Structure, Form, and Architecture: The Synergy

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Lecture – 21
Framed Structure

Hi everyone. Welcome back to online course on Structure, Form and Architecture: The Synergy. Today we are at lecture number 21 and it will be on of Framed Structure. So far whatever we have discussed, we have seen the advantages of load bearing structure and also we discussed about the limitation of load bearing structure, regarding the span, regarding the height of the building and also we discussed something on the temporary structures that to support it.

But in order to overcome the short comings of load bearing structure say for example, being a greater span to cover reaching to higher heights of the building to be developed. So, framed structure actually help us to make that.

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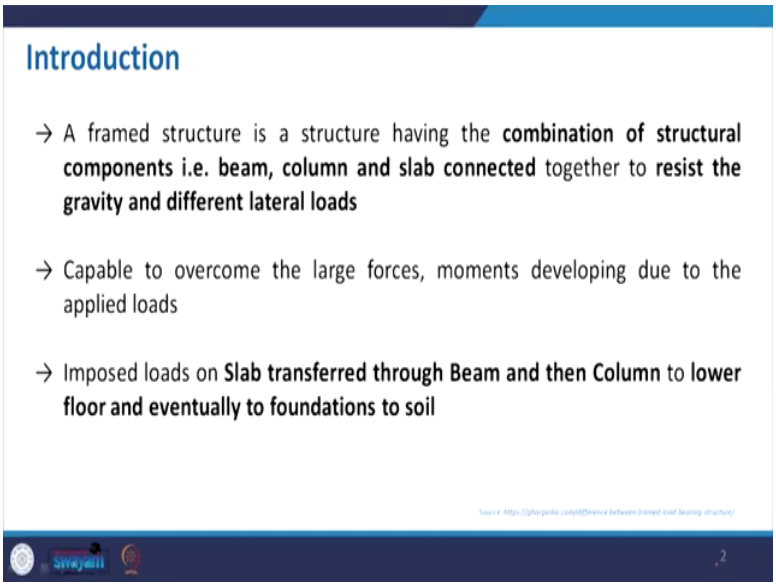

So, let us start this discussion on framed structure. Now framed structure what it says like a frame structure is a structure having combination of structural components like beam, column and slab connected together to resist against the gravity load which is basically also referred as the actual load you know which is acting vertically like transferring from slab to beam, beam to column and then column to foundation and to soil.

Along with that the joint of beam and column and slab will also protect the building from the lateral loads like the wind load that we have discussed earlier. So, here it says about that it is a combination of the structural component. Compared to the load bearing structure there we have seen that load is basically carried by the wall. So, wall and then we have the slab. So, there is no such combination of beam and wall. So, in comparison to that now the structure has you know three components; major three component slab, beam and column.

So, column will be taking the vertical loads. Now it says also the capable to overcome large forces as because now in the frame structure, we will go for the like either steel or maybe the reinforced concrete the concrete mix with the proper rebars or reinforcement bar of steel. So, which will ok; so, which will basically make your structure more resistance towards the load. The imposed loads on slab transfer through the beam and column to the foundation that already imentioned.

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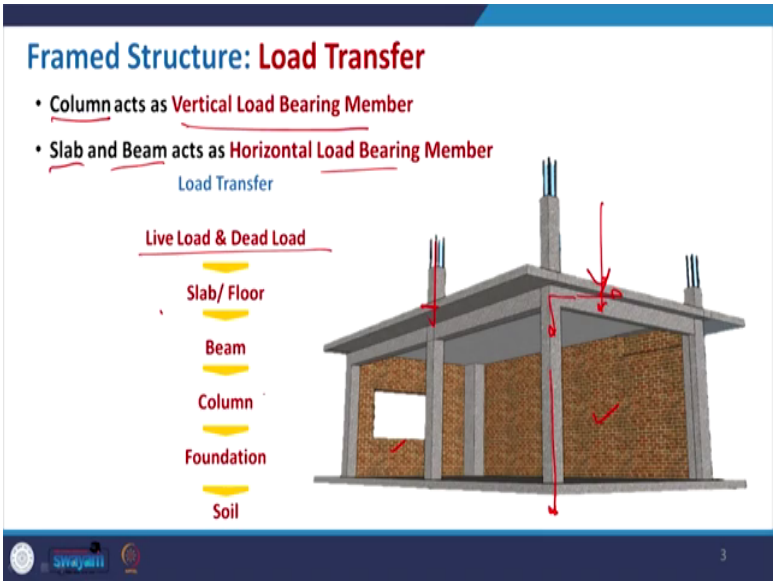

So, here if you see typical schematic of the frame structure though I have shown you the wall, but these are not the load bearing walls. So, they are just used to protect your interior from the outside environment. So, basically the loads imposed on that the dead load, live load; all kind of loads is transfer from your beam to column. So, say for example, this is the slab I just put some load on it. So, this will be transferred to the beam first, then beam will transfer to the

column, column will transferred it to the lower floor and finally, it will reach to the foundation footing and that transmit the load to the soil.

So, in this case column act as a vertical load bearing member compared to load bearing structure where wall was the vertical load bearing member and slab and beam acts as horizontal load bearing member for this case. So, in this case the load transfer the live load dead load that will transfer to the slab or sometimes we refer at refer this as floor to the beam, beam to the column and then foundation.

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Now, this is something what we are talking about the frame structure. Here you can see that there is no wall being construct as of now. This is some under construction building I have shown this picture earlier also like here like it is just a frame or sometimes we also call it the

skeleton structure. So, in the skeletal structure, you can find that arrangement of your beam and column.

