Glass in buildings : Design and Application
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Lecture - 52
Facade Fundamentals

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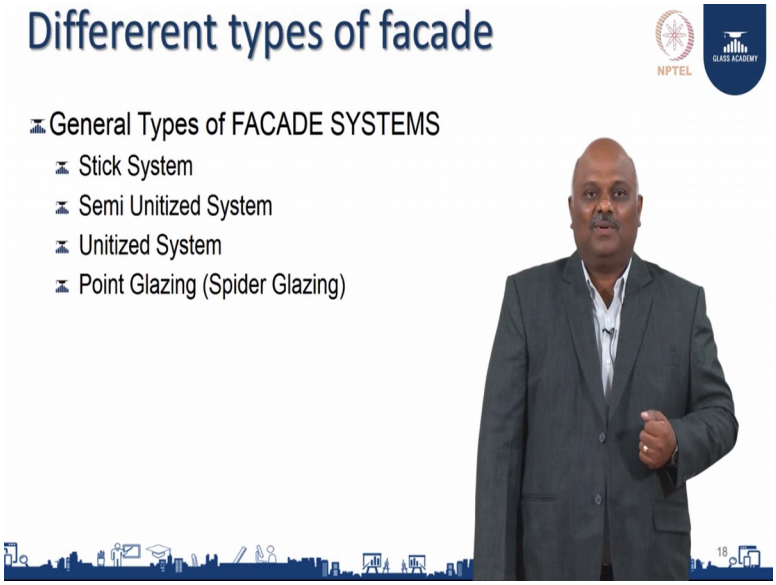

Now we start talking about different types of Facade Systems what they do? So, mainly these are the systems still you are studied in practice. So, we start with the stick system what it is? That was a old invention when people found glass or other material they found a easy way to stick something onto the world. So, example this a improved version of system, a evolution has brought them in with material with glass with aluminium, steel with wood what and what not. So, the systems are mainly into these three categories Stick System, Semi Unitized System, Pressure equalized fully unitized system.

So, now let us see what is semi stick system. A curtain wall system in which mullions are install first withdrawn some and a glass panels are inserted into the mullion framing in the same arc rate quantities. So, you make a grid when you are building. So, you have a facade of building, where you create grids using steel, aluminium, wood or whatever. So, you make vertical line horizontal line through the requirement of architecture client, then you start putting glass piece by piece at site, how you do that labour intensive and when you design such big building stick system need not perform unless you have a system

where it can take care of all the impact. So, the invention came into place in still they practicing system in certain part of the world, but it is almost taken out of the facade field.

You can use it may be in small buildings where you know you have one floor two floor swap you like to do some sort of a small work, where it does not have too much of impact from the nature, that we can start using heuristics system is a old invention where people used it when the technology was not available or the systems were not available. But today there are good systems available, but it is very labour intensive today the world does not have skilled workforce to executive your work. So, think loudly your choice of systems and limitation of systems play a major role in designing a facade.

So, stick system invention has gone. So, what people thought how I am going to go forward, what is going to happen? So, they started to understand how I can bring little bit work towards my factory, here they started getting lot of quality say example, I have to install 1000 glasses at site by fixing each piece by hand if possible nowadays. So, they started understanding all this problem plus they do not move, they do not expire they do not contract even though the design is there, but they there lot of limitation. So, then the invention went to semi unitized system.

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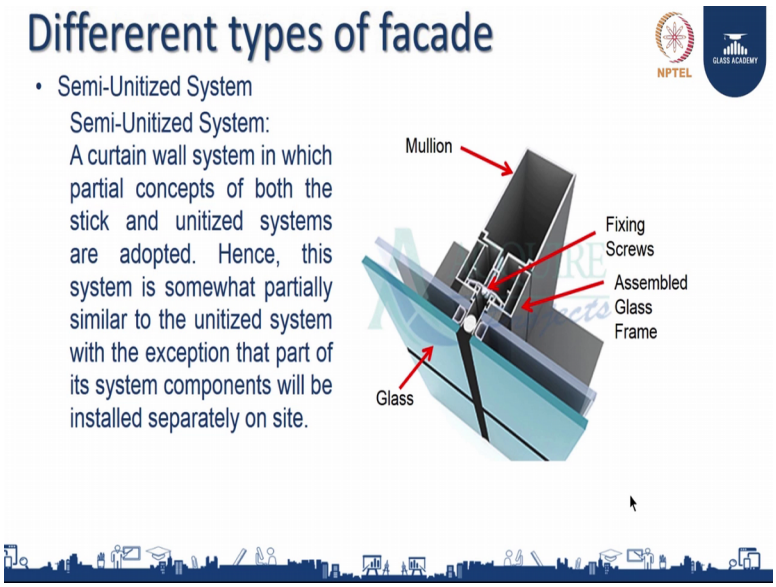

