Structure, Form, and Architecture: The Synergy

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Lecture – 19
Load Bearing Structures

Hello, everyone welcome back to online NPTEL course on Structure, Form and Architecture: The Synergy. Today, we are at lecture number 19 and this lecture we will cover up different components, different arrangement of Load Bearing Structures. So far, whatever we have seen in previous lectures with the compressive structure and as well as tensile structure we have seen that how different arrangement different materials they are acting towards like to resist against the compression and tension.

So, today basically this is another arrangement that we initially talked about the wall slab structure in the structural typology. So, here we will discuss it in more detail about the load bearing structure.

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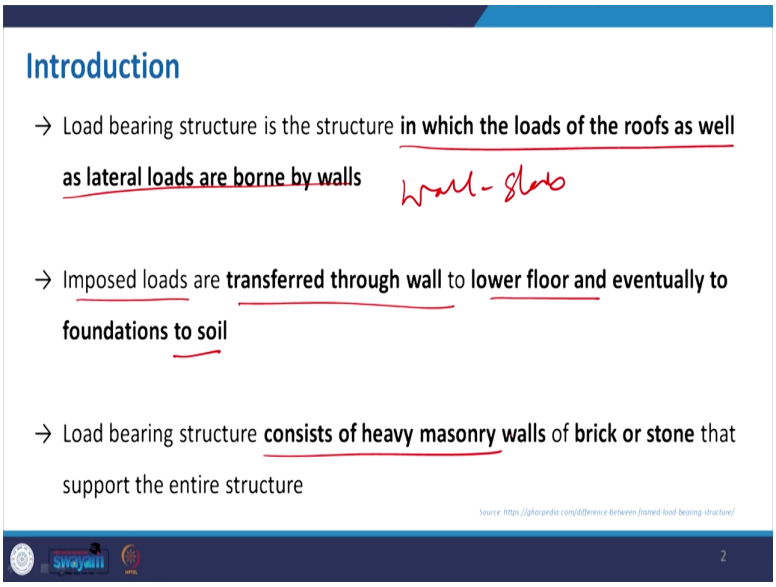

So, at the introduction load bearing structure is the structure where the load of the slab or the roof will be you know carried out or that load will you know transmit through the wall. So, wall will be the main component load bearing elements of the structural system. So, this is one the lateral load again will be taken by the wall.

So, two kind of loads preliminary; one is the gravity load that will come from the slab or the upper force that will transmit to the wall to the foundation, the other one is basically give lateral load, the wind load and other different you know the rain road. So, then this kind of lateral load is also be taken care by the wall. So, wall will be the main component in this case.

So, here it says the load bearing structure is the structure in which the loads of the roof as well as the lateral loads borne by the walls. So, it is basically leading to the wall slab kind of arrangement structural arrangement. So, what exactly happens how the load has transferred.

So, impose load on the upper storey the slab or the walls transferred through the wall to the lower floor and eventually that will to the footing or foundation and to the soil.

Load bearing structure consists of heavy machinery walls as because the whole load will be taken care by the walls. So, the thickness of the wall should be substantial and the as like the material that can be used to you know make this kind of wall is either brick or stone sometime the block. So, in the history like till we like got of the reinforcement or the steel in the picture of the construction industry we have seen that the building's mostly dependent on this load bearing machinery walls.

So, whether it is in the Greek period or the Roman period even sometimes in the modern age where like there are some constant. But, we have to understand that the application of this load bearing structure will have some limitation because as because we are increasing the thickness of the wall so, maybe for that we have to compromise with the interior space, at the same time as because it is only of the machinery work.

So, it will not be really you know acting in a proper manner during the earthquake activity where like there will be some you know vibration so, very regular tension compression. Though masonry work they are good in compression, but they will not really act very well in case of tension. So, that is why sometimes you know it is good for a low storey buildings say up to four storey or so, but beyond that there are some limitations.

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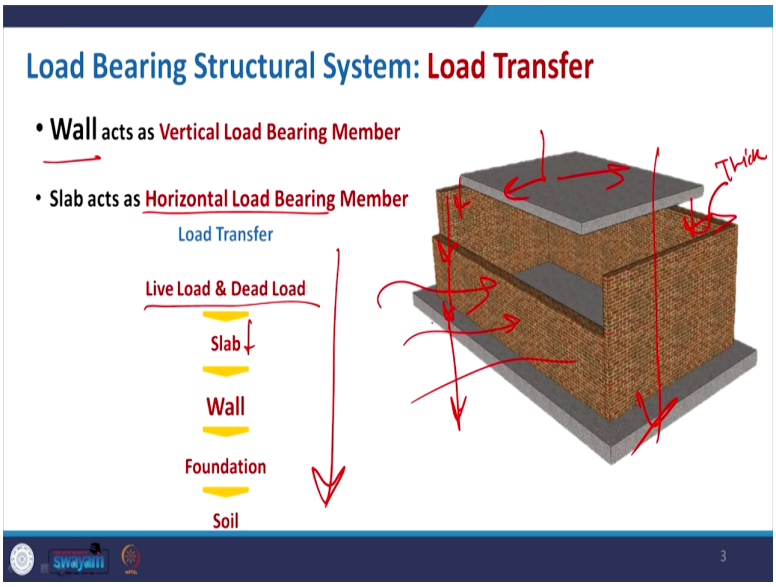

So, with that we proceed so, basically how they transfer the load. So, it is basically the wall, they act as your structural element the you know supporting structure and slab here is basically the supported one. So, the all the load like which is there on the slab so, all this horizontal load will then transfer to the wall so, adjoining wall. So, adequately the thickness of the wall should be little bit thick than the normal frame structure wall partition wall because this is taking the load.

