Structure, Form, and Architecture: The Synergy

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Lecture – 13
Structural Arrangement

Hello everyone, welcome back to the NPTEL online course on Structure Form and Architecture: The Synergy. Today we are at lecture number 13 which is basically will be talking about basic Structural Arrangement. So, in our previous lectures what we have seen, different kind of forces that is acting on a building components and on applied force how they are reacting like compression or tension or torsion or bending. So, on that basis in this particular lecture will be discussing about some basic arrangement of structural elements.

So, before we start this lecture, let us again quickly recap what we have covered in just at the previous lecture that is talking about different structural property. So, we are know that if some object is placed like that and when we just put pressure in this direction so, you know the particles they will come close to each other and that is basically the compression,

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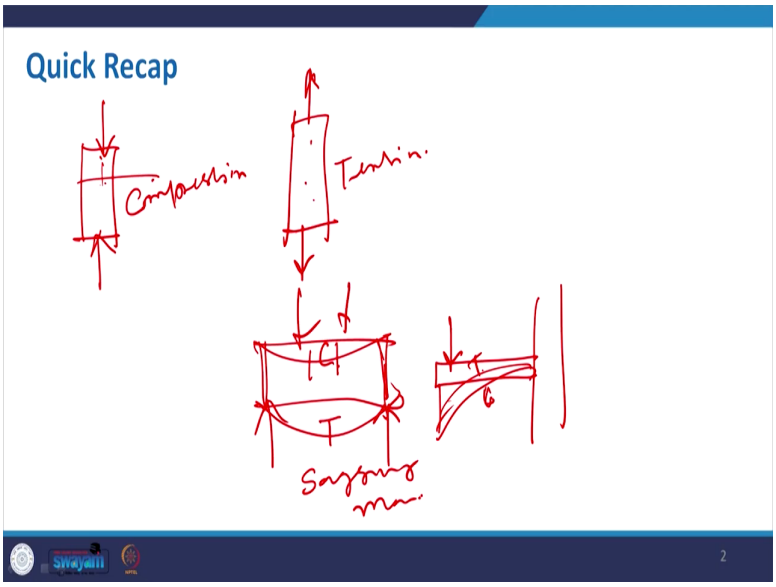

And if you pull that particular same object so, then those you know particles they will try to go away from each other and that will form the tension. And whenever it will try to bend; so, basically that will be a combination of both.So, on applied load on this; so, it will try to bend like this. And then basically, in this upper portion it is compression and the lower portion, it is tension for this kind of sagging moment. But that is just the reverse if we have a like a cantilever something like this and then we apply load on that. So, it will try to bend like this. So, in that case the lower portion do you have compression and the upper portion will develop tension.

So, these are very basic you know forces and accordingly like how our structural element will behave that are very much fundamentals to know about the structure arrangement. So, with

this you know basic concept of compression, tension and bending will follow up different kind of structural arrangement and basically the structural element.

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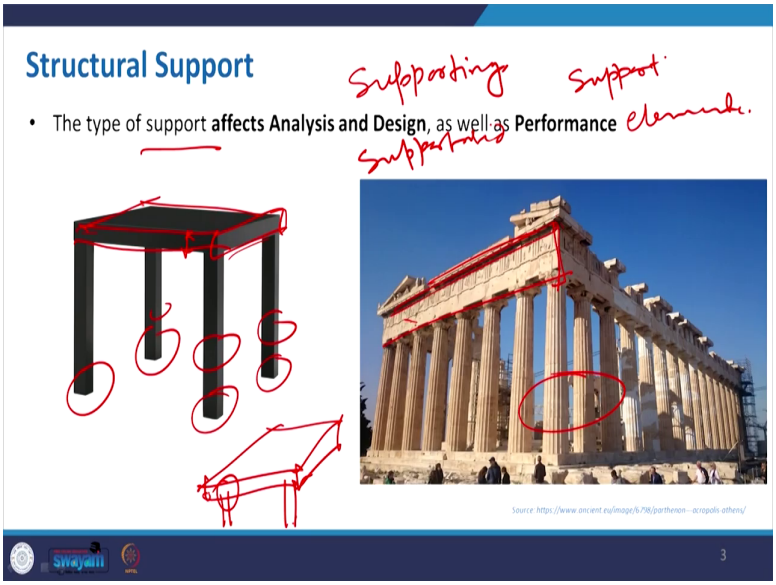

So, in this case like here I have given two examples. One is just very common in our day to day life we use it that is a table and the other one is great example of Parthenon from Greek, but there are similarities. And, I know all of you can find the similarity is basically in this case also there are some pairs or we can compare it to the like column of a building and then we have a, you know slab over it.

