Glass in buildings : Design and Application
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Lecture – 54
Facade Fundamentals Part IV

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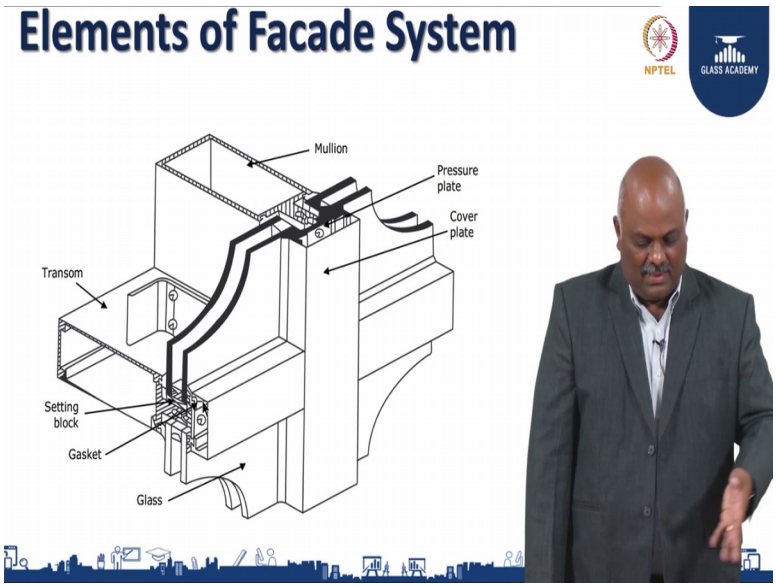

So, they simple connection of a four way of facade system, there have a glass, then they have a pressure plate, they have a mullion, this is the mullion vertical anything vertical as I said it is a mullion. This is a transom which connects horizontally. This is a glass then they have a mechanical pressure plate to hold the glass in place. You can see a simple representation of AZTEC system. So, all these you do at site and you get the glass and then you put them at site.

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This is a example of an aluminium extrusion you can see you know how this extrusions are. They made to the profile you make the shapes you like. And then they coming. So, as I said they are easy, malleable, corrosion resistant because of the protective coating you do, easy to design and easy to form and finish it. So, you can cut, you can do anything on this. Steel, the next available material is steel, but it is hard to work out. Yes, still people are developing steel systems in different parts of the world, but it is not commonly used structure for a high rise building. So, aluminium is the material which you when use for facades.

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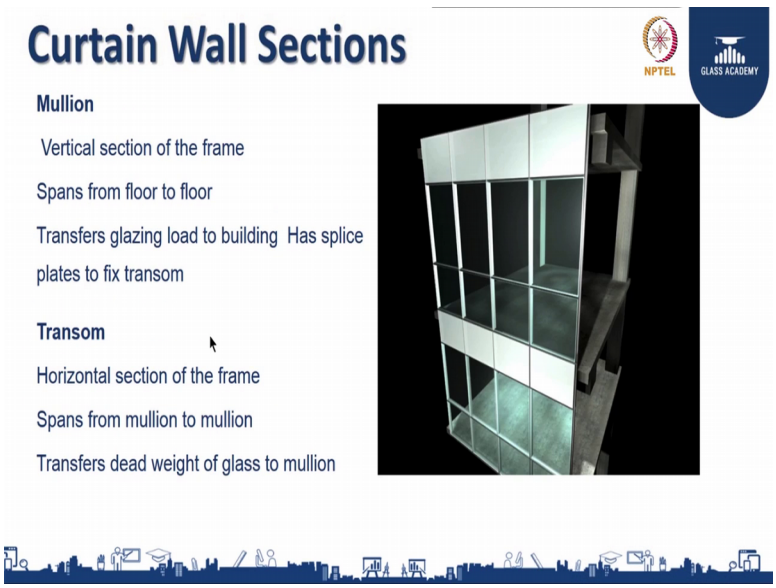

So, these are the section. Now, as we saw before whatever is horizontal we call it the transom; whatever is vertical we call it mullion. Then of course, the bottom of this panel we call it seal and head. So, it is like us we have a head, a foot you call SO, mullion when you starting look at the design, it more of a simply supported structure from here to here. The column spans like your column here its spans from the floor here to the floor above. So, the design have to take care of all these design. When you are designing a column what are the factors you consider, you have to consider the same whatever is required as per this specifications and requirement by the codes.