So, load transfer is live and dead load that we calculate for the slab or the upper floor. So, dead load is the self weight of the building materials as well as when we consider the live load is basically the load of your furniture's and you know other elements moving elements. Then, the load will on the slab will then transfer to the wall and wall will transfer to the lower floor

and then the footing. So, this is the way they you know transfer the load and here we are talking about the transmission of the gravity load. So, the load acting towards gravity.

But, along with that there are the wind pressure and other thing. So, those lateral load will also be taken care by the wall as a main structural supporting members. So, this is the features where wall is acting both for taking the lateral load as well as the axial or the gravitational load.

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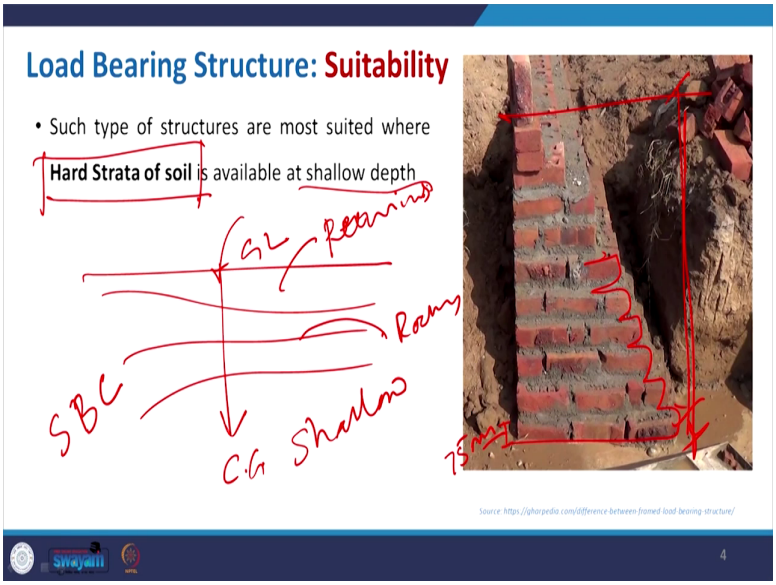

And, now definitely the application there are many you know considerations by which we will pick up one particular structural arrangement that initially when we discussed the purpose of the structure and when we apply what kind of structure. So, one of that is basically the criteria of the geological aspect, the soil condition.

So, as because the load bearing structure cannot be really taking the huge load and that is why that we cannot make multi storey building on that. The one of the major consideration for load bearing structure that the soil should have very hard strata with very lesser depth; that means, when you see that you know if you virtually make a cross section of our wall surface, so, at the top the ground level we call and then if we go towards the center of gravity center of the earth so, then we get a sectional profile.

So, we have different kind of you know strata in that particular profile. So, sometimes we get some you know very loose strata sometimes it is basically very pervious layer sometimes you may get something rocky, sometime it is sandy, clayey. So, depending on the soil condition we have to assess the SBC Safe Bearing Capacity of the soil so, the way it can hold the load of the entire building of the structure.

So, wherever we can get this you know hard strata as very lesser depth maybe within a limit of 1.5 meter to 2 meter and we get that rock strata in those conditions this particular load bearing structure will be useful. So, here you can see that with this straight hooding how like this with the offset only with the brick they are making the foundation and you can as is the height of this brick is varying from 75 mm.

So, you can actually estimate virtually as says that the height of the foundation the depth of the foundation. So, it is basically not that much you know having that depth. So, this type of small depth foundation is also referred as shallow foundation, alternate to that we have de foundation where we go for like different kind of pile foundations and all. But, with this load bearing thing it is basically the shallow foundation and the main criteria that we have to check that it is where we can get the hard strata as very shallow depth. So, this is one suitability of this kind of you know application of load bearing structure to be checked.

Now, along with that as we discussed like the main component of the load bearing structure is the wall, it may be made of stone masonry or maybe brick masonary, but basically the wall. But, now depending on the requirement like arrangement of those walls may vary and that is why how you design the structure that will also vary you know case to case wherever you go

for a residential building or maybe something like in a you know school building or maybe hostel building.

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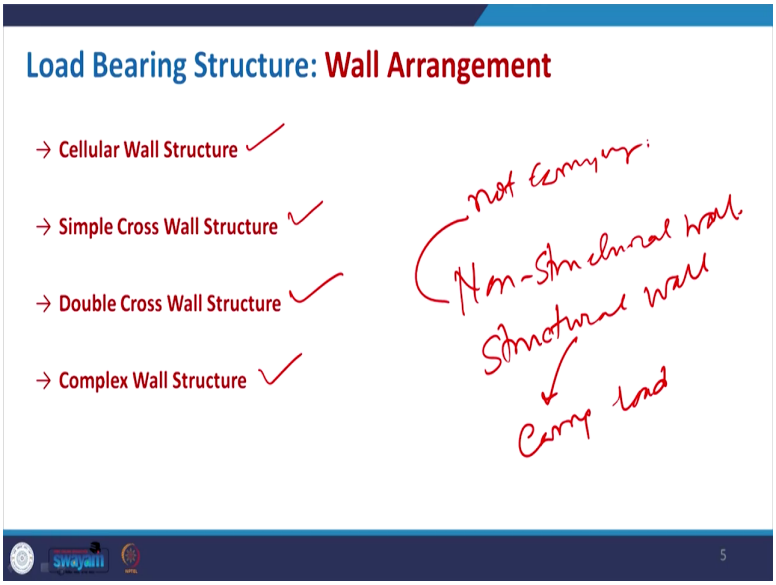