So, after that so, be essentially all the load will be taken care of by this beam and column structure. The load of the slab and the other you know furniture's, then the moving elements. So, dead and live loads both will be taken care of by that. And in order to create more you know partition and function, we can also use the wall at the later stage and as because this wall will not essentially carry any load.

We can reduce the thickness of the wall where the load bearing structure the wall thickness is one and half brick or maybe even sometimes it is gone up to say 1 meter 3 more than 3 feet thickness and that will also have limitation to go up to say 4 storey building or 5 storey. In some exceptional cases, it may went up to event 16 story that we discussed in that presentation.

But in general with this frame structure we can go even more storey's. So, 20 to 30 storey we can go and definitely there will be again the shortcoming when you go beyond that then along with your gravity load, there will be you know more pressure on the lateral load. So, wind pressure will be more and that is why like we have to add something extra some component extra to the frame structure to make the, make it solid.

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Now, these are other two pictures that is showing the frame structure is basically like you can only see the beam column arrangement and then based on the requirement, based on the opening to be created; we create solid and void you know combination with your wall. So, thickness of the wall for external normally taken as like your 10 inch, one full brick thickness or internal partition wall like we can reduce up to like 5 inch or sometimes even 3 inch wall which was not possible for the load bearing structure.

Now so far the material is concerned, we can use the R.C.C Reinforced Cement Concrete to make this framed structure. We can use the steel frame and we can join them together to create it. Nowadays also it is very common to have the frame structure the steel and the glass being used or some other light weight material being used for making those partition and the

opening and sometimes we can also go for some composite material, some advanced material to make this frame.

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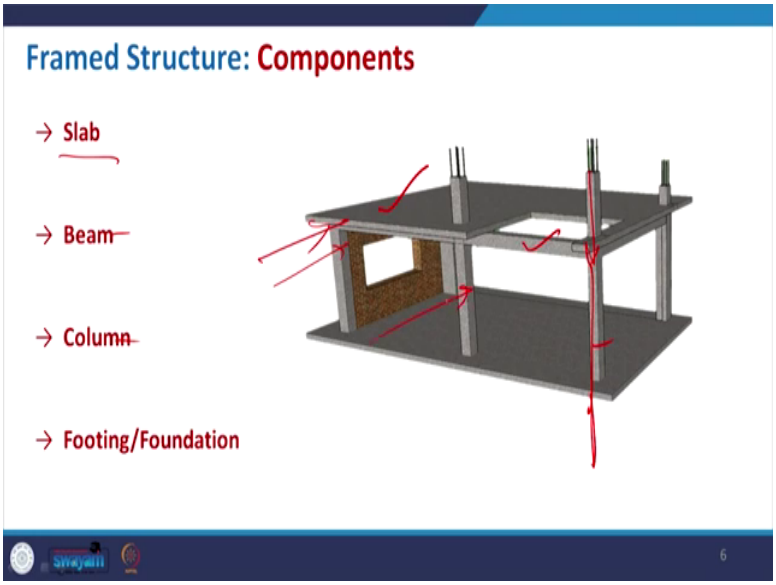

Now, the components of the frame structure as we discussed already that will have the slab then you have the beam and then the column and then the footing and foundation at the lower level like the underground structure. So, the superstructure is combination of the slab, beam and column and load transfer is basically through this. The actual load the horizontal load will be taken by the beam and then partially with the column as well.

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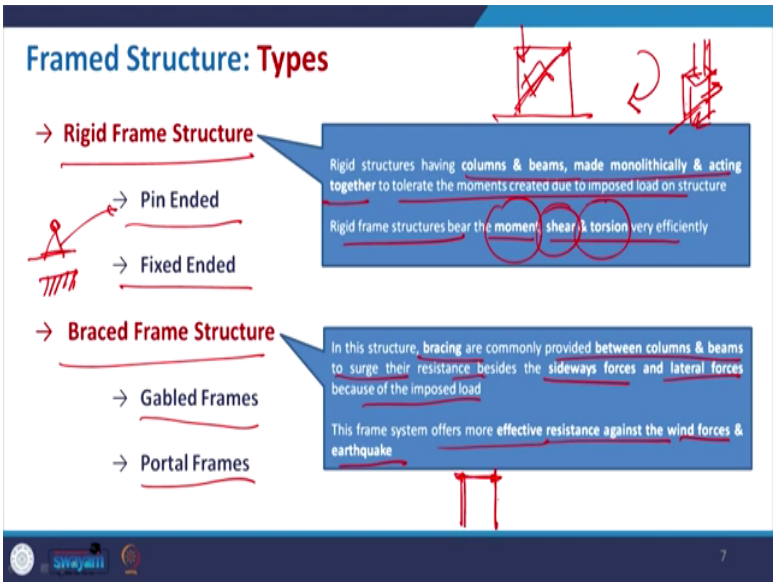

Now, coming to the framed structure that type: so, basically based on the joint how they are actually combined together, how they are connected to the footing. Based on that we have majorly rigid frame structure and braced frame structures. So, bracing here the braced frames come from the bracing that we earlier discussed also like in order to overcome or resist to the lateral load like wind load and all sometimes, we connect your frame with some diagonal member.

So, which will make it more rigid, which will make it more resistance resistant against those kind of load. So, this bracing will help us to protect against that. Even this bracing will help during the you know unwanted movement or very irregular movement during seismic activity if some earthquake happens. During that time the vibration like very frequent and with

different scale different magnitude vibration. So, that will be taken with that along with the dampers.

So, we will come to that during the group discussion. So, in the rigid frame joint the joint may be of pin joint and it may be the fixed ended joint. So, pin joint that the representation of that is something like that and the fixed joint that we already discussed when you discuss the different support of a structural system. There we discussed these in detail like what is a pin joint and what is a fixed joint.