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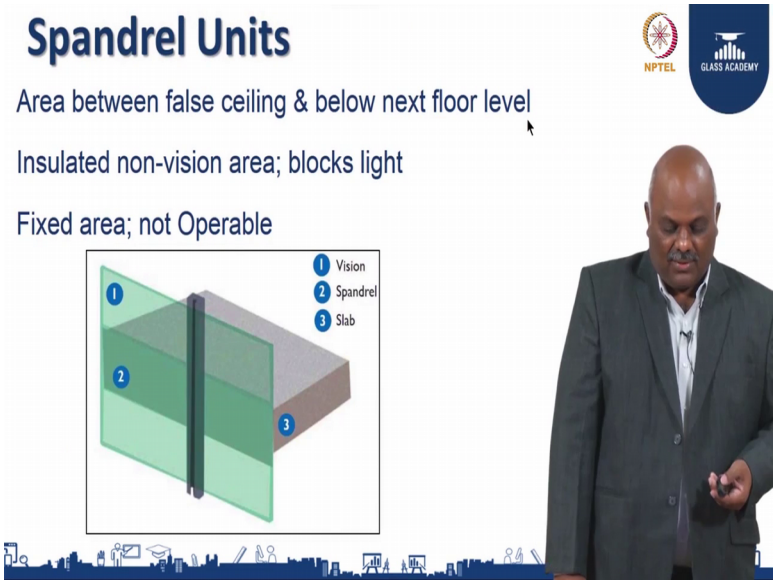

So, non-visible area which is called spandrel like you see here whatever is visible where you can see through is called vision simple, whatever is non-visible you call it spandrel ok. This is where you know you cannot see through, but you want to contain it you know we want to contain something behind you know like a slab like a beam or you know all your details this is where the spandrel panel happens.

Of course behind the spandrel there, are lot of things you can do, where you want to put granite, you stone, metal whatever, but basically the shadow box acts or spandrel acts as a media which does not allow the spread that is number one. Then again you know you contain whatever you want to contain between floors whether it is fire, whether it is heat, so you contain it in the spandrel. So, this plays a very crucial role. Of course, you know to get this spandrel to get along with the façade, there are lot of choices you know we can

put shadow box, we can put lot of glass different types of glasses, stone, metal, is a choice of architect.

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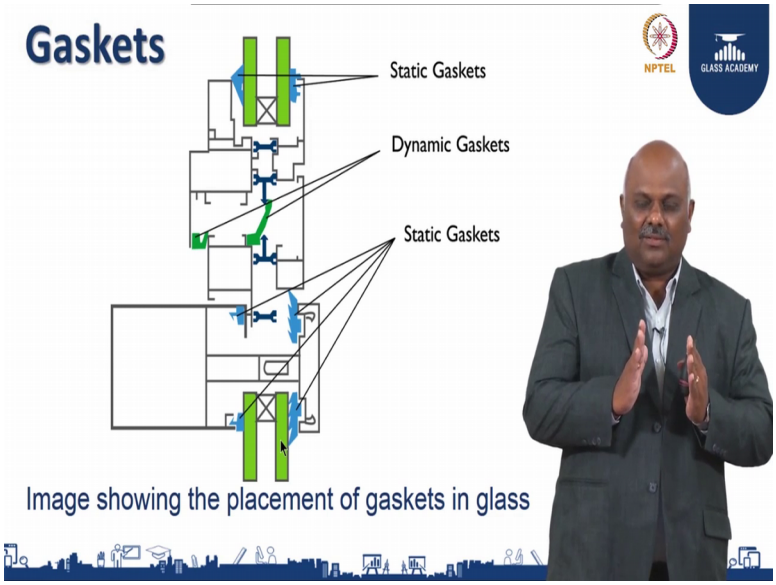

So, talking about gaskets, there are different gaskets like starting gaskets what we call and means it got a function of static, which is static means you are compressing something, and it holds the main portion. Dynamic gaskets are something which moves along with the system with their dynamic, because it has to flux it has to open and close they have to be dynamic which goes along with the system. So, static it is completely static; it means it is fixed, they just expand and contracted gap.