So, based on that we have the classification of a wall arrangement. So, a the cellular wall structure then you have simple cross wall structure, then double cross wall structure and the complex wall structure. So, in the subsequent slides we will try to understand what this arrangement are and where we actually require this kind of arrangement for the load bearing structure.

But, remember one thing even you know in the load bearing structure you may go for some partition wall depending on you know space distribution and all, but overall like the load will only be carried by the load bearing walls which will have a higher thickness and that also turns with the load to the foundation. The other partition they do not need any foundation as of like

they are not taking any load from the slab. So, those are basically also referred as non structural wall.

So, we have like two thing into consideration. So, one is your structural wall, so which will basically carry the load and the other one which is not carrying the load ok. So, mainly the partition wall that we can create for some purpose.

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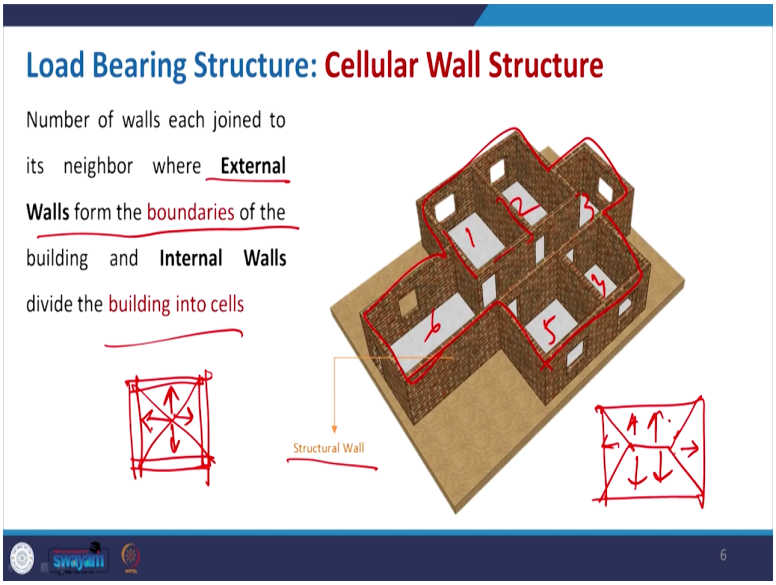

Now, come to the load bearing structure cellular wall type arrangement where like the number of walls they are joined together and basically the external and internal they are you know combined to each other in such a manner that the internal you know you know what we can say that the external surface external walls they create a boundary this profile and the internal walls they both are load bearing walls and they create the division and make it cells.

So, basically it is making rooms in practically, but here it is basically they are creating difference cells so, 1 2 3 4 5 and 6. So, so many cells being created the outer walls is giving the boundary the internal walls they are making the division and cells. So, with that here in all cases they are all structural walls; that means, the load bearing walls and this arrangement is called cellular.

So, in this kind of structure how load will be transferred it depends on like the position. Suppose if I take a square slab and we have like this you know wall you know all the sites so, the load will be transferred very uniformly. So, it will give transferred the load from the slab in and the four walls symmetrically ok. But, the moment in state of a square 1 if you get something like a rectangular then the distribution will change.

So, basically in that case the maximum load will go for the you know longer side and accordingly the minimal will go to the shorter side. So, depending on the wall position and direction the load will also transfer accordingly, if at all the other parameters the homogeneity the thickness of the wall all the site will remain same.

Now, moving to the next one the single cross wall structure so, many a times what we want that you know the load bearing structure the other problem that again we will discuss during the disadvantage that we cannot really create big openings because the moment you create big openings to that wall. So, it will become void and it will not that much capable to hold the load. So, that is why the opening size should have some limitation.

So, sometimes you know due to that reason you know there is some problem to you know maximize the daylight, the sunlight into the corridor or the interior space and many a times that is why the arrangement of those walls to be done in such a manner like we put those walls in parallel direction and the other part we use some non-structural partition wall where we can create some you know opening without compromising the load and load carrying capacity and the safety.