So, in this case rigid structure having columns and beams made monolithically means as if it is a single structure and acting together to tolerate the moments created due to the imposed load on structure. Rigid frame structure bear the moment shear and torsion very effectively. So, in this case like you have three different forces acting one is your moment like when we see that there is a pressure and that will create a couple so, that will create the moment.

So, it may be your like clockwise or anticlockwise moment, then the shear is definitely we discussed that sometimes due to inadequacy of your reinforcement bar or something. So, then there will be some force which is acting in opposite direction and there will be failure in shear and the torsion is the twisting activity especially for the high rise building due to the wind pattern with the dragging effect the positive and negative you know force that will make it.

Compare to the that the braced frame structure is the structure bracing are commonly provided between columns and beams that already I have shown here will have some pictures there and then the resistance of the side wave forces or the lateral forces. So, the previous one where the rigid frames and other combinations we mentioned. So, basically that will take care of the gravity load. So, due to the gravity load whatever the things happen, they will be taken care of and this is basically taking care of the lateral load.

The frame system offers like basically this kind of frame system offer more effectiveness during the wind force and the earthquake that already mentioned that along with the frame structure beam column connection. If we can connect this diagonally with bracing, then that

will make it more resistance towards your protecting your building from lateral load that is wind load or during the movement the vibration during the earthquake.

Now, in braced frame structure, then also we have these gabled frames and portal frames. So, frames will have something like where in state of the joint. This is acting as a single portal will discuss this in subsequent slide.

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So, before we go in to discuss that, let us just go through some of the examples. So, this is some famous building and Burj Al Arab in Dubai. So, this is really a very good building we appreciate it, but basically if you see the structure; it is developed on the rigid frame structure.

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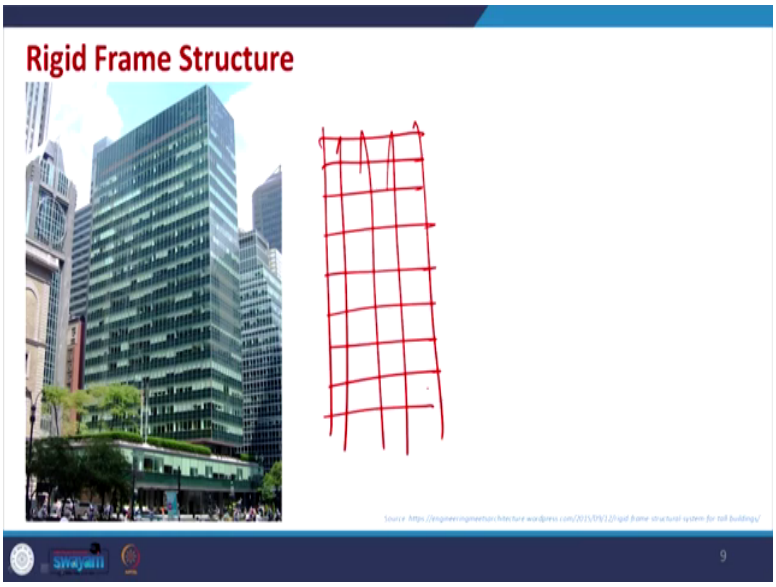

The same kind of thing like when you not go for this kind of you know hotel buildings in Burj Al Arab or so. So, this kind of office towers being also be constructed with the frame structure where it is very simple form that straight you know frame. So, the combination of your beam and column is making the whole skeleton and we can actually use the space more efficiently.

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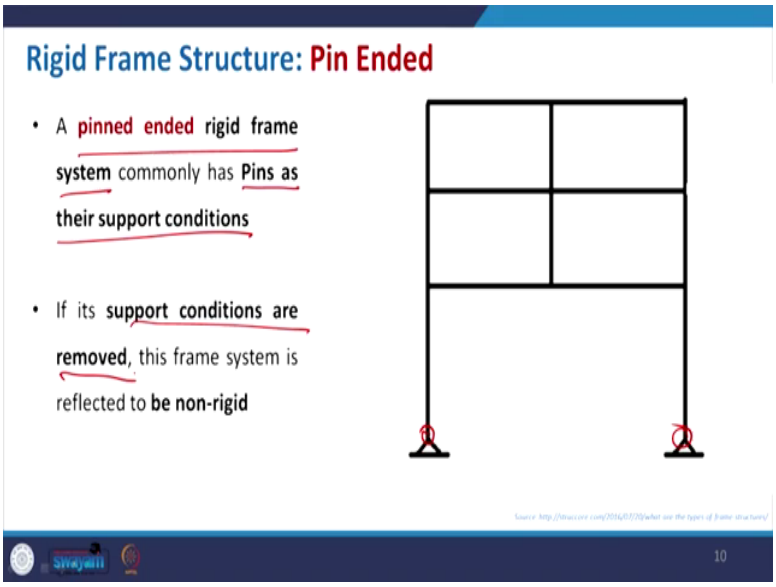

Now, come to the pin ended joint rigid frame structure. So, a pin ended rigid frame system commonly has pin as their support condition. So, here if you see that in this portion and they are joined with this. If this support pin is removed so, that will be considered at non rigid. So, the support condition removed means it will be non rigid structure.

