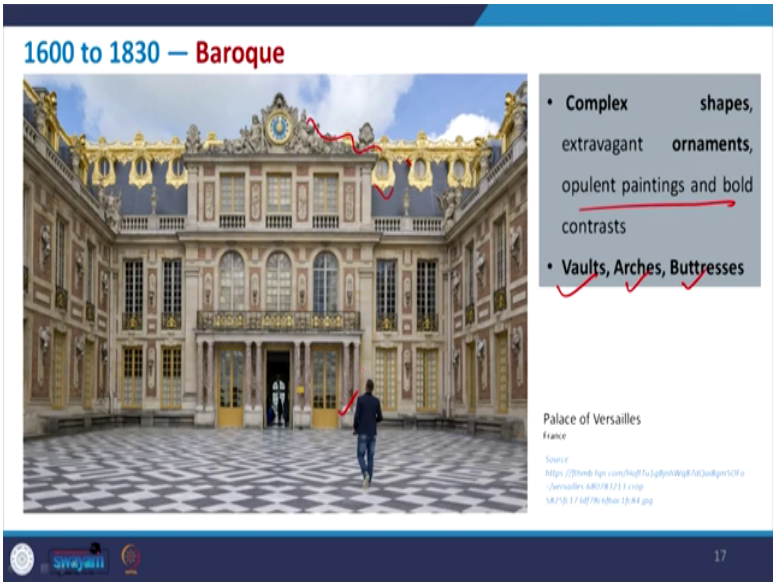

Now, come to the Baroque architecture. Here basically the structural arrangement has been followed through your Gothic and all, but more ornamentation and very complex is the curvatures and other to be made, at the for the decoration purpose and again vault, arches and buttresses as your Gothic architecture they have used to support the building.

But more importantly it is creating some contrast with the you know traditional architecture, so, ornamentation of structure creating some false column that was used here so, that is in this period.

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Then Rococo is again farther decorative design and you can see those moldings. So, there also the delicate geometric patterns being followed, some involute and symmetry that has been made there and basically in this case again the structure is being followed like the same with your the previous one, where you get this particular Baroque architecture or Renaissance architecture.

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In the Neoclassicism were like little bit modification has been done, again the symmetry is followed and there again post lintel post slab kind of structure being used, then the user column, user column and the blank wall is in practice. Even this kind of an intimate of column we can see in like our Parliament House in India also, you can see those structures. So, it is basically a combination of the form and again your structures now being modified little bit and then dome and arches being used in this phase.

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Now, Art Nouveau basically this is the age where different art form being added to the architectures. So, again instead of street wall then curvature been maintained then decoration for the arches, balconies etcetera being made, and then it is basically the asymmetric shape and in order to support that then there are different other you know different arches being used and overall ornamentation is being made.

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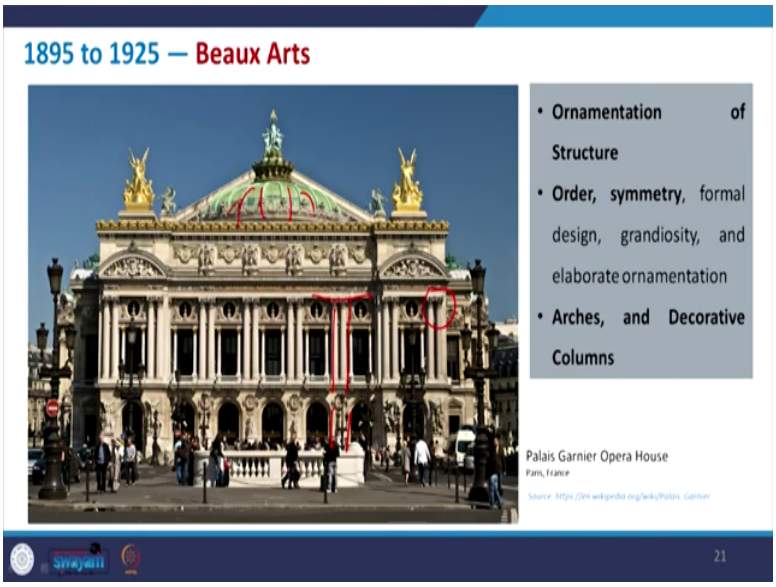

Now Beaux Arts is again a modification, so, this is example from Opera House in Paris there you can see the beautification. The basic structure remain the same again in this case is, like your column then a portion is basically being supported with this lintel. And you can see those you know Corinthian order in the column capital again use up ribbed dome, so that has been supported.

But again it is again the beautification and ornamentation that we see and again symmetry is maintained in this case.