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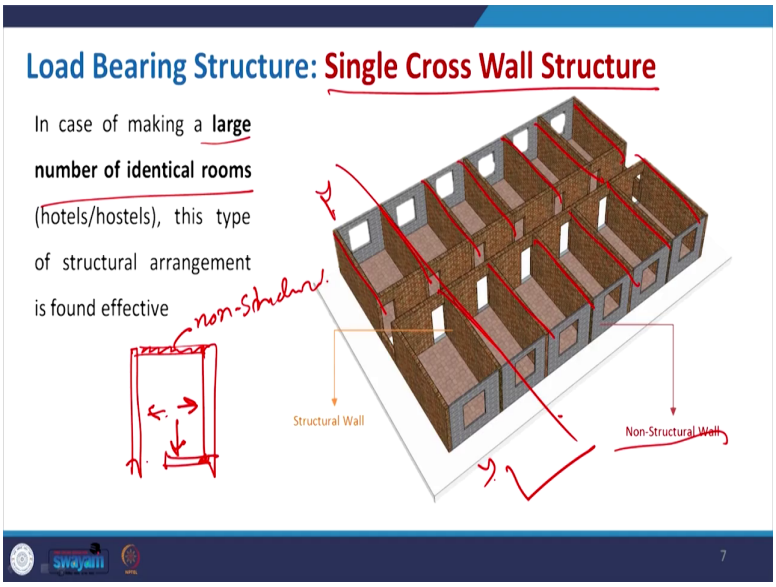

Say for example, in this case the large number of identical rooms were to be placed; say for hotels you get typical you know room you know placed one after another and also like for the hostels it is the same. So, in that case we can go for some arrangements. So, here you can see the load bearing structure that you can see with the brick color the other one is of non you know non structural wall so, they are having lesser thickness or where you can cut the opening. So, maximum load will be borne by this parallel arrangement of your walls.

So, basically this kind of arrangement is called your what we say there is single cross wall structure. And, in this case what exactly happened so, when the load will be distributed from the top as because we have this wall as you know non-structural I just try to make the pan of that. So, non-structural so, load will not be transferred by that. So, in that case the load will be transferred to the parallel walls.

So, the main load bearing structure like walls will take care of the load and these are something. So, if you place another wall here. So, the some portion of the load will also transfer to this wall. So, this is one kind of arrangement which is single cross wall and the main reason to create the opening and you know having more light inside the building.

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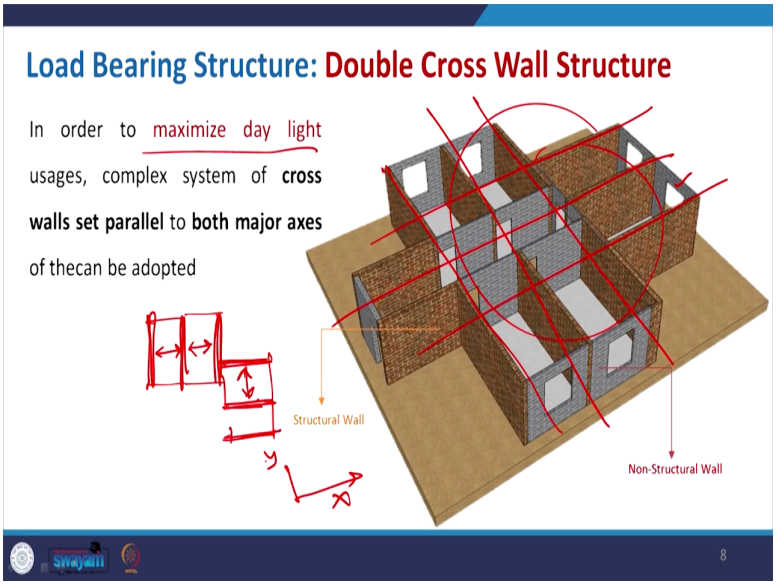

Now, in addition to that sometimes not only in single direction, single axis will have the parallel load bearing walls, but it may be of the both the axis x and y so, here it is the same. So, if you just compare with the previous image, this hostel one and this one so, here you say that so, in this axis we have some you know load bearing structure ok, the structural walls. And, along with that also we have in the other direction in the perpendicular direction and in order to maximize the day light and all what was the purpose basically? So, we create some non structural walls.

So, essentially they will not take much load or transfer the load to the foundation. So, main load will be carried out by the your both way both axis you know placing parallel walls and that should be also in grid in this particular arrangement to satisfy the need. So, this is double cross wall structure. So, it is also very common where you actually you know see the you know apartment building or small residential building something we can think of that, but at the same time when you go with a very regular shape and all distribution will be always easy.

Suppose say if I just want to make the plan of this thing so, basically if I draw these are the structural wall and then you have connection the thinner one is basically your non-structural wall. So, in this case if I draw this particular portion so, you can understand easily. So, in this case load will be transferred like this and in this case it is at the you know perpendicular direction. So, the previous picture what you see that it is all aligned with axis. So, if I just refer it to the y axis so, it is only with the y axis direction, but in this case it is both your x axis as well as y axis. So, they are placed depending on the grid and the need.

But, in actual like when we think of you know making division depending on the purpose like we cannot have the toilet of equivalent size of like your bedroom. So, it will not have equal size. So, bedroom must have a bigger size and dimension because of the you know furniture's to be kept in that whereas, the toilet we can reduce it. So, then there is so many variations and in that case probably this kind of parallel wall system will may not work.

So, then portion of that building will some part of that will be load bearing structure thick wall and the other part where we make the partition as I mentioned earlier also we can go with a thinner one, but they all will be non structural walls. Or sometimes they may be made of some other material not even with the masonry. So, sometimes we can go with some wooden partition or something like that.