So, this may be made of wood or compressed wood or MDF wood like for furniture and whereas, in the building the material like we change it to concrete steel or brickwork depending on you know the span, depending on other calculation that we have study that in

order to get the requirements. The structural requirements that we have to go through the, you know assessment of load and then finally, we calculate all probable impact on that.

So, in this case again it is a series of column put one after another and it is holding a beam on that. So, the structural arrangement is pretty similar. In this case, we may use some carpentry joints, sometimes in some cases we just use adhesive to just you know club two elements together when you make like the model for our architectural design or we create any handmade thing, then either we go with the joint or else we use some adhesive to fix them up, but overall the concept of this arrangement will remain same. There will be two major components, one is basically you know the support and the other one is basically the element that will be supported.

So, in this case, we will have two major component one is supporting structure, the other is supported structure. So, again I repeat one is your supporting and one is your supported. So, supporting structure means which will essentially carry the load and will support and the supported means which actually transfer the load to the supporting structure. I make it very simple in this case if we consider this tabletop; so, this is basically being supported by these four supporting members.

In this case all this column, they are supporting members and this overall like whatever we put up on it, like which will transfer those basically I refer to the slab and this particular support will definitely affect all the design. So, that is why we should also know the kind of support that we have to give to make our structure stable.

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Now, in this case, I have you know given two different pictures side by side and I just want you to guess like what could be the reason to put this, ok. So, maybe you can find it out very easily where it is something a very low; low height structure and made of brick masonry, you cannot see any such concrete column or something like that fully made of brick.

So, this is one kind of support you can get and the scale has changed now this is a multistory building where as of now under construction building it is only showing the beam and column and the slab. So, you can see this thing like as a column, then the beam and then the slab. So, depending on our design, depending on the span, depending on the load that will be imposed on it will determine like the size of the structure, material of the structure as well as the kind of support to be given to the structure.

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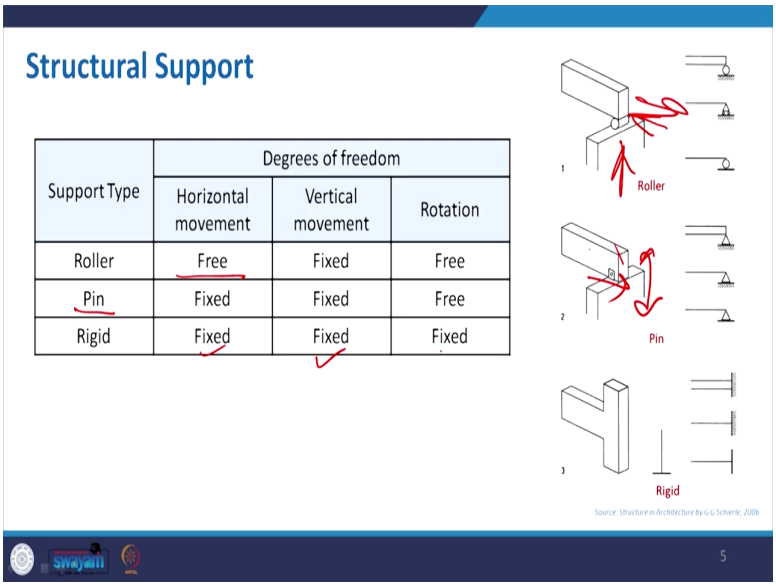

Now, in this case again if you see this the structural support, there a different way we can fix it up one is of the roller type. So, roller type support, we can see in this that one end of the structure will be resting on a roller and normally this structure being used for a bridge. So, that you know during this particular you know movement the oscillation that can roll over it and it can transfer.