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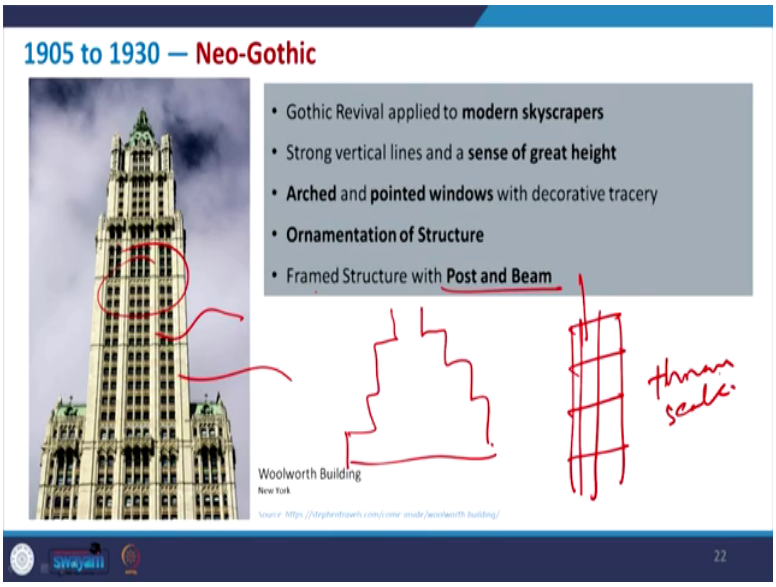

Now, come to Neo Gothic, it is basically a transition to the modern skyscraper, but adding some features of the Gothic. So, Gothic again it is a revival period where those kind of ornamentation is made.

But now in this case like what we have these frame structure with Post and Beam, so, frame structure come into point and when we go for the multiple floor. High rise structure being made, but again due to that lateral pressure and all, it is again have these particular step cut architectures where you know when you go half the cross section of the building it reduced to you know resist again the wind load.

So, this is some advancement to being made where the scale been reduced to the human scale ok, the space is optimized, but again ornamentation is still on in this particular period.

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Now, Art Deco movement again is the frame structures, still being introduced already. So, again Ziggurat or you know terraced pyramid shape structure being made in this case. And steel concrete used as a material to give the form, and again it is basically the high rise structure that was the need to create some high rise of its building or the residential building hotel buildings, and this is one example of that where definitely overall it is giving a nice aesthetic look, but basically the structural point of view it has moved from a typical like your structure to the frame structure at this moment.

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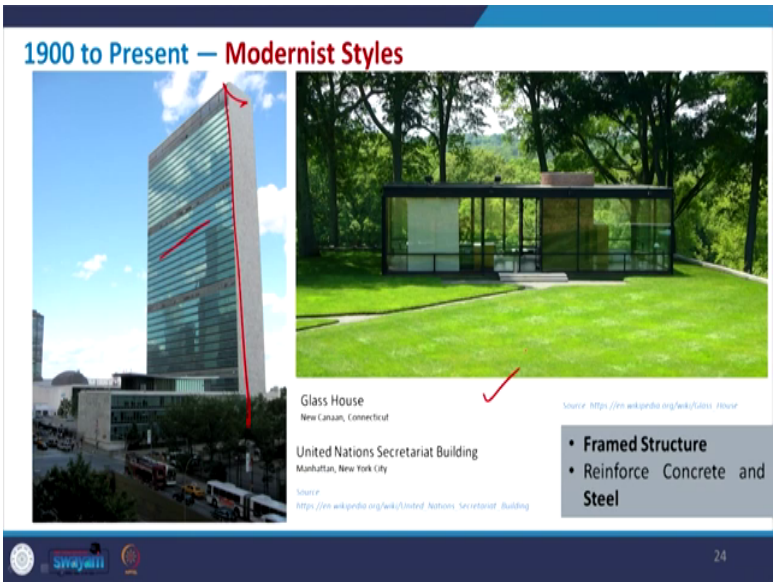

Now come to the modern style. So, here also it is the time where like architects and designer they prefer the minimalistic form with the structural you know application. So, this is one example for United Nations Secretariat Building, the multiple building very simple straightforward building, a frame structure use of steel and concrete is very predominant and very simplistic no such decoration and so, as true for the Glass House, again it is like the use of steel and then you use a glass.

So, basically in the modern style decoration, ornamentation that was not given prominence rather than that the space creation and the use of the structure to create the to reduce the thickness of the wall to carry the load being given importance. So, that is why since then we create some multi story building with this.