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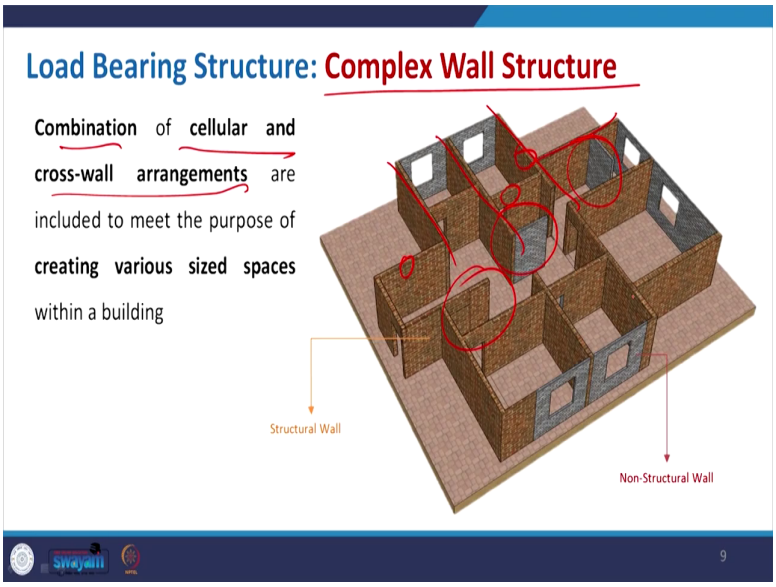

So, they will basically make the complex wall structure system. So, if we compare to the other picture it is just the modification of that where you can observe that the allied alignment of this is basically your cross method and the simple method. So, combination of cellular and cross wall arrangement is making is very hybrid.

So, here you can see the irregularity of the space where some space being created so, for some privacy or for some you know making some storage. So, they are not essentially taking any load of the slab and contribute to the load transferring. So, all these you know brick color was which are the structural walls in this particular arrangement will be responsible for this. So, this is the complex wall structure.

So, sometimes we have been based on our need or maybe it was not planned initially and then in subsequent period will impose something more like we just modify the plan and create such

small spaces as per our requirement, then we can go with this complex wall arrangement system.

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Now, come here now we will see some of the photographs where this load bearing structure being used. So, this is very simple and like just only you know one and a half storey, almost two storey building in this case. So, what you can see here that main walls and this is being supported by some of the you know lintel or something. So, mainly they are taking the load; the load will be transferred the transferred by your wall, but at the roof also you can see here it is very light structure and not you know flat slab. So, this is something where it can be easily made.

And, one of the advantage of making this you know load bearing structure so, it will be cheaper compared to the frame structure if you consider only few storey building. Definitely

when you go for high rise then if we at all go with this load bearing, then proper you know care to be taken and then the cost effective cost will not be really very low. So, for the you know low cost construction so, sometimes it is very helpful to go with.

And, in this what we have seen that this complex structure can also be made with the modification this is a building from Chicago. So, it is 16 storey load bearing structure. So, that can be done, but for that we need very much calculative very well design and the execution as well.

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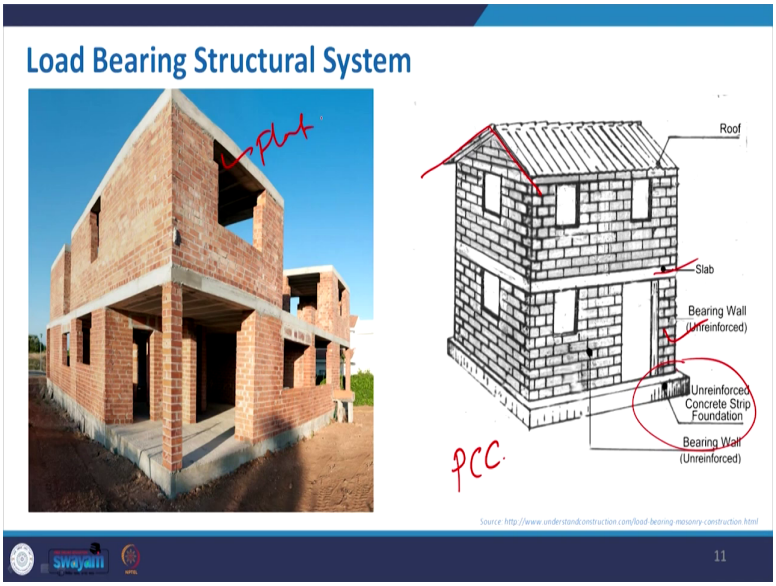

So, in this if you see that other image compared to like if I compare this particular building with this it is like schematic one where the roof and slab load will be transferred by the bearing wall and where there is no reinforcement, right.

And, then you have something like you know unreinforced concrete strips. So, without reinforcement we can go with some PCC, Plain Cement Concrete as a base to give act as a foundation. So, this is the similar kind of thing, but instead of the pitched roof the slant roof here you have the flat roof. So, this system is available. So, mainly for low cost housing we can really think of this load bearing structure, but at the same time we also need to take care of the soil condition.

If we get hard strata, if we can go for this and then get the strata in the shallow depth the lower there at very low depth then we can recommend this kind of load bearing structure. But, this is not like being used for the small structure, sometimes some huge structure in history was also made with the same concept.