So, in this case what is going to happen, in degree of freedom for roller horizontal movement is free because it can go this side or you know this side on that. bBut vertical moment is not like free it is fixed, but the rotation; definitely in that case it may happen with this particular point it may rotate.

So, when we go for a pin jointed you know structure, then in that case both your you know horizontal and vertical movement will be fixed up, but the rotation still on with I know you

know combining these two can do that. But when you go for a rigid frame so, then all this movement will be fixed. So, sometimes based on the requirement, based on the load calculation and the purpose to (Refer Time: 08:47) the building we will select up this structure.

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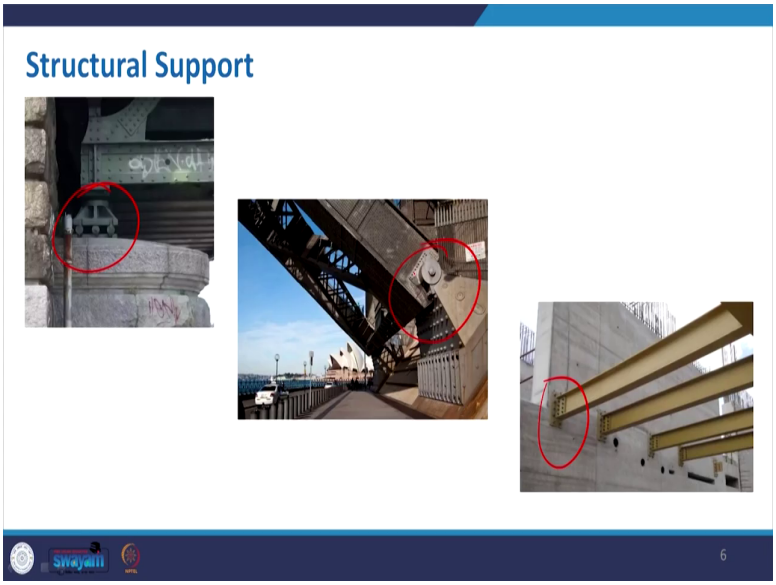

Now, in this case in order to make it more clear to you, this is the example of a breach at the one support you can see, this is a roller type support. A joint in one end where this is the other one this is your pin joint and here it is fixed to the wall and neither of the pin or roller it is basically the rigid joint. So, depending on that also we will have the arrangement.

So, in the previous slide and this slide, our main intention to understand the type of support that we can develop and what are the, you know flexibilities in that. So, depending on where

we do not want my structure should move either horizontal or vertical or even there will be no rotation. So, we will go for a rigid type of support.

Now, come to the basic structural element and which are very important because once we know the elements, then we will think about their organization, their arrangement. So, some of the elements will basically take the vertical load, some of the element will take the, you know horizontal load or the lateral load. So, these are very important. So, in this slide if you see these are very very basic elements of a building.

Now, here I am not talking about any material to be specific, but as per there, you know conventional existence and their purpose so, we can see basic four type of elements in a building. So, we start with the wall then slab and then beam and then column.

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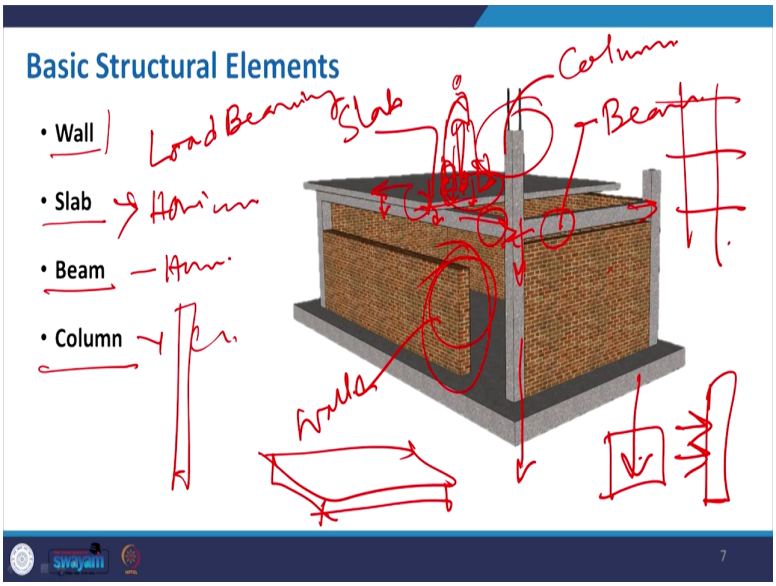