When a turbo dynamic gaskets, say example a openable window, the gasket goes along with it and when it comes it should close back. So, these are the two commonly used names for gaskets. So, dynamic moves along with a system it opens and closes as per the desired requirement. Static is something which is very static, but takes care of compression, elongation as per the design. So, material we saw later earlier.

See, the gasket was pulled out of the frame to show where it is fit in real one with the glass. So, it does whatever it has to do. Sealant we would have seen we should have seen the slide along with the double side tape. However, this is a material which has been invention of 50 years now I believe. So, it is byproduct of petrol. And yes this material keeps any you know bonding to where they bonds the structure together they have high tensile and high shear stresses. So, they can be used as a structural sealant, it means

holding something structurally (Refer Time: 05:14) element or whether say that it means you can seal a joint not to let air or water go it. So, they call normally these are the two things they call whether sealant or structural sealant.

So, structural sealant is something which holds any form of structure against straining member. Like in our case what we have done if you see in the system what we been designed. So, example here, here we use a structural sealant, structural sealant. We hold the glass into the structure see here. This is where use a structural sealant. And this is what you call a weather sealant; it means normal metal to metal you know there will be a small gap where you can use that to see weather sealant.

So, structural sealant holds structure against a structure like you know mullion, transom wherever you want to glue the glass too you use a structural sealant which holds them together. Again you have a different whatever material you see here I am just going through very briefly because all these material in specific will be taken care by other colleagues of a us where they will give you complete detail about each product.

So, here I am just simply telling how it goes with the fundamentals of facade that is all. Not going in depth what sealant is made of how it work because that will be taken care by our colleagues in depth for you. So, it is much easier. So, sealant commonly these are the two sealant you use and inside that you know you have various sealants available two part and one part, non beading, non staining, lot of things are available that commonly structural and weather sealant.

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So, they come in tube form or you know two part comes in container like this, you mix them together like whatever you know adhesive you see. You have an hardener, and you have a base, you mix both of them together, then they start chemically acting within a time frame, and then they get harder and harder as we go on. So, sealant takes care of lot of things, adhesion to the substrate.

As I said if you have a (Refer Time: 07:29) fixing the glass, and also it is rubberized, because the whole system say example if I go and put a hard [FL] to hold the glass, and I what will happen when the system bends or moves back and front, they break. But, sealant is like a rubber, it is rubberized, so they expand and contract. And as well, they take care of weather you know the seal, they joint, so water, air, cannot pass through.

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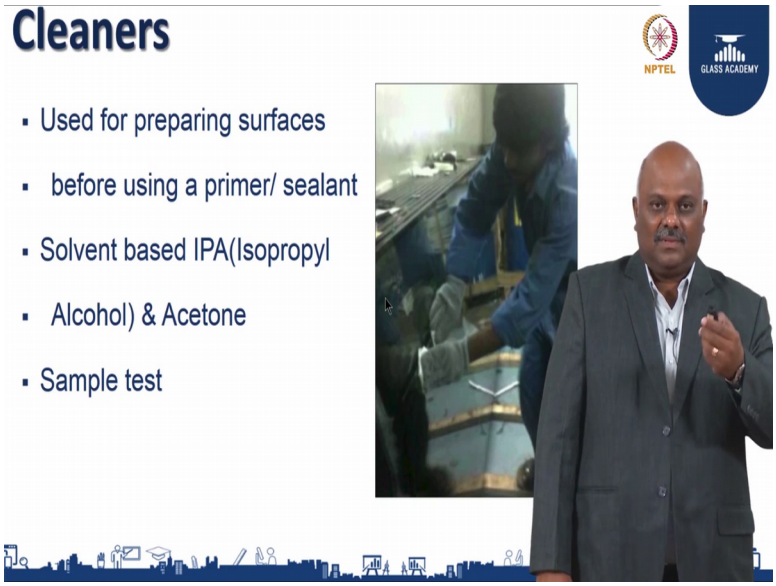

This is application. You know when you are applying the sealant, you know you use a cleaner, you clean the glass, then you lot of things IPA solution, alcohol, acetone. So, use those kind of specified cleaners, to clean your substrate, sorry then only you will be able to do away with the glue. Otherwise, what will happen if you substrate is not clean, then whatever you want attach to we will fail. So, there are specified cleaners available, this is called a surface preparation. Whatever surface you want to prepare to glue your class, you have to do in the recommended way.