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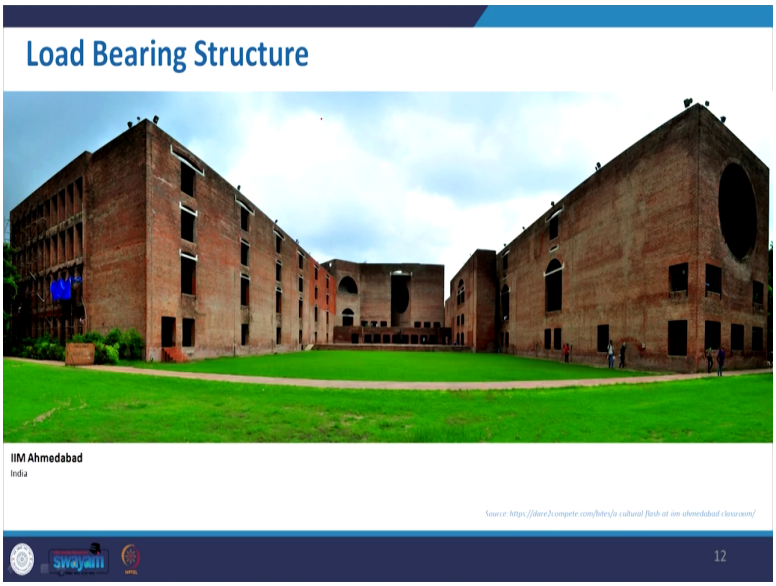

So, this is a building in India. So, IIM, Ahmadabad which is also a big machinery load bearing structure and you can see that how beautiful you can make that design. You can also create the opening not at very large opening, but whenever you create you can give some geometry to come up with some good appearance and this is something which is modern one.

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So, this is another arrangement where even the top of this particular structure is also having some brickwork, so this is again a load bearing structure. Along with the walls, so we can also create the column or pillar or made of brick. So, this is also possible to you know make this structure and where everything all the loads will be transferred to the wall, to the foundation. So, walls or walls and the brick pillars are responsible to transfer the load.

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Now, this is something where the it is not the brick or stone it is basically the sun dried earth or sometimes also we refer it adobe. So, this is used to make this kind of structure. So, again it is a load bearing where the you know the modified earth, the sun dried mud is taking the load of the entire structure and just to you know give support at the roof, so here some of the wooden plank used in this structure.

Now, this is something where I have shown like the material can be of a different quality. Nowadays also there are compost earth material, then composite materials some material made out of waste daily waste. So, that can also be used as a substitute for the conventional brick and make these low rise structures.

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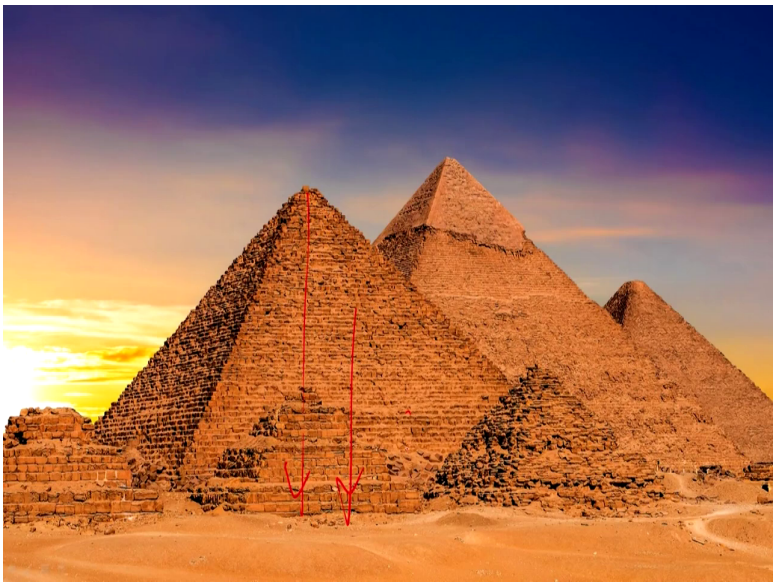

Now, this is something which is grid. There is no concept of the low rise, but here also it is the masonry work and again here the load the gravitational load and other load being taken care by this massive structure.

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So, it is also being used the similar kind of load bearing structure way back in the Roman period where this Colosseum, this arena was designed and where you know those gallery and this is transferred through the wall on this particular surface. So, it was there also in history this load bearing structure.

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And, this is something which is always appreciable and great architecture. This is also made with the concept of this load bearing. So, here also you will not get the frame structure or some different structure. So, again, the step by step like this Taj Mahal was made taking the concept of full load bearing structure.

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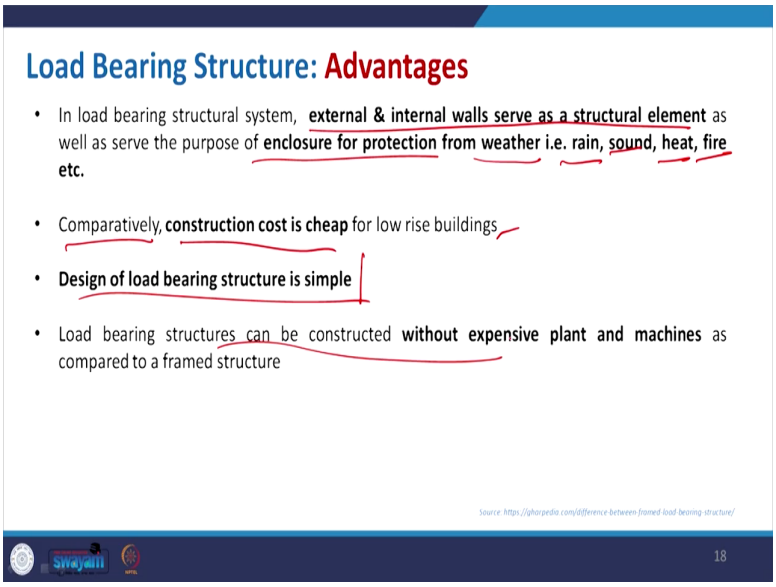