What they do with the semi unitized system a curtain wall system say, but they dislots the glass and made it in the factory and they bring in the glass with the frame and fixes it

still it is a form of stick system, but little bit advanced in a way they add a little bit of moment into the structure the structure can move that can expand and that can contract, but still semi utilized system is labour intensive you need to have a big workforce again you install 1000 pieces of glass at site.

It is (Refer Time: 04:10) you cannot do it how you supervise it. So, still the questions were asked how I am going to have a system which can take care of everything which is happening around us, which including you know skill work for safety and so on, so forth. So, invention went have to say yes I want have a system which can be done at ease less labour intensive, but at the same time taking care of all moment, yes semi unitized system still can be used still in its use in certain part of the world, but with limitations the limitation is yes.

Wherever you need faster changing of glass example, but that also got nullified today, but people started understanding (Refer Time: 05:01) like small offices or shopping malls I have talked about air force yes this there they can use semi unitized system where you do not have a lot of movement lot of factors in form of you know whatever factors we discussed before like thermal expansions and other factors limited factors, then you can use a semi utilized system otherwise today's environment and buildings today require you to think for something more advanced, but at the same time it should take care of all these factors.

Number one you do not get skilled workforce today at any part of the world people are not ready to go and work in the field. So, what you do you still sit down and say an adamant no I do not want to improve. This is what know I want to do no they have found different systems, where all this can be minimised.

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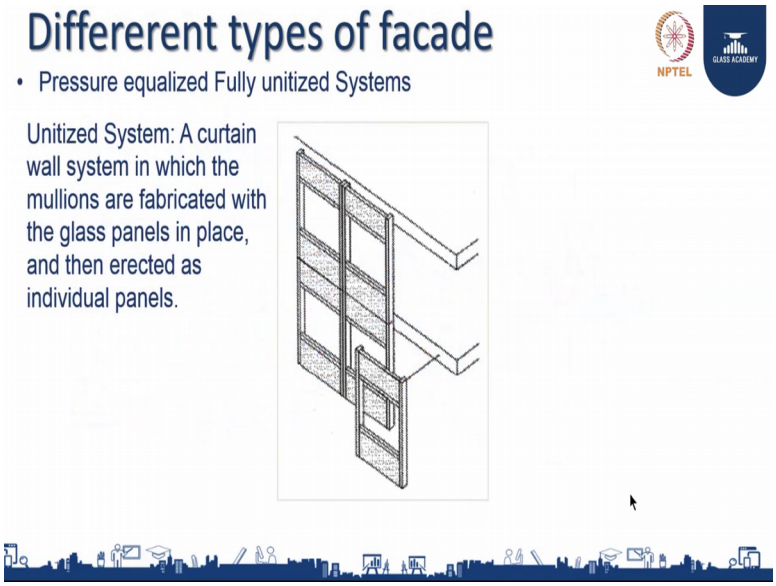

So, then came a pressure equalized system here what happens is if you see the previous slide again here you know mullion is attached as a grid like in the semi unitized.