So, in this you know schematic model just I want to show each of them. So, basically I represent this as wall with a brick, but this wall can be made of any other material as well. It may be like concrete block or some you know composite block you know wall or maybe it may wooden wall. So, depending on the position normally wall is like in short, it is a slab which is you know up standing. So, if you have a slab like this with the thickness and you just make it stand on its edge so, it will become wall.

Now, come to the next it is the slab that you can see this is basically the slab, ok. So, this is your wall and beam is basically it is in connection normally for the frame structure and all; we make it as a frame with a vertical and horizontal arrangement. So, this portion where it is actually carrying the load of the slab and transfer it to the column, it is basically the beam. And whenever we go for this kind of frame structure with column and beam the purpose of making this wall is not to carry the load essentially, ok.

So, whereas, in case of a load bearing wall, load bearing structure so, all load will be transferred to the through you are you know wall. So, that will come with some example, but in this case this is your beam and the next one is the column and you can identify it easily that this is the column. Now, this again I am saying these are very basic elements and we will just try to know the concept and different kind of arrangement which are very basic in nature.

But, in you know nowadays in the modern building those arrangement a basic component may be same, but the arrangement the material and the way we execute it will have some difference and we also can name those things in a different manner. But, basic arrangement that will learn through this particular lecture will have a relation strong relation from the ancient age to the modern age and it will be clear once we discuss that. So, basic four elements wall, slab, beam and column.

So, again slab is basically responsible to oh you know deal with the horizontal force and then beam is again a horizontal and also vertical both and then column is basically vertical and wall is again a vertical. So, now, when we are talking about load so, what exactly this load transfer? So, whenever we create any structure so, we have learned this thing. Thus, there will

be some self weight of the material referred to dead load and there will be some you know movable object like we human being, furniture's that will be the live load.

So, again along with that there are some other load; so, all loads will be applied to the structure, either horizontal in nature or it is gravitational. So, it may act like this or it may be just like wind load a lateral force to it. Now, when this load will be implied to that, it will transfer the load to the you know associated member to it.

So, if it is on the slab; so, say for example, in this I am standing on this slab and I am I know carrying some I put some weight on that. So, this will be transferred to the beam, then beam will transfer to the column and column will go again and again and then finally, it will transfer load to the foundation and foundation is support it again with you know the soil.

Now, finally, we transmit all the load to the soil and then whatever the reaction will have and then we have learned about the static equilibrium. So, by which we can maintain the equilibrium and our building will stand stable.

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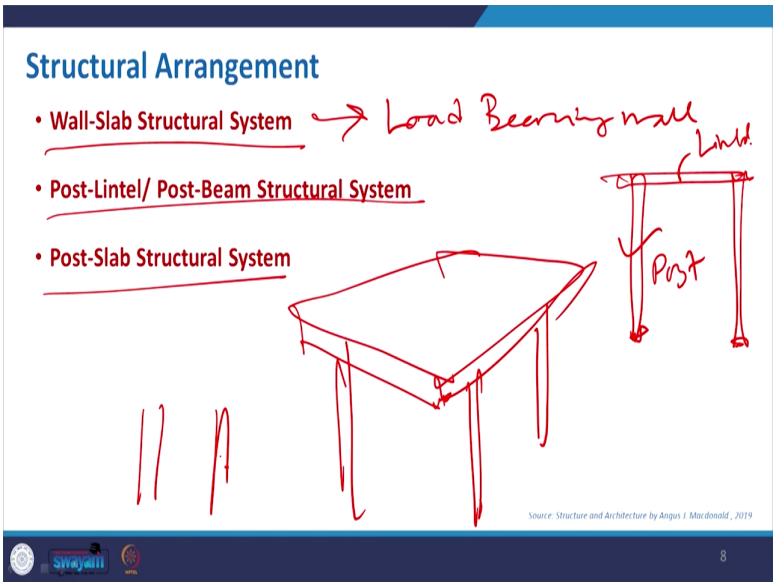

Now, again I am as we know the component with combination and permutation. We can say about three basic structural arrangement start with the wall slab where there is no role of column and specially, it refer to you are traditional load bearing wall. And, still we invented those you know the concrete and the, you know concept of the frame structure and other thing. So, most of the buildings in history we have seen that it is basically the wall slab kind of structure which is load bearing again.