Now, come to the advantage in very short already we have discussed the advantages. So, here we just summarized it. The load bearing structural system external, internal wall serve as a structural element. This is something which is there like they will be soul responsible to carry or transfer the load but as well as it will give protection. As because of the thickness it will give protection from the external weather, then like it may be the rain it may be something like the heat, it will be effective, then the thick wall will also help from the fire as well as it will also act as a buffer to you know create some protection from the noise. So, noise resistance is also there for the thickness of the wall.

And, comparatively construction cost is cheap as because like for as I mentioned that for the low one storey, two storey building. So, that can be done. The design of the load bearing structure is also simple because that will also design a grid. So, different arrangement that we have discussed we can go with that. There is not much complexity unless we really go for a

very complex design, and then probably you know the last of the fourth type of arrangement that we will discuss the complex wall arrangement, then there will be some problem.

Then, the load bearing structure can be constructed without expensive planned and machine, we do not really require heavy machinery or plant for that, what we need some brick and mortar. So, with this masonry that can be done even in this case means you can take help for skilled or as well as the unskilled labor. So, there is something easy to construct and the design is very simple to design all these walls and then hence it can be really you know be easy compared to the frame structure construction. And, at the same time like in this case like the type of materials required is also less so, complexity of procuring material will also be very much easy for this kind of.

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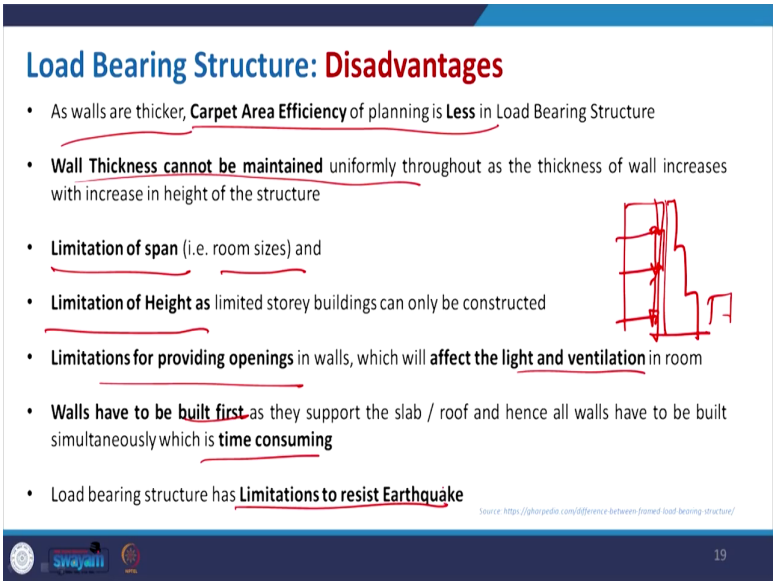

Coming to the disadvantages here also we need to know that as because it is basically you know you have to provide the thick wall so, the carpet area means the interior space we have to compromise. So, the carpet area efficiency in planning is very less and that is why nowadays is not being in practice and we move to the frame structure or some you know thin wall structure or different steel structure where we can maximize the interior space as well.

Wall thickness cannot be maintained uniformly throughout because whenever you go for a multi storey building when height will increase then the thickness will also change because you know the very beginning we have design like if you have multi storey building the load of upper storey transferred to the next storey and like this. So, basically the load profile will be something like in a pyramid order. So, for that also you need to change the thickness when you go up you can reduce the thickness of the wall at the base it will be bigger than that.

The limitation of span as because like it is only taking the you know slab wall type of construction. So, there we have to also restrict to the size of the room. So, all old building if you visit that though they are giving very nice environment that you know thermal comfort the you know they are making the balance with the you know interior and outside their heat transfer, but definitely the thick wall actually you know limiting the space inside, then also the limitation of the height this is there.

The limitation for providing openings is also there because we cannot cut those load bearing structure for the ventilation and the light. Walls have to build fast; this is a very nice point where it says that as because the wall is the only supporting member. So, all walls to be constructed first then the slab. So, we have to wait till all the walls are constructed the same height and then you go for it. So, that is the limitation in this particular case and which is sometimes time consuming if you are you know area is too merge and so, many walls to be constructed.

And, another one is basically this load bearing structure is not really very good in terms of you know earthquake resistance. As because during the earthquake, the shock wave creates very simultaneous you know tension and compression and as because this masonry they are poor in

you know tension because there is no reinforcement no steel which can actually help to manage the tension so, it will not be really good for specially the high rise building. So, that is why the limitation of the height and the number of storey is there.