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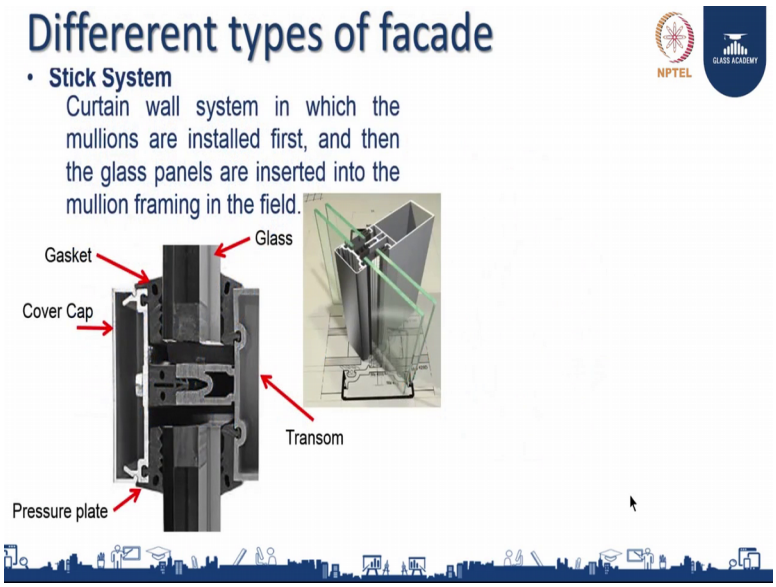

And then the glass is fitted at site, but if you go to unitized system everything is done at factory.

It means floor to floor or two floors or whatever module the grid you form you make everything in factory and you bring them together and you install at site. So, it means people work from inside you do not need to have a external access to the building, you

work do everything from in standing inside the building, it is safe less manpower it will the system itself its more advanced, which have take which when to take care of all your factors building movement, screen, expansion contraction. So, unitized system is the system available today which takes care of all these functions.

Possibly the best system you can design for your building. So, lot of advantages and disadvantages are there ok, commercially yes it may be slightly expensive, but you know you need to understand how to work around it with different systems; however, understanding the limitation if you do not have a skilled workforce or if you are adamant to say yes. If want to put 100 people at site to put piece by piece glass rather I will get a 20 skilled people, I will assign to work in factory are the types of provision. So, pressure equalized fully utilized system, this is what we are going to see in the presentation.

I did not want to go back and you know explain how this stick system works or semi unitized system works if you can cover the pressure equalized system that will give a transformation as well how it got transformed to this level. So, today commonly in the world this is what they used for all high raised buildings, this unitized system have made a big impact in the world in form of design. So, the whole world today believe this is a way to go and that is what it is happening all tall buildings no matter where which part of the most of them or all of them I can say are done with the unitized system. So, now, let us start understanding what is pressure equalised fully unitized system.

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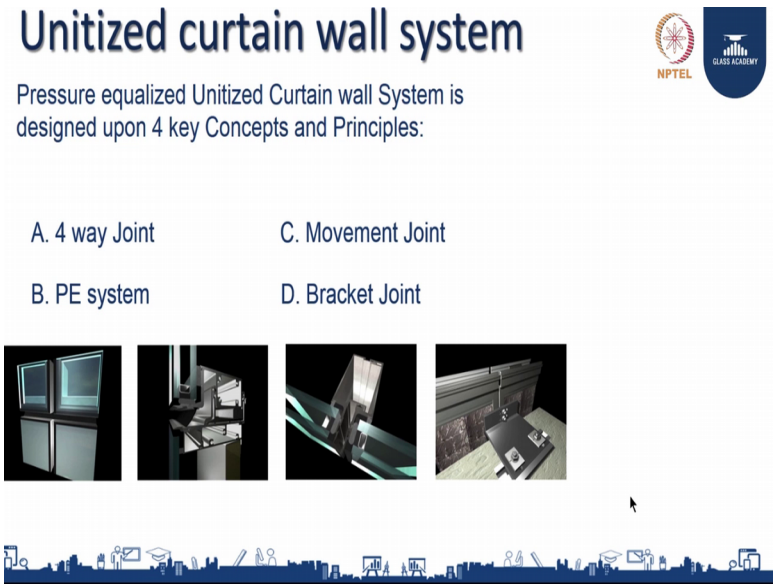

When you talk about pressure equalization in curtain wall system there are four factors which governs the design.

One a 4 way joint if you see here of a panel, two are P E chamber we call it the p e chamber what is p e pressure equalization, I will talk about this after please then a join which moves; that means, you saw a mullion semi unitized system, where it is a solid box, but here this picked a mullion then make it move to move, but what will happen in semi utilized system when there is a thermal expansion it will be taken care of by the gaskets which is not good, but here the system itself will expand and contract.

Then the bracket, so, you this is a bracket you used to hold it to the structure, but at the same time taking care of all the building movement. So, now, let us understand each and every component of this.