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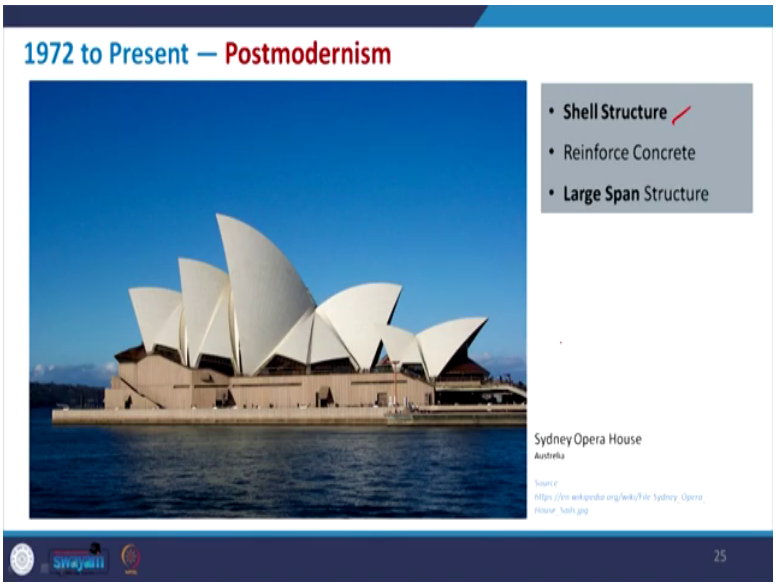

And post modernism it is out of the frame structure then also like the design and they tried the sales structure to reduce like to reduce the number of columns required and it is creating with some you know reinforce concrete. So, that it can create the interior space. Large span structure and we have seen in many you know indoor stadium even in the example of your Lotus Temple that has been used. And in that case also like in Sydney Opera House it being you know made on that category.

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Now come to the Parametricism, this is the current age architecture, were not a perfect geometry or something. So, it is being played with some Parametricism.

And here you can see that the nice wave and curvature being made and it is only possible because of the sales structures and different other structural advancement and innovations of different material, which can actually bring this into reality with minimal thickness with you know the application and maintain the stability.

So, large span structure being made and there are many examples. So, this is one of them. So, there are examples of different high rise building many buildings been designed by Zaha Hadid. So, this is a overall transition from a simple you know post beam or post lentil structure to this kind of form; this is a long journey, and due to invention of steel after the industrial revolution this is been you know so, popular even we have seen your Eiffel Tower that time so, that has a change.

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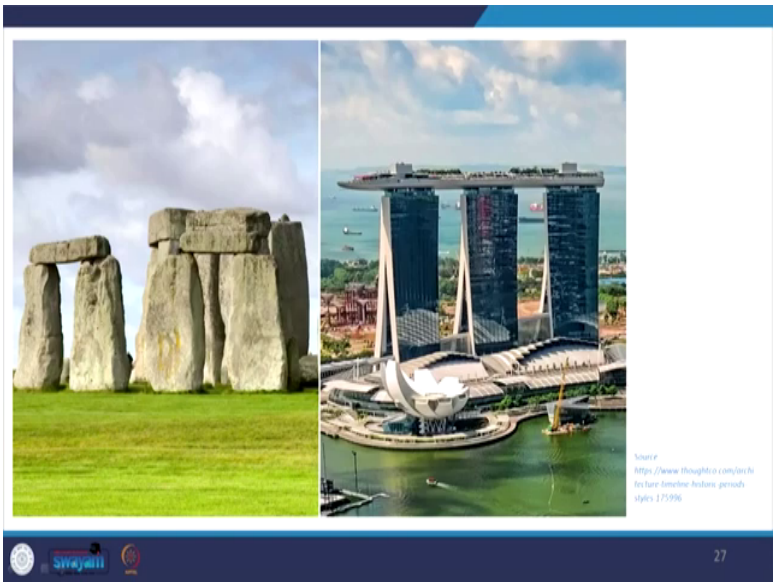

So, you can just compare these two image, this is one example from the Singapore and this is the old you know dolmen kind of thing. So, basic idea remain same but the transformation if you see the thickness and you can compare the thickness a huge difference. So, idea concept being in practice so, from the history we learnt so, many things that we use it but with some modification in the structural arrangement, and so basically we have discussed all.