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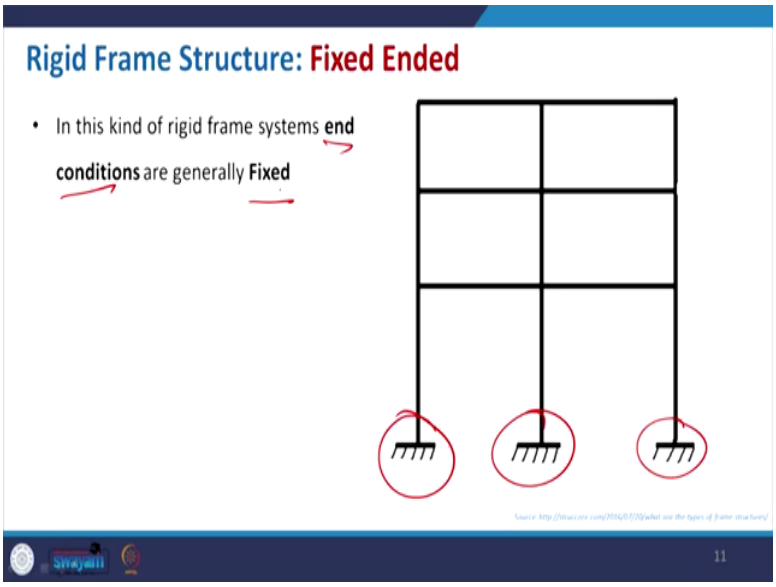

And come to the fixed ended. So, here you can see that the particular representation of the structure has changed. So, now, it is shown like it is fixed end. So, in this kind of rigid frame system, end condition are generally fixed not the pin one.

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So, coming to the braced frame structure: so, in this case along with the frame we have some structural bracing. So, you can see that this building or this building you have some vertical structure along with that those are connected with some additional bracing which will help this building to protect against the lateral load.

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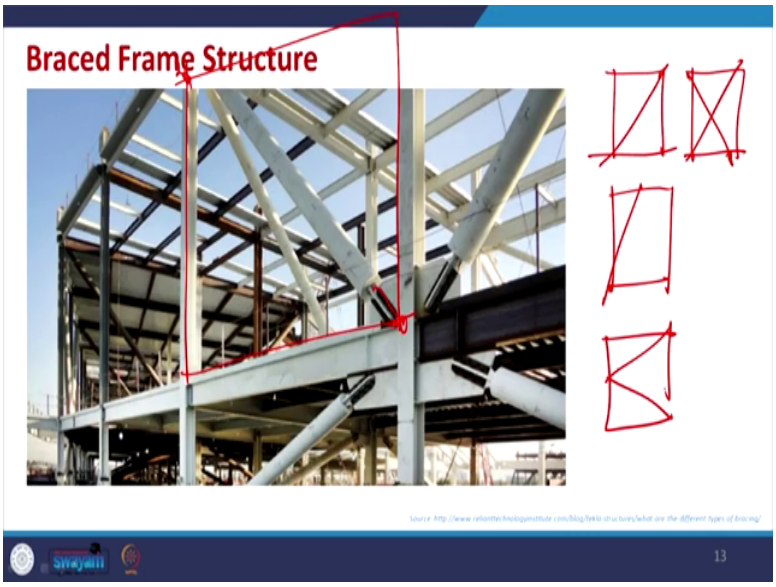

Now, so, as true like when we discussed about this braced frame; so, here this is another structure. The earlier structure again it is very straight forward very enclosed form. So, here it is something like where you can get those members very clearly that how they are connected.

So, this particular frame if you just visualize this so, this is connected those beam and column they are connected to the diagonal. So, this diagonal connection, it may be like one sided; it may be of two sided like this to make more like in this picture we have this or else it may be something eccentric, it may be of like k type. So, different kind of bracing can be used to you know protect it.

So, we will discuss those kind of bracing and their advantages in detail when you discussed about the high rise structure. Because you know as we mentioned that there are some advantages of the frame structure to go a little high in height, but after certain 30 storey or 40

storey building depending on the location and other constant. So, we will be using some different kind of bracing structure and in for high rise, we will move to the tubular structure; then braced tube structures truss in structure.

So, these are something which will be required for the high rise building. But for the frame structure in order to protect it, we like protect from the lateral force acting on it we can go for this kind of bracing. Now, brace frame structure the gable framed; in this case if you see that the gable thing where you have a reg.

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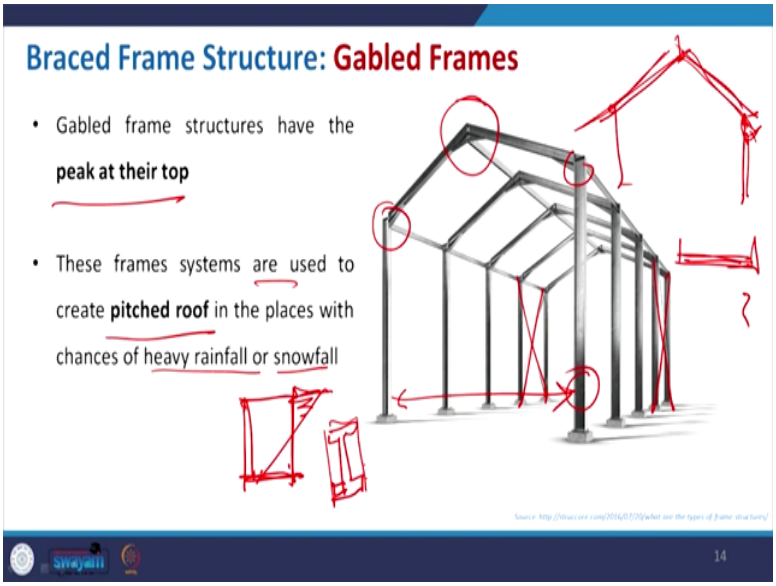

So, the member this particular frame we have little bit height. So, gable frame structure have a peak at their top. So, here you can see that how it is connected and at the same time in order to protect it from the lateral force, you can identify here easily that these are actually braced

with the members. These frame systems are used to create peach roof in place where you have the heavy rainfall and the snowfall.