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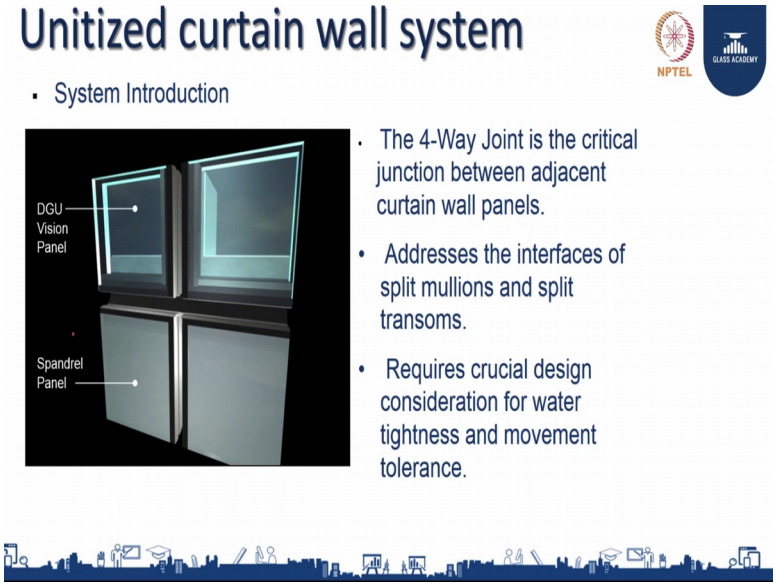

If you see there are two panels, which put together by mean now they creating a 4 way joint. So, it is a simple simulation to show how panel support together like example this one panel imagine floor to floor now your second panel you join this panel and then you bridge them at understand and you know put all the details what is required in the design together. So, you created a good intersection of joint which is considered as critical value start designing.

How these things are done. So, understanding unitized wall its as simple as a you building a wall unitizing it in an factory environment. So, you it is like manufacturing a furniture you know you lose furniture what they do it manufacture the furniture in the factory, that assemble it that site you mean they pulled few screw when you have a furniture, but in this case say you make a full panel in the buildings. So, example this is a full floor or whatever you see here.

So, this is a complete unitized system of panel which brings a whole thing together.

So, you put the panel you go in detail to understand the design, then you know you have your panel 4 way joint clearly done and it is ready.

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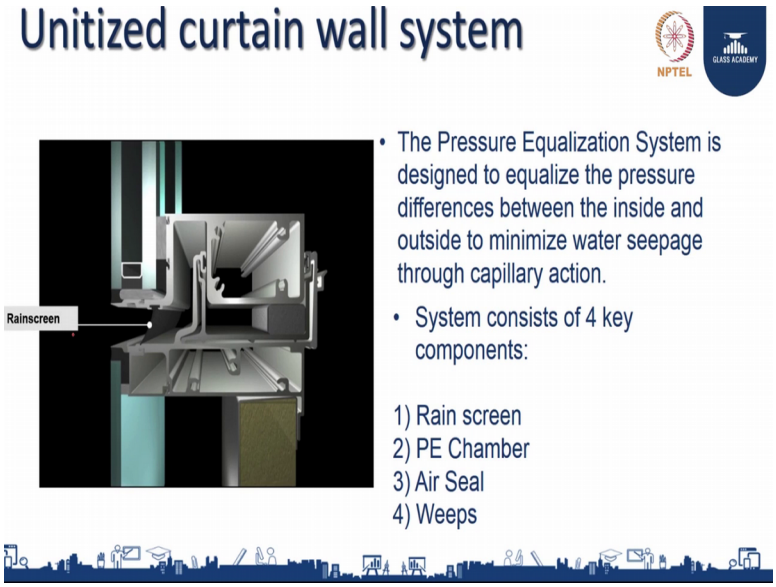

So, this is what I was explaining about pressure equalization, what is pressure equalization? Always we start looking at a external and the internal pressure and your wall which you create stands in centre. So, external there is a pressure which is always higher and internal there is a pressure, which is always weaker. So, we call it in engineering term positive and negative.