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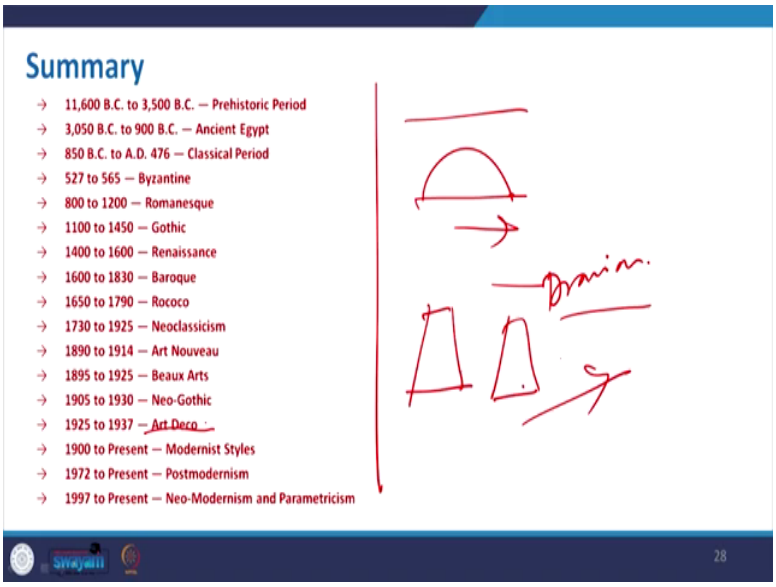

So, during this phase also in Indian context we have seen Indus valley civilization where also there are examples of some of that structure, like the bath the Great Bath and all. Later on we move to the Buddhist architecture, we get the dominical structure in Sanchi and then also the rock cut architecture to create those Stupa. And then also we have seen the Dravidian temple in that era where you know the again the form of you know mountain or some Pyramidal form of the temple being made that time. And then slowly move to the other you know phase where we have seen the Islamic architecture like again Taj Mahal and other thing where it is a beautiful example of the structure, the symmetry and also the ornamentation.

So those kind of structures being made even in Fatehpur Sikri we have seen different you know use of those barricades and their ornamentation, and the letter on like in the phase of the British era or you know your colonial era, there we have seen the use of different you

know column and also mean like they have created some buildings following these you know old order like Doric, Corinthian and all and.

Later on like after post independence also go for the you know global movement. So, during that you know Art Deco and Beaux so, there are different buildings been made and we followed up.

So the history of Indian architecture is also very reach the transformation we have seen from the structural point of view and the overall scale, but here we have just focused on the overall scenario of the world. So, and we discussed some of the changes that like from basic structure than ornamentation then again in the modern era you know stick to the very minimalistic form on go for most of space creation and then in the modern we create again something very dynamic structure and which is possible again because of like day by day we are getting more material that can replace the existing one, we are able to reduce the thickness of the wall, we can go higher and higher and we are breaking the record of creating tall structures.

So, that is only possible with this transition and again some of the buildings they followed the traditional, classical architecture as a decoration also not as a structural point of view. So, overall architecture and structured they balanced each other and we the invention we keep on doing those you know new practice and we move from one phase to another phase.

So I hope that this will really help you to just get a look that that transformation, but again I am saying that I have taken very few examples of that and there are many. So, I suggest you that you also go through those links I have provided in each slide. So, that you can get more information about those buildings and you can search similar kind of building, so, that it will help us to understand about this transformation.

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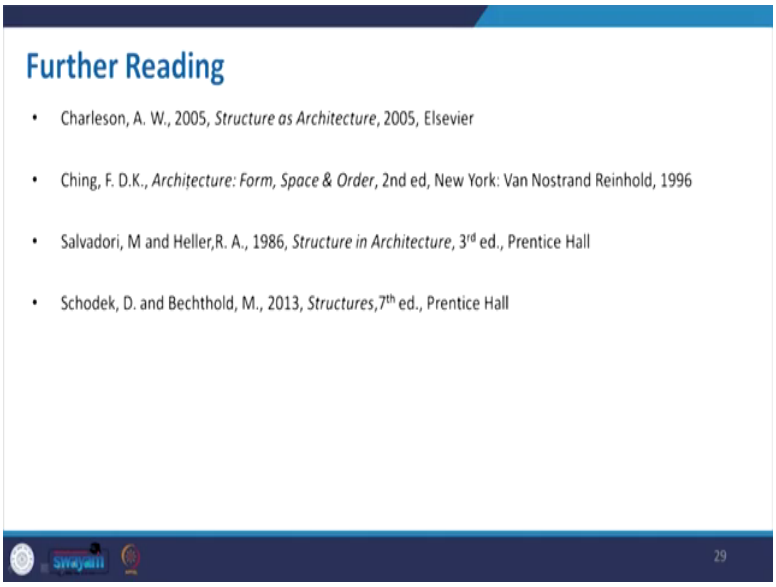

So, with that I conclude this particular lecture and these are the same reading, materials some reference says are given as a book. So, you can go through that and the next like we will discuss about different factors that affect the structural form. So, with that I thank you all for you know participating in this lecture.

Thank you.