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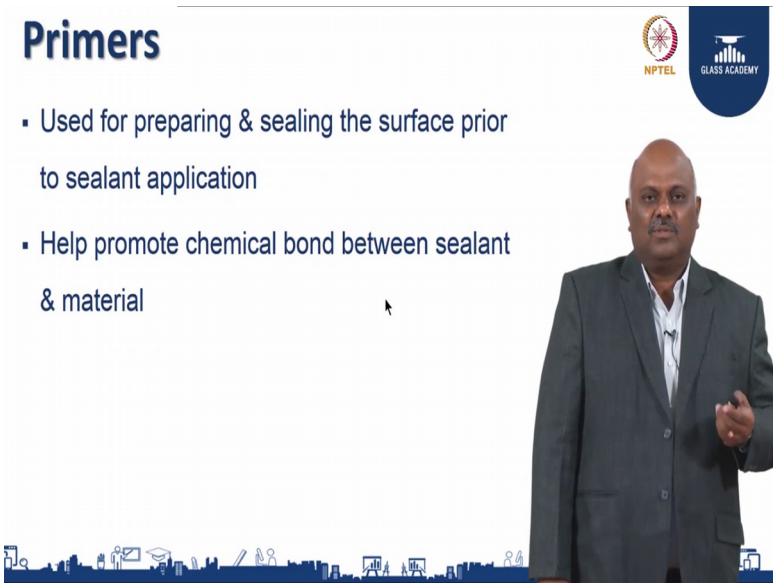

Then of course primer, you know sometime you have to apply primer to create an chemical bonding between the substrate and the material. So, you apply the primer on the substrate, and then you apply the sealant, and then put the glass or any other material. So, what it does you know, it creates a bonding a good bonding, and (Refer Time: 08:53) advisable to use primers that will be covered by sealant manufacturer later. However, these are the principles you know. When you are manufacturing, these are the principles you know you adapt.

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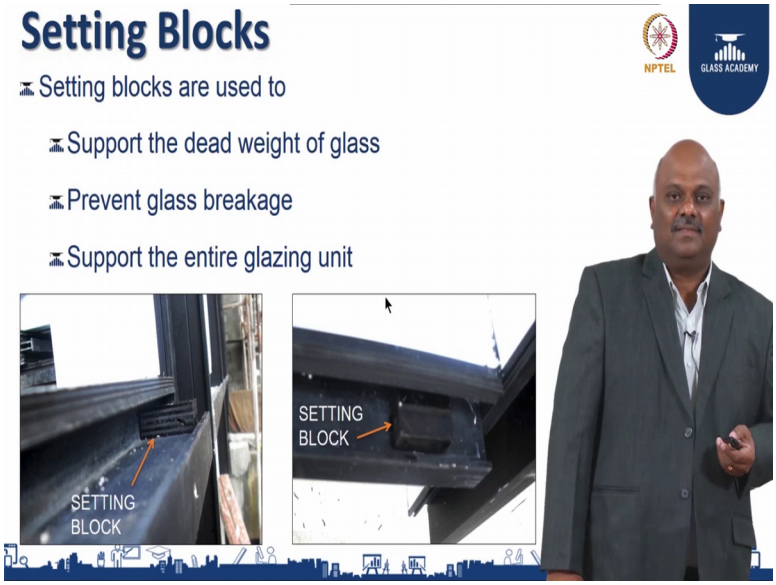

Setting block. Again, this is the form of a rubber done out of VPDM. As I said here the show hardness have to be higher, because dead weight of the glass have to be transferred back to the frames. Say example, I have a glass in the frame, I have to transfer that weight back to the frame, how I do that, so I use a setting blocks. So, setting blocks are kept at one-third or one part of points and at both sides, then you leave the glass, the dead load will sit on to this VPDM.

(Refer Time: 09:36) without this what will happen, you go and rest the glass against a metal directly, they will break. Why, because aluminium goes up and down, they contract, they shrink, and then glass cannot take that. And also they are dissimilar metal and material available; they go through operation as well. So, better you have to is a must use a separator, where it sets rigidly, and you start transferring the load properly into the system.

Otherwise if you start putting without all these things, without setting block if you put a glass what will happen, the load will not be distributed equally, and then things will start cracking or you know whole thing will go for (Refer Time: 10:20). So, setting block design is very critical. And also the hardness, it can be too hard, it can be too soft. It has to be designed with a proper show hardness, so that you know you will be able to take the load.