So, it means your wall whatever you design should withstand both. So, you are applying pressure outside because that is a natural pressure you created by wind and other factors, then internally what happens there is a suction because you created a barrier, so barrier is your curtain wall. So, if you make an curtain wall too tight too what you call rigid or too

sealed what will happen they have to be heavy because you are not letting the air to pass through. So, you are containing the air with the system. So, you design the system to make sure you let the air to pass through, but not to create a heavier suction inside because internally what will happen as it is weak always you have a tendency of you know pulling anything inside.

So, while you design a system you first four factors you have to see is 1 2 3 4 what is written here arrange screen. So, it means if there is wind and water together they will find a way to go into a building. So, you want to shelter the building against wind and water. So, if you talk start talking about rain screen so, you control the water getting in through the joints because this joint what you see here is called a stack joint. What do you say stack joint? You have floor to floor a building moves because of creep or settlement they start moving.

So, you need to create a stack where the mullion or the transom can be split. So, they move inside each other which allows in the next slide I will explain in brief how the movement is taken care, but when you talk about pressure equalization you have to equalize the internal and external pressure by letting them to go inside the chamber, but in a calculated way, I cannot say I make a big hole here into the system to let my water to go when in air to go in through here, where I do not have anything happening on the internal part this is inside the building this is outside the building.

So, internally as I have a negative pressure, outside I have a positive pressure. So, air is blowing here. So, internally I have a suction which is pulling in. So, what will happen if I let the whole have to pass through when there is water they all dry and so, it does not work. So, you need to create a design which takes care of all these factors. So, the design should take care of all these elements and you should know how to do a pressure equalization. So, it is not just as simple as I am saying. So, your design have to take care of how much air I let to go in and these are the chambers you see you there is a chamber here there is a chamber here there is a chamber here there is a chamber here.

So, the air which goes through a system should have a control it means; it should be in the controlled way you cannot just let the air to pass through and then you say the system is not working. So, you control the air pass through the system and you equalize them here, it means the air coming here into the chamber and this air the suction getting

weaker and weaker. So, you do not get too much of suction happening. So, whatever is happening you equalize them here and make it 0.

So, at the same time you need to design the system as such say example if I do not create a air seal, this is called air seal it means I need to seal the air coming through the system because this system is paid this is upper floor this is floor below there two of them join at somewhere around the floor level this is your floor level. So, they join, but you allow them to move when you allow them to move you should take care of all this seals which they played major role alright, this is a vertical suction of a building where you start to see the head and seal happening we call this is as a seal and we call this as a head.

So, you allow them to move and what happens if there is wind for sure there will be water, but we have to control the water still there will be droplets of water which can get into the system with the wind that you collect here this is what we call gutter, you collect the water like that gutter in your in your building you collect the water there, but very negligible because we are not letting too much of water to go into the system at first place. So, they start draining off and one more most important thing while you are designing this, you have to take care of capillary action as well.

What is capillary action? If any suction is there I you have air and the pressure, you have water. So, if you allow air to escape level they will push the water up it means; say example, I do not have this air seal now what is happening with air seal is weak so, my suction is there it means I am I am I am any pulling the air. Now whatever water I will have here or even if anything goes wrong with this water will start going in because you do not have a proper air seal. So, this is what you call a capillary action.

Because the air is sucking inside it can raise several floor you know I have personally seen lot of failures at where you can see know water rising for two three floors inside a joint. So, whenever you design anything and facade make sure your air seal is proper and tight, here yes you can have sometimes damages or whatever, but if your air seal works right then this can be managed are you the failure can be managed if your air seal breaks even you put a pinhole here small hole they will suck inside. So, be careful, when you attaining to a design whatever form you must ensure your air seal is in order.

So, this stack joined as I explained is designed for movement. So, the more four important factors Rain screen, Pressure Equalization Chamber, Air seal and Weeps.

What is weep? Weep is nothing as an like our two eyes had you weep. So, any excess water or any water which gets into the gutter they have to drain out here. So, I make few holes on the head for the water to get out if there is a water, most of the time there should not be any water inside the system not much as we think because it is controlled.

If a air seal failed then yes you have lot of water, but still you know you are to find a way to drain them off. So, you make holes in the system to drain it off so, that is how you know you work.