The next category into it is your post lintel or post beam; so, post refer to column; normally, you know we had this term like light post goal post. So, basically this is a vertical member and then when it is lintel; so, this is again a horizontal member. So, these are post and this is lintel and then we name it alternatively this is post beam structural arrangement.

So, again in history also we have seen this kind of thing even in the Parthenon it is post lintel type kind of structure. Then post slab is something different where there is no role of the lintel. So, directly we support the slab with post or the column. Now, this joint is very interesting now, how can it be. So, we will show you some of the example like where there is no such a lintel or bend is directly supported. So, on top of some support we just put it.

So now, if we go back to this example; this furniture example. So, here if we consider that this is the thickness of the tabletop. So, here you can see that it is being constructed with this particular portion of say the material the table top and it is been just been supported. And now, the connection it may be a joint it may be a carpentry joint or it may be fixed with some nail or it may be fixed with some adhesive that is a different way of attaching it, but basically these three type of arrangement is there.

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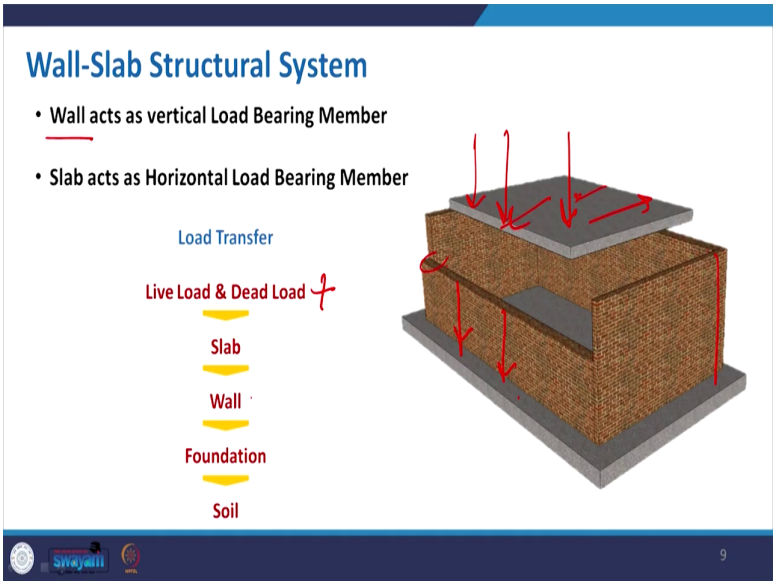

Now, come to the wall slab structural system, again this is a very representative you know structure and this is just for showing you the purpose that here you can you are not able to find out any you know column or something like that is full wall. And the, for the load bearing kind of structures definitely the thickness of the wall at the corner or wherever we go for you know some kind of you know connection.

So, we can change the thickness of that accordingly and on top of it we put the slab. Now, this slab it may be of concrete it may be in earlier days we use some you know wooden batten and then sometimes I section and on top of it we just create the slab. Now, in this case what exactly happening the wall acts as a vertical load bearing member. So, whatever the load imposed on this so, that will be distributed depending on the arrangement that I will come to that discussion.

So, it will transfer load to the wall and wall will transfer load to the foundation. So, here it is the live load, dead load and additionally plus all other kind of load that is applicable for this building or structure when it will be built, then it will basically go through the slab, then the wall, then foundation and then soil, this is the hierarchy.

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Now, this is one example where you can see that there is no such column and you can see this is just like you know brick pillar, but most of the cases is just resting on this particular portion this slab on one. So, this is one composition.