So, the basic reason is that like when we discussed about different types of force acting on a building different kind of loads acting on a building so, we discussed about the snow load and rain load. So, for that it is always advisable that you should have a pitched roof or the slant roof where like the rain can easily drain off and they can be connected with a gutter and can be easily taken off from the surface. Otherwise, if you go for the flat so, due to some failure of the rainwater passage or something like that.

So, in that case like there will be some additional load of this. So, it is advisable and that is why in the country where like snow fall is very common, most of the buildings will find that they will have this pitched roof. And this kind of frame structure, this portal structure not only helping you during this you know heavy rainfall or snow fall, but also you can see that that can create the longer span compared to the other load bearing structure or typical frame structure with the beam column combination.

And here are the steel being used to make the portal. So, that like you can also reduce the cross section of those columns. As we discussed earlier also how to improve the section like as because you know in a regular rectangular section, the main building face developed at the outer surface. So, that you can improve the section you can use the I section instead of a rectangular which will be capable enough to handle the load.

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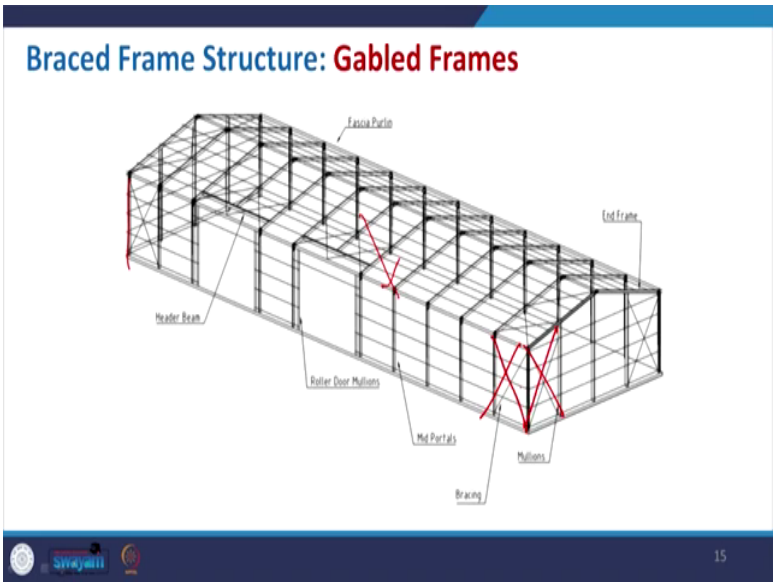

Now, this is something which you can see that it is mostly being used this kind of frame for the manufacturing unit some of the factory. Then it is a very regular arrangement. So, multiple frames are put in parallel and then that will be covered by some light material or some times maybe some translucent material. So, that you know they can maximize the daylight uses inside it and along with that we are also have the bracing to protect the structure the frame from the lateral load.

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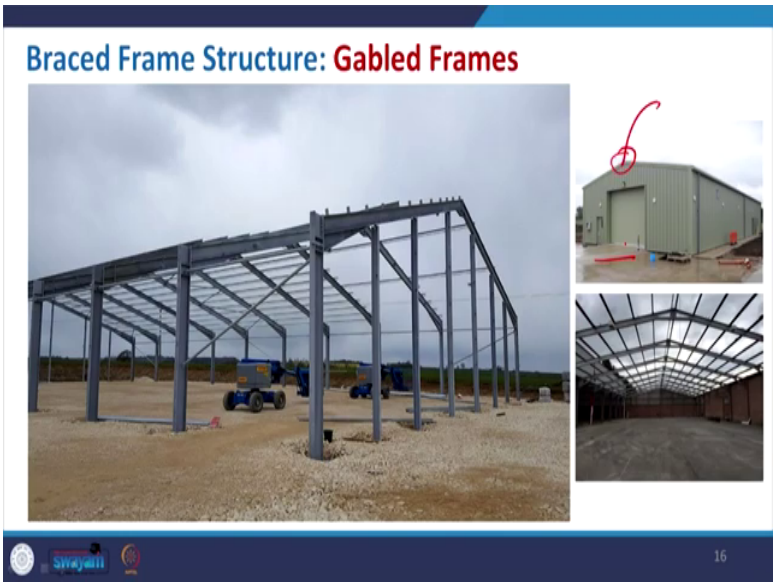

Now, these are another two pictures where you can see the this is something where it is under construction how this been made and it is something where it is very enclosed form. So, this portal frames the gable frames where the main difference is like you have a peak on top of it. So, this is also helpful.

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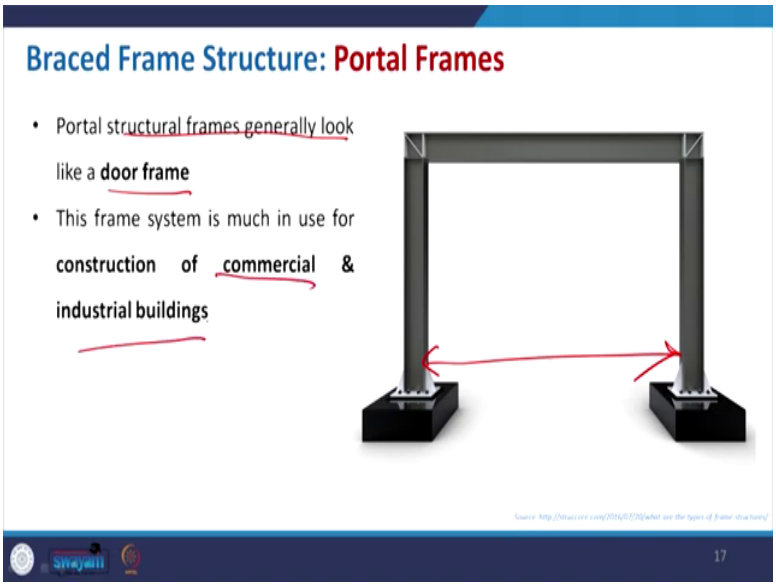