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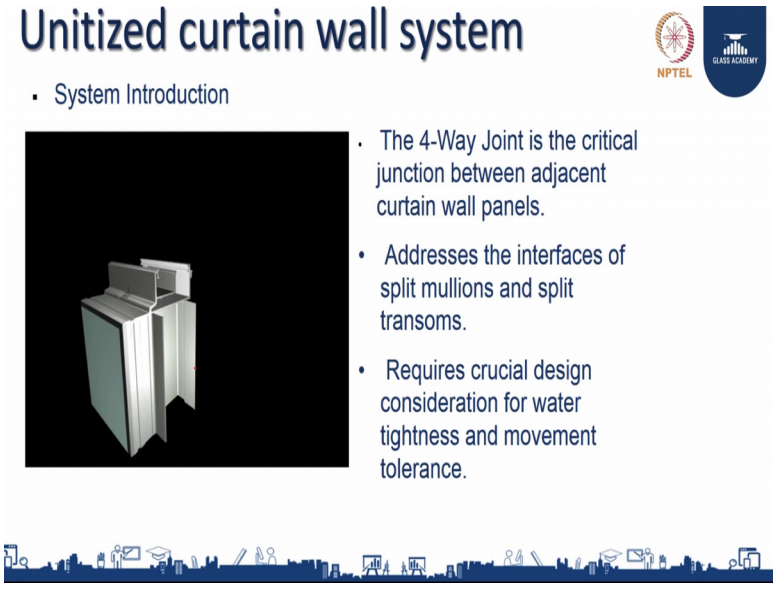

So, if you go back you look at the 4 way joint on the system, which is critical because you put two panels together you must understand how to make a 4 way join and second when you design the system make sure we understand this concept rain screen, pressure equalization chamber is not only at this point also, but in the horizontal as well if you look at the previous slide.

You see they mullion which comes in there also you make a pressure equalization chamber. So, rain screen, pressure equalization chamberr, then air seal the most important one and then weep if there is any excess water, you throw it off that is how you start with the design.

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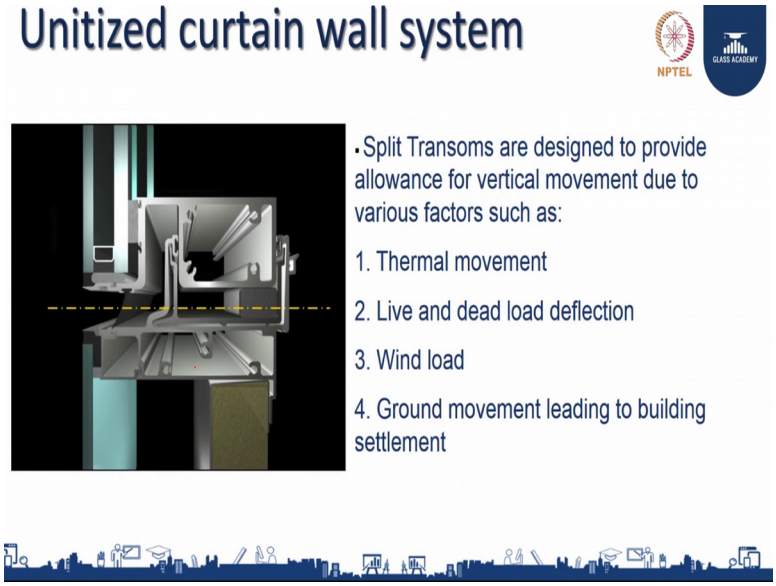

Now let us start understanding the stack joint in depth, see we call it a split transom. What is a transom? You in a building you have a horizontal beam example that is your column is called as mullion your beams have called here as transom, but here we the same terminology can you use and in a unitized wall what you call anything vertical you call it column.

So, anything vertical here you call it mullion anything which is horizontal the beam. So, call here as transom or mullion sorry spit split transom or transoms. So, here the terminology goes like that so, to make all understanding it is easier. So, what you see here this is called as head like our head right and this is called a seal, it means the lower level because this joint happens at the floor level ok, it is get connected to the floor below this panel. So, here later I will show you how its gets engaged to the structure. So, this we split the mullion.

What it does? It has to be designed for thermal movement ok, in this case what you see here is an aluminium system, inside advanced aluminium system where aluminium you know it is found for expansion and contraction with thermal if there is excess heat it expands if it is cold yes of course, it contracts. So, throughout the day throughout the year it start moving, we that also can be calculated sometime you do for 1 millimetre or 2 millimetre, but it can be calculated. So, you design have to take care of the thermal

movement, if I make a rigid system what will happen they will tend to bulge out that can create a head out for it.