Backer rod. See again, you know when you start doing any sealant work, you cannot just simply press sealant, it is not properly, it is not viable commercially, plus it will not work, because sealant will take time to cure. So, for sealant, again they have a calculation, which will tell you what is the width and depth ratio. To contain the width and depth, we use a backer rod.

Backer rod is nothing as an a spongy foam, where you know it is a closed cell foam done out of different polymer, which you press inside the join, it just flexible. You press it inside to the required depth, then you start applying the sealant, then only the sealant also will function properly as well as the system (Refer Time: 11:22) properly. So, these are key important things, which involves in your manufacturing process.

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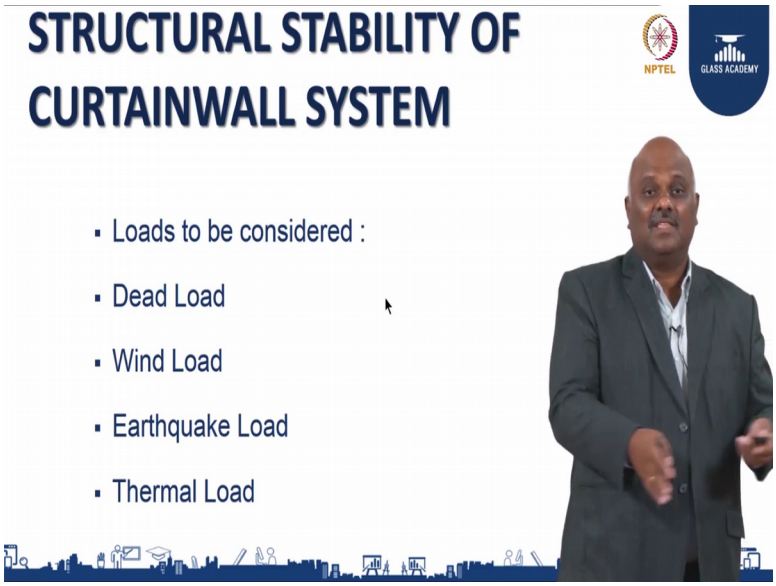

Hope I have covered most of the things very briefly, and very some in detail. Now, how you design a system, what are the key things you consider, and how you put them together, this is what we are going to see in the next few slides. Now, when a design

system, what I should consider, these are some of the loads what you have here, dead load. Dead load is nothing has its own weight. Wind load; of course, the external force, which is acting on to the system. Earthquake load; of course, seismic, you call it. Thermal load; of course, heat is not going to add weight to the system, but thermal load also adds to the expandability of the system. So, without calculating the thermal load, if you go and design to tight a system, then expansion happens, things will start bulging or bearing out. So, these are the key loads you consider, while you design a system.

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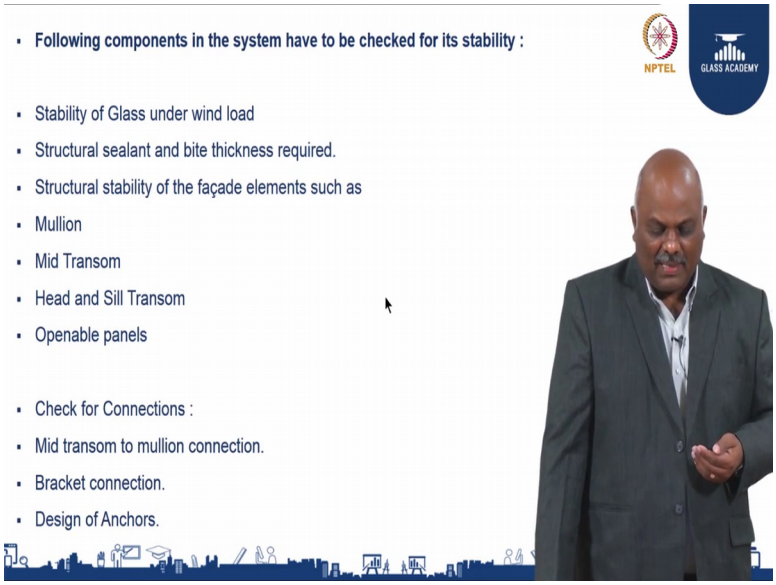

Following component system have to be check for its stability. So, when you say example all these you know giving a example of a unitize system. So, these are the elements, you check them individually. First, what you do, stability of glass under wind load so, you take a glass and you with the size, and then you check. What are the things we check, we will you check against the wind, what happens to the glass, how much of things is bending, where is it within the tolerance, what you call by tolerance ok. There are course of practice, there are lot of course available. But, for India, yes today you know you follow MBC 16, which is in purview today.