Now, the arrangement of wall is very crucial because when you go for load bearing structure we will have some restriction on the span selection or else we have to create our structure like the thickness of the wall so huge. So, sometimes it may be a very regular from structure where like basically you create it is in symmetry. So, all this wall, you know like with little bit punchers somewhere and all for the wind opening and all so, we create it.

But, again for the load bearing wall the proportion of the opening should not be like really high, because then that probable load that it could carry will be hampered. So, this is one obstruction, but this is somewhat which is more easy to build up this load bearing, but

sometimes it may be something like you have the longer side the wall thickness which are essentially carrying the load, and then maybe there are some internal partition ok, to create some interior space which are not load bearing.

So, whatever the slab will be resting on it so, basically that will be on these two walls. So, looking at the span we have to design accordingly this particular thing. And again that has some restriction because when you go for this load bearing structure so, heavy mass will be imposed to that and there is restriction on height as well. So, there a study where we have seen that it may go with proper treatment, but normally we cannot go for a high rise building, because then this function, this arrangement will not really work again all impose loads to it.

And now, the next example is a very famous you know creation and it is the example from India; the Indian Institute of Management Ahmadabad, again it is a load bearing structure where the you know use of this expose brick wall and all is very beautifully placed. So, come back to this again the basic idea to make this kind of arrangement, it is not to go for really you know some inferior kind of structure where it will have some limitation, but this is just the arrangement.

Now, if you transfer this thing we just change these particular wall like from brick to something else and then we improve this you know strength and the rigidity of this material, then this height restriction can be waived off and then we can go for a higher side.

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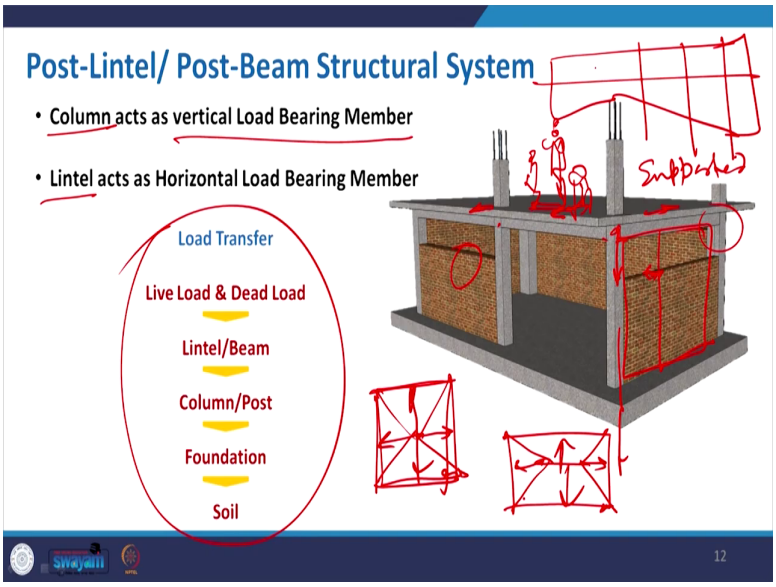

Now, come to the next type of the arrangement where already we discussed above the Parthenon which is a post lintel or post beam kind of structural arrangement. So, two component; one is the post or the column which act as a vertical load bearing member and the other one the lintel or beam is basically your act as a horizontal load bearing member. So, what exactly here it is going on so, this slab is now become supported structure and supported by beam first. So, wherever load suppose again I put the load some furniture and other thing here.

So, it will transfer the load and distribute based on the arrangement based on the design how we fix it; say for example, if this is just a square grid. So, the load will be distributed like this. So, it will be equally distributed if it is homogenous material and all the construction remains same, but if it is something like rectangular then again it will have some distribution like this. So, this portion will go like this, go like this. So, load will be transferred to the beam and then

what will happen here. So, beam will transfer load to the column and column will transfer load to foundation.

So, that is the overall you know transfer of the load and here the role of this brick work is basically to create the division, create the privacy and you know protect your building from outside environment. So, essentially it will not act as a structural member and that is why with this structure we can really reduce the thickness of the wall considerably. So, normally for earlier structure for the brick work we may have like one meter thick three feet thick you know wall for old public buildings and some buildings of you know earlier time.