Then live load and dead load, whatever loading, which you have to consider while designing a building. So, that can be impact load that can be at dead load of course, a dead load is itself create of the panel plus the factors. What you call about live load? Live load there can be human interface, human impact plus your main load plus your other loads what we consider we have to add. So, all this put together you have to arrive to an factor that are to be considered that is right.

And third one most critical one wind load. So, the system what you designed have to take care of wind load as well, say when wind is blowing sometime you have (Refer Time: 23:59) if you start to get the two rigid system what will happen, it will become very very hard and then sometime it will end up to break or it will get to rigid. So, you allow the system to bend to its limitation. So, you design it with factors you design it with safety so, you do not make the system I just to tight you make it little bit flexible. So, considering the wind load you have to allow the system to move.

Like example, when I am moving my hand of course, there is a joint here, but this joint is not fixed they are held together by means of nerve and flash on skin, but if you see two bones they are not connected, similarly here you look at here stack joint they are not connected they are split.

So, they let them to move all these factors ground movement leading to building settlement, buildings you know they start going down negligible amount sometime it can be bigger certain buildings you know gone even two foot three foot down after construction. So, the system have to take care of those things those elements those factors are very important. So, this stack joint is very critical when you design a system your stack joint places key role to take care of all those factors what we explained.

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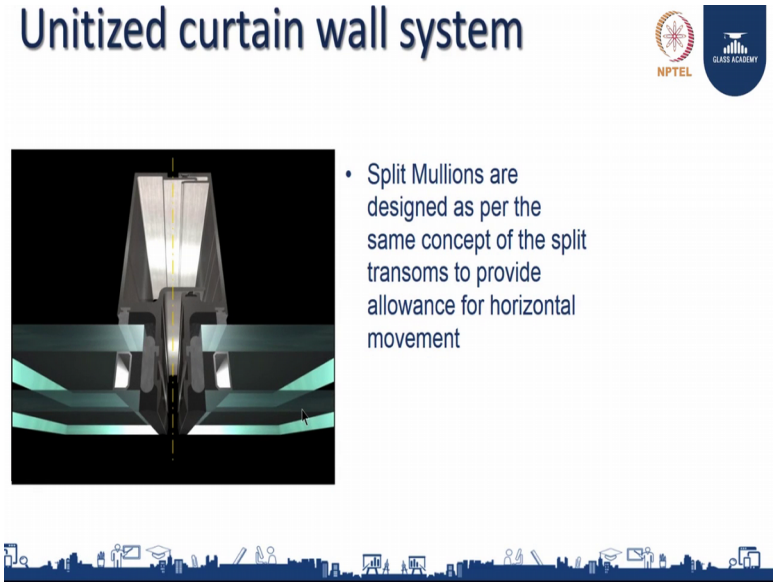

Now what you are seeing is a mullion, you do not look with do only with the head here also you make a system which if you see there will the movement it has to move see the mullion is also split, which allows them to expand and contract horizontally as well the stack joint what we saw here which goes vertically up down another building when it moves or anything happen if it just makes around the movement they move up down.

When you start looking at horizontally the mullion also is split so, they can move and close. So, this is how the system is designed. So, the mullion also is split you know way which allows the system to completely move forward.

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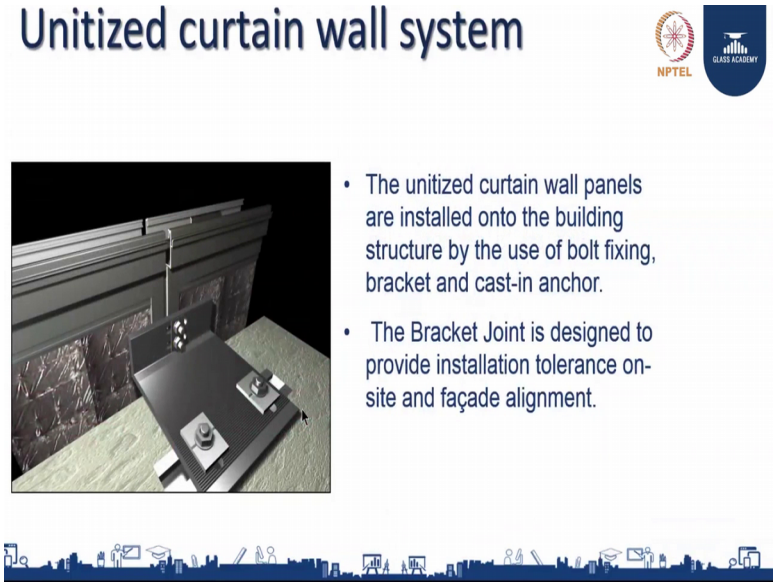