When it is a small design like one storey, two storey building then there will be not much effect on this you know earthquake, but we have limitation for this. So, probably in this case like the thickness of the wall if it is two so, that will also sometimes keep a filling towards the like the megalithic structure. So, that can be fruitful during the earthquake or it will give the overall earthquake resistance, but not for the building having more height. So, these are the disadvantages.

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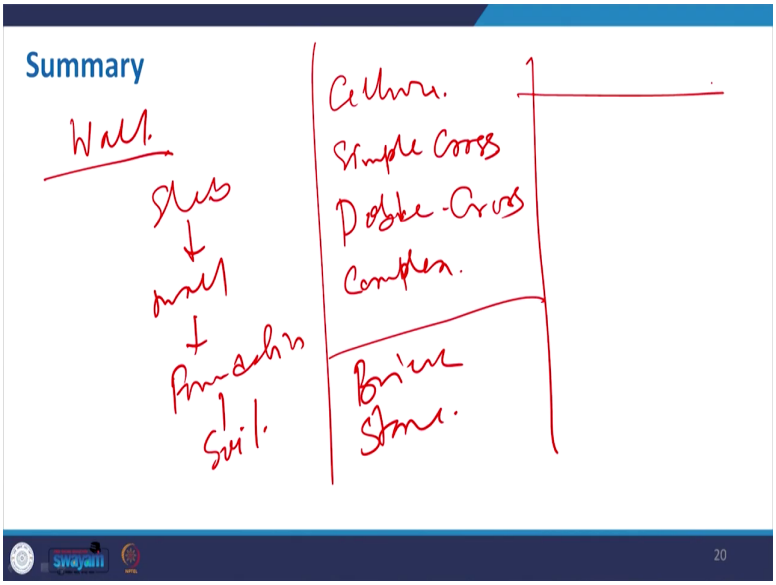

So, with that if we just summary these things already we discussed. So, in this case the main structural component is the wall that will take and the load transfer slab to wall to foundation

and then to soil. So, that is the overall transfer the arrangement that we have seen that it may be cellular where the external walls they make the boundary the internal walls they create the division, so that they create the cell and cellular.

Then we have simple cross where the parallel walls are being constructed to will come light and maximize the light and this kind of arrangement can be helpful where we go for a very identical rooms placing one after another like hostel or hotel. Then double cross both the axis like the x and y axis both the axis will put some structural wall and in order to will come light we provide some non-structural and create the opening.

And, then basically what we have the complex one. So, complex one is basically based on the requirement we can actually make something non-uniform the internal arrangement and where we have combination of non-structural thin wall with the thick structural wall which will be responsible. So, it is a combination of your cross arrangement as well as the cellular arrangement of that.

And, we have seen that from history and the recent times the use of this and basically for this brick masonry or the stone masonry was used. So, earlier still we got this in you know concrete in construction. So, most of the masonry work that done even in you know Byzantine period and those Gothic period. So, many of the buildings are made of this machinery and acting as a load bearing structure. Sometimes they being supported with the flying buttress to reduce the thickness of the wall and increase the interior space. So, this is another arrangement.

But, the disadvantage is basically you cannot go for a larger height. You cannot really make for it a long span, as well as like it will not really effective if you go for high rise and in earthquake prone area. So, then it will be a problem and wherever you can get a good soil strata or hard strata at the you know very shallow depth, then this kind of foundation this kind of you know arrangement like your spade fruiting with your brickwork is fruitful. So, load bearing structure can be, and as because like compared to the frame structure it is cheaper so, for like low cost housing or something this kind of load bearing structure is helpful.

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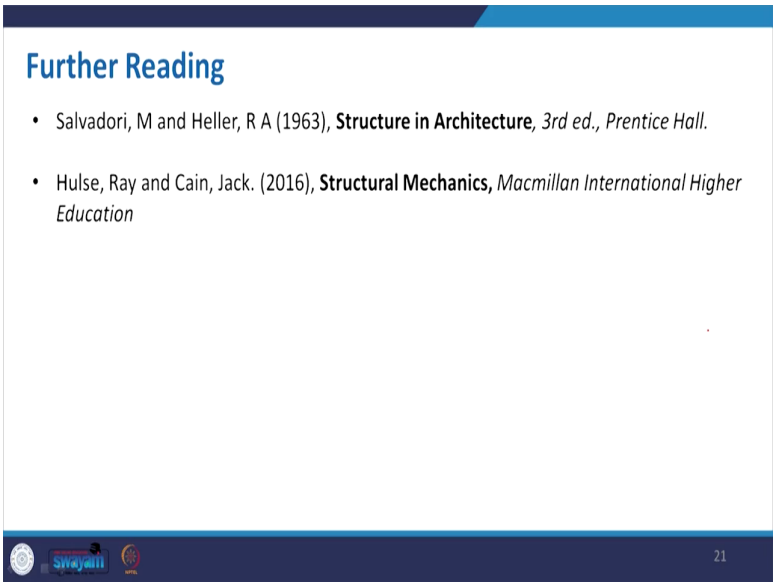

So, with that I conclude here. So, these two are some reading materials where you can go through it or else you can also go through the links I have given in some of the slide so, you can read more on it. So, with that we conclude this section.

So, next we will be discussing the temporary structure and then we will try to know that the need of those structure in the concept of the construction and you know in the context of your you know typology or how it can help the you know making the structure as required. So, with that again I just would like to say thank to all of you to take part in this course.

Thank you.