Now, come to the portal frames like instead of the gable now the portal frames that will have a very rectangular section. So, you can identify the portal structural frames generally look like a door frame ok. So, it can also create some you know space. So, it is also being used in some commercial and industrial building where the frames being used.

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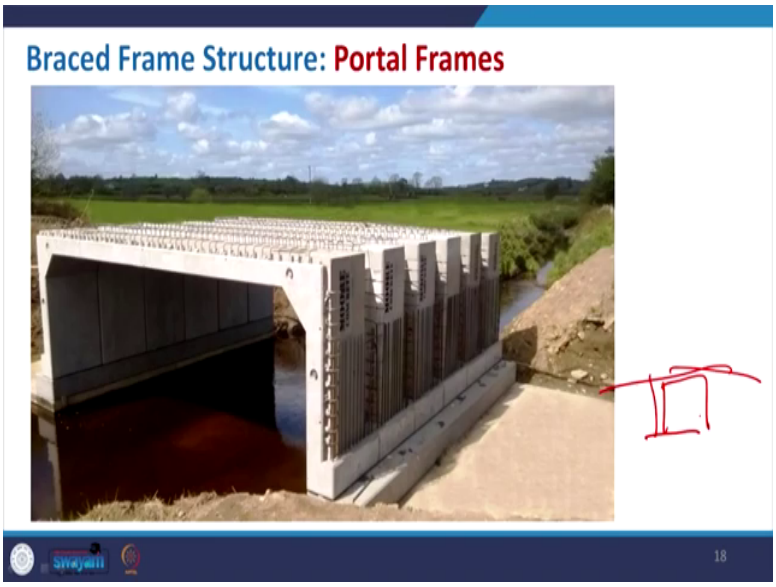

So, in this case this is not made of steel, this is just with the concrete the shear wall kind of construction. So, this is just creating to you know underpass to pass this particular water or the candle they have. So, this kind of arrangement, this kind of bridge sometimes we need the portal and if you compare it with this steel representative portal to this, it is pretty similar and that will actually helping to make it.

Sometimes you know this underpass being constructed not only to you know pass this particular water body or cannel or drainage sometimes even for the crossing of the pedestrian. So, when a highway or expressway is passing through. So, we have to create that particular underpass. So, that is also required some kind of you know portal frames that can be used to solve this purpose.

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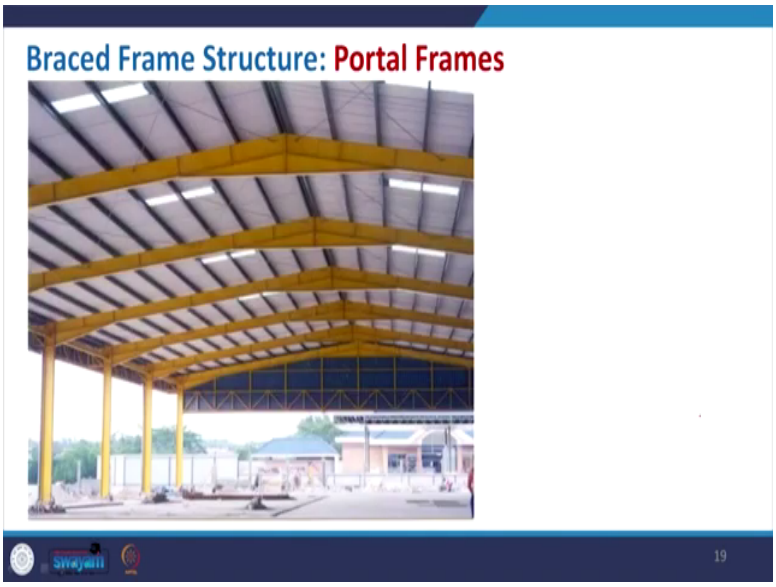

Now, in this case also it is another example of the portal, it is pretty similar to the earlier one and now it is made of steel. Now, coming to the advantages of the frame structure so, there are multiple advantages of frame structure.

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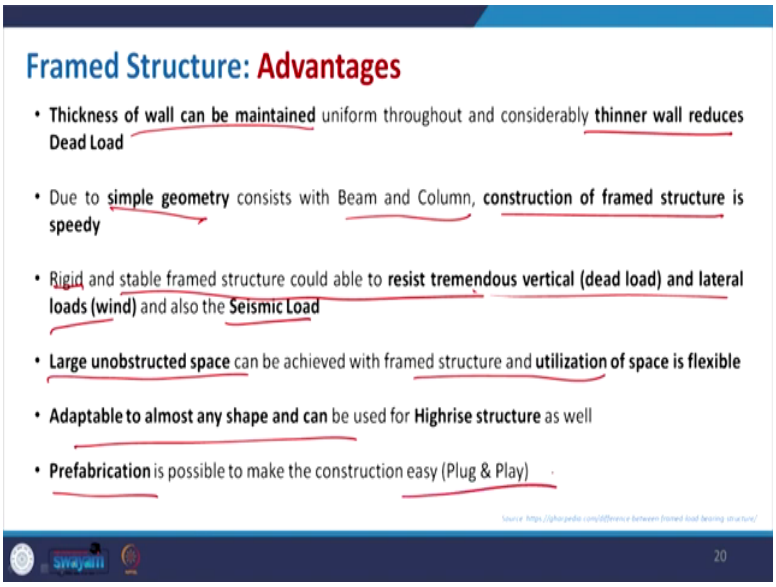

First of all compare to the load bearing structure. Now, the thickness of wall can be maintained uniformly throughout because like thickness of wall will not essentially matter the load distribution because load will be taken care of by the beam column and footing the walls are just to make the partition. So, that can be there and it can be an as a result that can also be thinner compared to your load bearing structure.