But now, we can reduce it even we can go with the 125 mm thick, 5 inch thick, 10 inch thick, brick work for the external and the for internal even we can reduce further. And as well as, the you know advantage of this particular arrangement that you can even keep this particular thing open, like the you know proportion of opening will be more.

The chances will be more to you know give proper opening and this particular thing can be filled up with some glass or something, some still member glass material. So, that we can also enjoy the environment even we are inside we can see through those glasses. So, this is one advantage of this particular structure.

But, again we have to remember that arrangement the spacing of the beam it may be regular of a simple building or it may be little bit you know what we call a symmetrical that we can have a building like this where the shape is something like that. It is not in absolute grid so, then in that case will like go for some kind of other arrangement.

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So, here you can see two examples where this is very clear that we cannot see any wall on it and still it is stable and still under construction and this is the finished building. So, this particular wall is just giving some protection, some privacy for the interior space and this you know particular opening created at the top is giving light or ventilation inside, but basically overall it is the post lintel structure.

So, these are example of the modern buildings where we follow it with traditional concrete as a material RCC like reinforced cement concrete is acting as a material. But, again we should not really you know restrict ourselves to understand that this type of arrangement are only is possible with this concrete.

So, again I am saying that material is something where it will be decided based on the purpose, based on the load and the requirement and the other parameters based on the cost also, but

overall arrangement here is basically the post lintel or you know what we call in this case the post beam structure.

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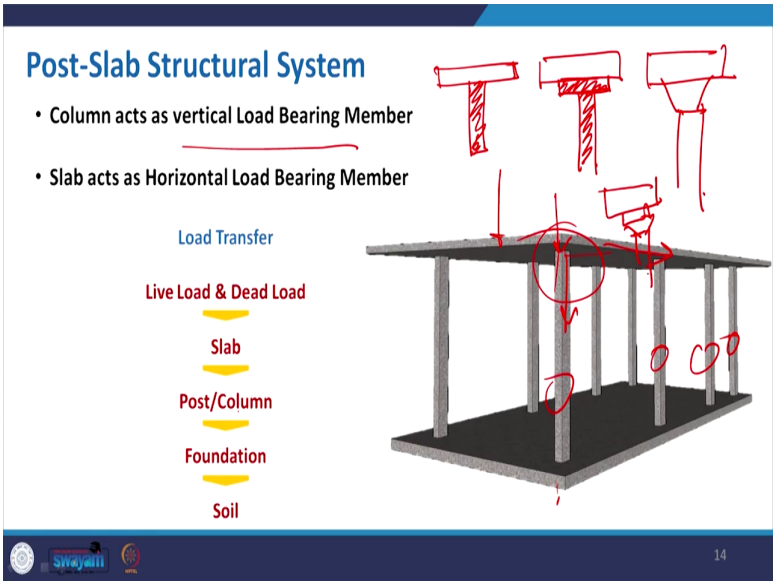

Now, come to the third category, in this case as I mentioned there will be no lintel on something like this particular bend. So, here it is a multiple column placing here and on just top of it this is been placed. And, in this case all these columns that we place here that will take the vertical load or vertical load bearing member where this slab is basically the horizontal one. It will again transfer the load and it will transfer load to the post and column and then foundation through soil.

So, this is the arrangement, but in this case this particular joint we can have different option. So, first option that we can go very simple one that this is your slab and this is your column; very simple type. The second type we can have some drops so, that it will give a sayings like

ok, yeah this is a created so, it will help, the other one it maybe we can create some capital on top of it.

So, it will hold like this and then it may be a combination of all these like we have a drops and then the capital and the column so, the arrangement will do. So, normally this kind of structure we see as a like shelter, temporary shelters, some bus you know shelter, bus depot, terminal.

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So, this kind of structures been implemented and this is not really something which will have you know inferior quality, but if you see this building as a great creation where you can easily identify with this image that there is no such beam. So, slab is resting just on top of this circular column or post.

So, post-slab is another kind of arrangement and if you change it like you change it to the steel and then the other one maybe some steel or this you changes to wood. So, material again may differ depending on the requirement or the purpose, but overall this arrangement is also possible.