So, now what you are seeing is how you attach this is simple form of attachment. So, you saw the panel now you bolt the panel to the structure. The unitized system are installed into the building survey by use of bolt or anchors or catch in anchor there are a lot of anchoring devices available, but a commonly used one we will discuss later what people use.

And bracket joints this simple form of fixation around the world. This is the only one you do in your site. So, this your casting channel this is your bracket, you do all your setting out in and out where you want the bracket face to be. So, you have serration here which allows the locking of you know horizontal movement and this bracket design itself we will take care of all sort of tolerances, which is required at site to get a good system fix and then what happens here? Here it transfers the dead load.

So, the bracket design takes care of their load first, second it takes care of rest strain assure against the wind. So, both direction the bracket will play a major role. So, whatever load getting transferred here that goes down to the structure by main of brackets finally, it will get converted as a small point load on to the structure. So, your bracket plays a key factor as well when you design the system. So, this have to be taken care by engineer considering all the factors how I will design a bracket, what are the loads I have to consider what are the factors safety factors. So, is a simple form of design.

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For bracket now I am going to run a small video to show, how this panel is getting engaged a unitized panel. So, I run the video so, it is the structure now you put the cast in anchor on to the structure. So, what they do? So, now, they are setting the bracket. So, if you look at here what they have done there is a cast in channel you see that horizontal thing what you have here this is what we call cast in channel. So, you embed this while doing a cast in and then you introduce a t bolt into this channel this is a t bolt you go inside and you lock there.

And then you put your bracket. So, you see the bracket you are adjusting with the slot and you lock them in position with the serrated motion. So, horizontally you do the thing will move because when the building is shaking you have to let the thing to move the whole system has to move like what if am doing now right. But if you start going in and out then the whole thing will get distorted horizontally when they move its ok, because it goes along with sway of the building so, you lock them in position whatever it is required.

And you are ready to receive the panel now the panel comes from factory fully done you put them there and you drill two bolts its a simple form of fixing the system. So, you see you put two bolts you alters then you are done that is it the panel is installed. So, what you see here this is a gutter head, what we saw the split mullion it happens slightly above the floor level this a mullion waiting to receive the other panel. So, the stack join now we

have the head portion of the panel. So, now, the next panel will be installed you can see now they connected floor to floor.

So, the next panel comes down they use the crane or something to leave the panel they bolt them together. So, you keep doing it see this size of the panel it covers floor to floor and it is done out of factory. So, you keep going you keep installing the panel as we go. So, bolt it keep bolting and then this is what the four way joint happens, now once you finish installation you do whatever design requirement is a you seal the head you put your gutter everything cleaned up then you bring the next panel. So, this is where your seal going to happen.

If you start looking at the video again you see they create a four way joint and then they keep going. So, once again I will (Refer Time: 31:04) so, you put your channel you put your t bolt then you put your bracket adjust the bracket for movement whatever in and out based on the tolerances of structure then lock them in position, your field work is done that is all you do, then you wait for the panel from factory you attach them with bolts two bolts into you are done. So, look at imagine this panel what you see here that three glasses plus spandrel plus all the other systems what you do you install all these at site.

What you see here is ok, you have one glass two glass spandrel unit system you do in factory you bring them all together and you pull it down, but the other systems what we saw before you just do the grid you put all the mullion transom then you do the glass piece by piece at site.

So, hope you understand the unitized curtain wall by now yes you have to spend lot of time and you know I have given you a very brief fundamental simple fundamental how the unitized system is done and why and it is been used as a comprehensive system nowadays. So, it takes care of contraction thermal expansion mean whatever you we saw before. So, the system is designed for all these and is a most advanced system.