And whenever you make your wall thinner, then definitely there will be reduction in the dead load the self weight the material weight material self weight to the structure. Due to the simple geometry as because it is the connection and most commonly it is a very rectangular connection with the you know beam and column. Sometimes it may go with some different geometry, but most commonly it is being very you know typical layout of your beam and column.

So, in this case the construction of m structure is very speedy and if you have like option to use the steel frame where it is something will act like plug and play. So, it even it will make it faster. The rigid and stable frame structure could able to resist tremendous vertical load as well as the lateral wind loads during like the heavy wind load or maybe the seismic load that we discussed. Large unobstructed space can be created those span like where it was a limitation for a load bearing wall.

We cannot have larger span for any meeting place or maybe some huge gathering with a like without exceptional you know implementation of like those load bearing that we have in the roman period and all which will have the very high thickness or very large thickness of your cross section.

So, frame structure the utilization of space will be more. So, we can use the space more. The interior space can be more due to reduction of the cross section of the wall as well as your column. Adaptable to almost any shape and can be used as because like you know go for the steel, I think so, the different kind of form can be generated as well as the concrete that to be you know when during the construction, it will be in semi liquid form.

So, whatever the form you would like to give with proper you know design. So, that can easily go with any shape and design. So, that is another advantage of the frame structure what like was missing during the load bearing where you have very limitation with the design and all. Then prefabrication is also possible you can make those column beam slab like in manufacturing plant and then you bring to the side and just you know make the arrangement and you can make your construction very speedy and you know it is basically the plug and play concept.

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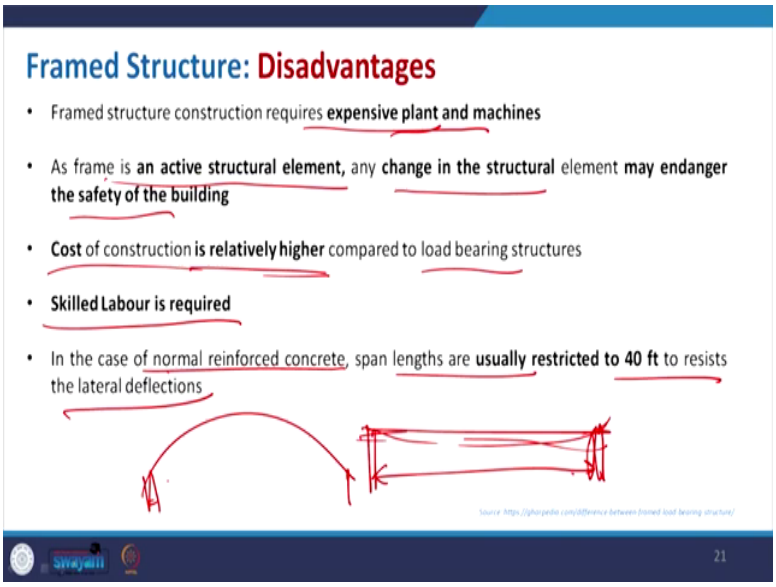

Now, come to the disadvantages of frame structure. So, frame structure definitely requires some expensive plant and machines because whenever you go for higher height. So, you need some other equipment machine to bring your material at upper storey. So, different cranes different leaves.

So, already like those machineries are required which was not much required for the your load bearing structure because of the low height like that can be managed with minimal scaffolding. But in this case it will be require you know proper machinery to make your construction easy as well as you also need to procure a different kind of material. So, the in this case, like you have a constant supply of the material. As frame is an active structural element, any change in the structural element may dangerous for the safety.

So, in this case basically the you can do alternation to the wall as because wall is not carrying any effective load of the building, but any alternation to the beam and column will be dangerous. So, that is why proper you know care to be taken if at all we have to do something on the beam and column the concrete structure. And that is why we all have experience you know in our post construction whenever we make alternation.

We never damage or we just you know cut any structural element the beam and column to that. The cost of construction is relatively higher compared to the bearing structure, but again if we just go have some limitation with the load bearing then effectively when you go for the high rise. So, this will not matter, but it is when you go for a low rise structure, then probably this will have the higher cost.

Then the skill labor is also required to have the proper finishing and in the case of normal reinforcement concrete, the span length usually 50 feet. So, the span of the beam can go up to 40 feet when it is a normally reinforced typical reinforced beam otherwise what will happen that it will have some lateral deflection. So, if you increase your span of your beam so, then they will have some your lateral deflection.

So, in order to account that so, accordingly we have to other supports. So, in state of simply support, we will go for your continuous beam column arrangement and you can reinforce your structure in a much better way to you know have the larger span or else in state of a simple beam column, we can convert it to like the arch and dome which will actually help to you know enhance this particular span.