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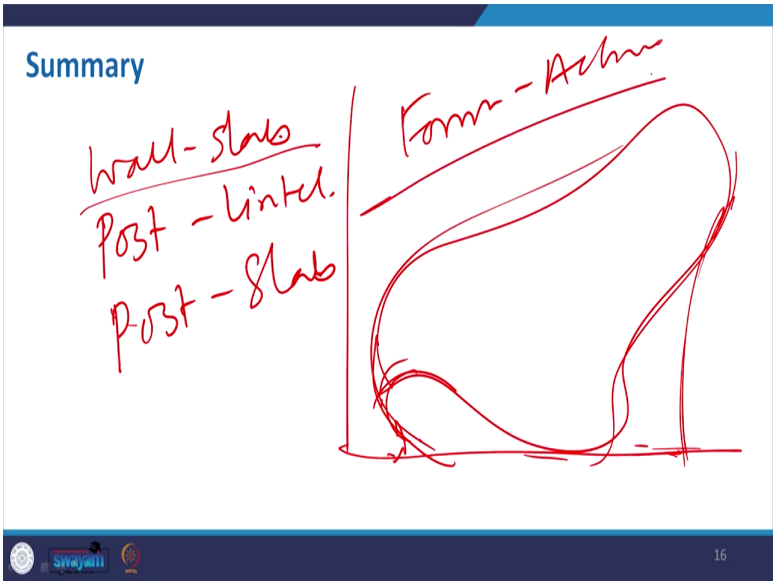

So, that is all for this particular lecture it was brief, but then also we got to know some of the basic arrangement. So, we started with wall slab and then we have your post lintel, then we have post-slab, and I have shown you some of the you know images like some construction images randomly picked up some of the existing buildings and good architecture examples. And, then I also want you to also make this list exhaustive you such a, such buildings where this can be this is already being implied it may be from some historic building, it may be in the recent time buildings and all.

Now, someone may ask me that ok, whatever these forms are being created so, what about when we have this kind of you know, structure some structure like this; so, where this kind of arrangement like whether it is nothing followed the three of the criteria.

Yes, in that case we will go by the form and it is formed even or you know form active structure or form the impression where you know there will be not a specific structural arrangement. There is a series of structures they are you know acting or they are arranging in such a manner that, that can create this particular shape or the sale structure or maybe some other pneumatic structures.

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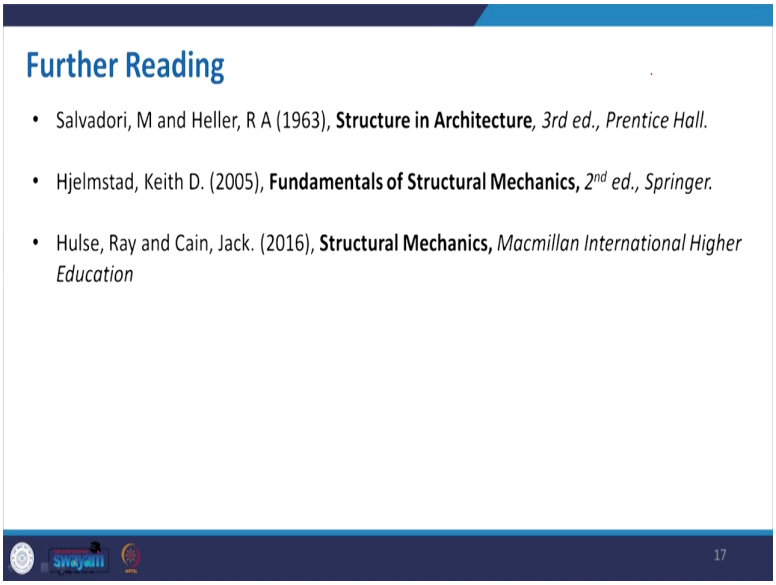

So, in coming lectures will be covering that these are again the same study material. So, with that I conclude here and the next lecture that will cover up that is also interesting that is basically different structural forms how we developed. The relation with the internal force that

it you know act with and how these shapes can also affect the efficiency of the selection of that particular structural shape. So, with that I again thank you to take part in this particular course.

Thank you.