So, as per the code, what the code says, what is allowable we call, the glass is been there for the size for this terrene, what is the load apply to, so you calculate it. And if the limit is within the allowable, then your glass is safe plus your factor load. So, your wind load, plus live load, plus your factor all put together, and then allowable. What is allowed, so

you calculate that. If it is within the allowable considering all these load, then your glass is safe; if not, then you change you keep on changing the glass until it is safe, same structural bite and thickness required. We saw this structural sealant, for that also we have a calculation, which is how much as I said you know that double side tape plays a critical role in the sealant size. So, you need to understand the requirement, how that also there is a design derivation for it.

So, you design the joint, and then you go back to the structural system, which is the mullion, your transom, your head, your sill, everything you design, your openable panels as well. So, you design, you check the system, you check then for all the criterias. What are the criterias, we check for connections as well. When you connect two system mullion and transom together, your bolting connection you how the screws are done your bracket connection your anchors. So, it is not just simply, you know every project I take similarity and go.

There is no similarity in projects, every project is unique, every project we have to design, every project we have to check. You cannot say (Refer Time: 14:53) I have done a building a, so I can cut, copy, paste, I can use it. No, it does not work that way. You calculate, you check properly, it can change, it can help, even though they are same, but different places, they cannot be same, different nomenclature the facade you know they logger with the module whatever you call the coursing the module itself. If the (Refer Time: 15:17) calculate, but it is better always every project you check, check all the material, whatever you are putting, you must check as per the course.

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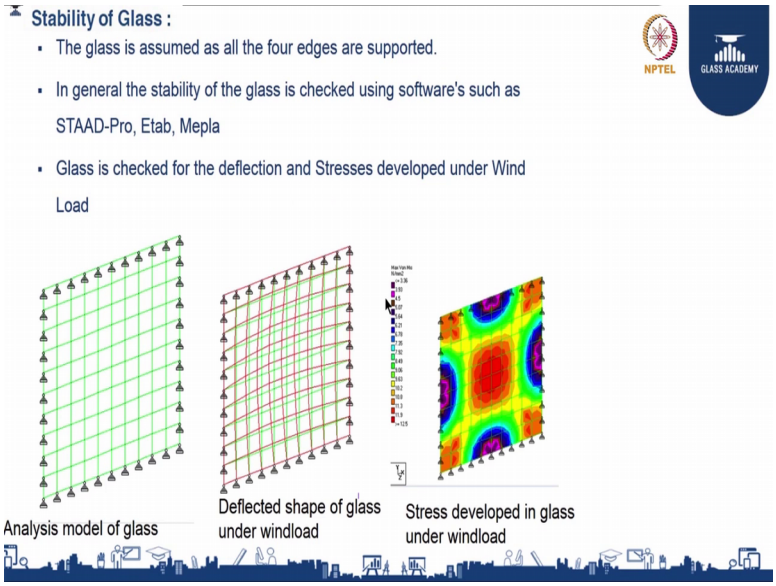

Say what you see here example. The glass here in this calculation, we have taken as a four side supported panel. Yes, you can do two sided, you can do single sided, but I am not going into detail that will be done (Refer Time: 15:42) by my colleagues. Here I am considering a four side supporter system. So, nowadays you have softwares, which are like STADD-Pro, Etab, Mepla and so on so forth. You apply all the loads and criterias in the software, and you check the design.

Like if you see it is four sided, and you see that the images here, they started to tell you how much they bend, and they started giving the minimum and maximum values of wherever (Refer Time: 16:10). And also they gives spots, you know the severe spot, where the bending happens in the red color one is where the maximum is, the green ones are on the safe zone. So, like this you know you get the stress check as well; it is like as you know you do a ECG you know. Similarly, in the software, ECG for glass is done, which gives you a complete detail of the material, before even you can think of designing the system. So, you check the thickness of the glass, size of the class, based on the codes and based on the allowable, then you go to your system design, start looking at them.