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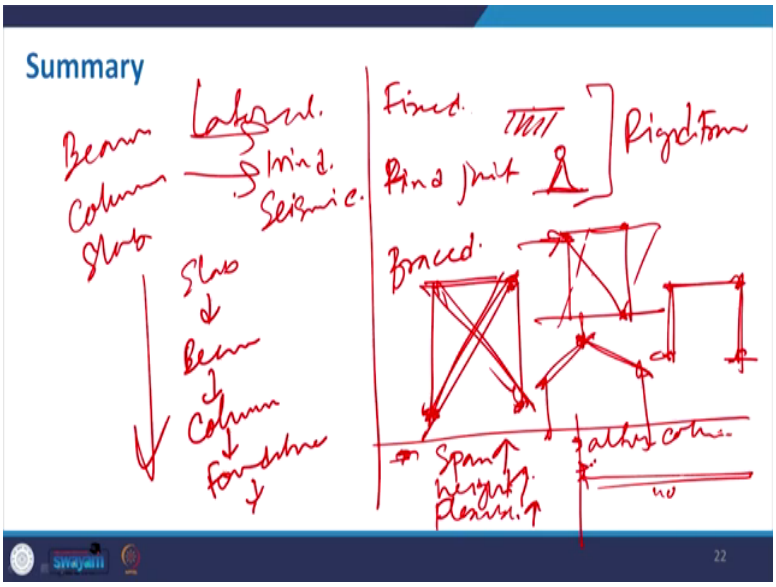

Now, coming to the summary section of this frame structure so, basically in the frame structure is a combination of your beam and column and slab. So, they are being connected to each other which will resist the axial load or the gravity load which is transferring from your slab to beam and then beam to column and then column to your foundation and foundation to soil.

So, that is your axial load that is acting you know vertically along with that this connection will also protect against the lateral load that is due to your wind or maybe during the movement or during the your vibration during earthquake. And at the same time also we have learned that the you know type of the frame, it may be of your fixed type joint where the support is being given with a fixed thing sometimes it may be your pin joint.

So, in pin joint also you have the similar, but again it has some you know advantages with a pin joint and also it is basically giving you the rigid frame structure to that. And then along with that also, we discussed about the braced frame structure where along with your beam column arrangement what we normally add the bracing. Another member and most commonly it will connect the beam and column diagonally to add some extra resistance which will protect from the lateral bending and that we have seen earlier suppose we have a simple connection and then we have put the apply load.

So, it will try to bent like this very easily, but if you just support either side of that so, it will enhance the resistance. In this also we have learnt like the gable frame where there is a peak. So, normally this kind of roof the pitch roof being used and it is being used for factory outlet or something. But most importantly where the rainfall with the snow fall is a predominant thing and along with that also we have discussed the portal frame. So, portal frame for where it is having a rectangular section and that can be made of the steel or may be RCC like underpass and all.

And coming to the end of this what we discussed about the advantage. So, with the frame structure, we can actually increase the span compared to the load bearing and then we also can go with the height and then your flexibility with your internal arrangement the design. But the disadvantage again we cannot alter the column and other thing. For the load bearing structure maybe some portion of the wall can be taken, but for this like replacing beam and column will be a very critical job like and it is dangerous too.

And at the same time, there are some other thing like this frame structure will require more machinery more skilled labor and compared to the frame structure like compared to the load bearing structure. So, this is all over with the frame structure and mostly like a with the frame structure, we can go up to 40 storey building with the proper you know shear wall or some portion of that shear wall.

And we can enhance it even for the higher height with the structural bracing maybe single side like single direction or maybe with the double direction. Like that this is very important and

the material used is RCC steel or sometimes composite which will help us to go for like utilizing the space the horizontal and vertical more effectively with the frame structure. So, this is all over the frame structure and I have shown few of the buildings, but most of the buildings in our day to day life in present day is basically with the frame structure.

There are exceptional thing where like you have the use a large span where the horizontal beam cannot hold beyond the 40 feet in general with the normal reinforcement, we can move to the some art structure and all.

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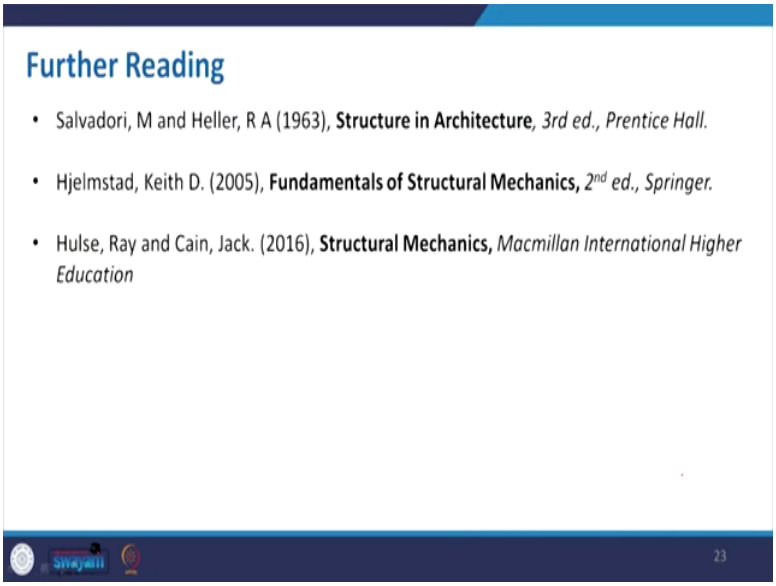

So, with that I conclude here. So, these are some of the reading materials that already been given in earlier presentations also. You should can go through it, you can also go through the given website links so, that you can get more information on that. With that I conclude here. So, next we will discuss about the arch structure different kind of arches different kind of you

know uses of arch their support and all in the next lecture. So, till then again I thank you to take part in this course.