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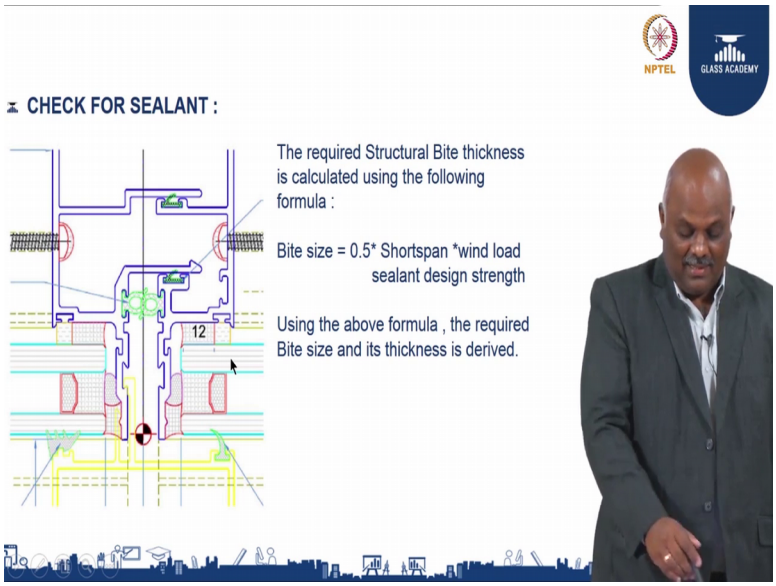

Now, what you see here is the bite. As I said seal and bite here, it shown like 12 millimeter. So, this is a 12 millimeter by 6 millimeter sealant is required all the four sides of the panel to hold this glass in place. So, in this system, if you see detail, this is the weather sealant, it just do protect water and wind, not go through this gap. And this is a glass material, this is the structural sealant. So, you calculate the size of the structural sealant that is the formula, which you like 0.5 times shortspan, which is your width, times wind load, and then the sealant design strength. So, a bite size you calculate based on the calculation done by the engineers and the recommendations by the sealant supplier, then you design this mullion.

Say example I need a 15 millimeter as per the code, then this mullion design will be governed by this. So, you start from your substrate, do not do the reverse. I have a mullion, then I have to should know. You take the module, you talk about the glass, and then say example there is glass (Refer Time: 18:00) your in fume, take that in fume and then design it, then only your system will start to work properly.

Say example I have a fix mullion, and then I want to fix something, it cannot work, then what will happen, you have to reduce your grade, and you do permutation combination to use your systems, so it is not advisable. So, each project you do a calculation to understand the requirement based on the modules based on size of the panels, then you design a system. So, here I will like to highlight that is why your of self solutions

provider are not helpful, sometimes you over do, sometimes you try to factor in that is not right. So, you calculate every project steady deeply, then you take a decision.

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Now, you check the mullion. See you are done the glass, now you bring it back and apply to the mullion, because mullion is the column, which takes should take care of a load. So, you have a female and the male mullion, then you combine it, and you do the analysis. So, you bisect the Aluminium mullions, and then start understanding how they work by simulating it in a complete form.

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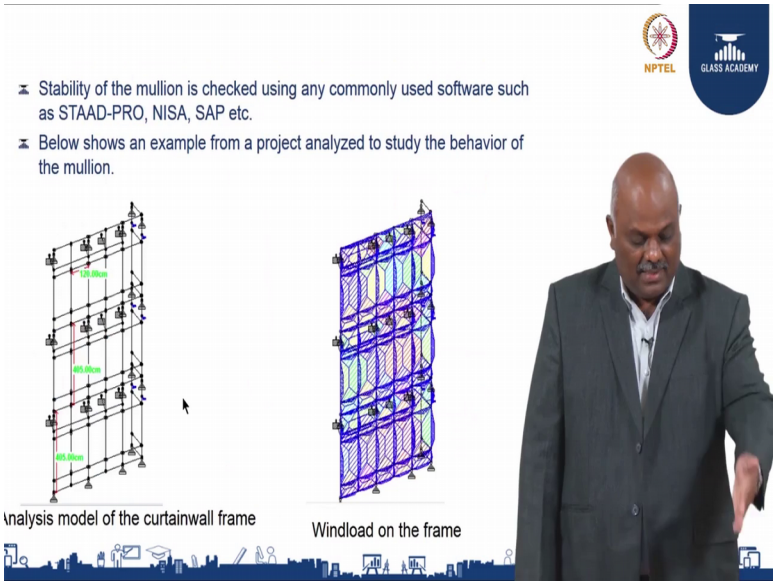

So, you run through STAAD-PRO commonly used software, you build the model completely with all the fact is given, you (Refer Time: 19:23) system, where it is anchored, what is the live load, and you know then you run the system, then you get a complete detail. This is a example shown for a building with floor to floor panels anchored in two places, how they react that is what it is shown here. So, you check the substrate first, check the bite thickness, design your mullion, and then you check your mullion.

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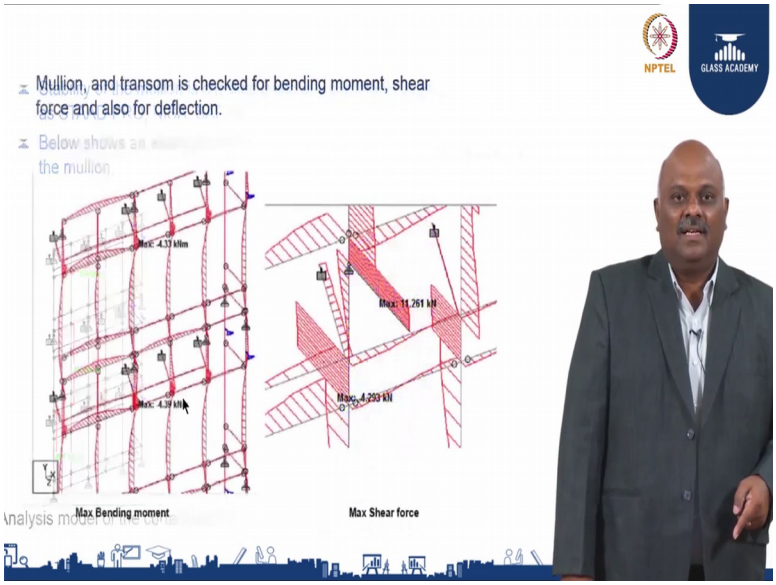

In mullion of course, you know you check it either you know it should go with the factors all the required factors. Most of the time, as you check a mullion facade, and as you know deflection. The mullion deflects more than the allowable, then the whole thing will collapse or you know start to deform. So, understanding the depth against the wind.

And dead load, it is very minimal you know there will be have to you know take that as a consideration, but your main criteria will be against the wind, what is the load, because that factor will be more. Sometimes you know the dead load can be heavier, if you put strong stones or anything but, most of the time, when you design it against the wind. So, you do the glass are the substrate design, first understand the requirement, sealant bite, then you design your mullion and transoms, and then you run your system check.

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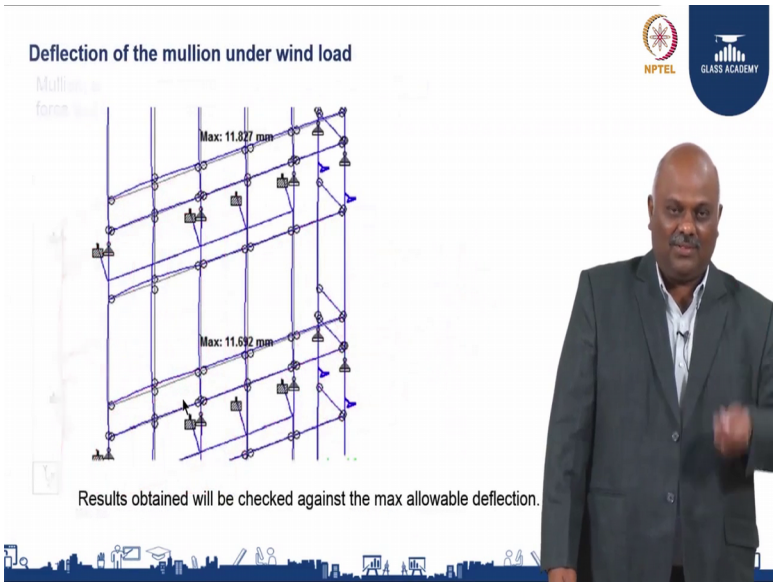

Like if you see in this 11.6 mm or 11.8 mm is shown as allowable, so you have to check this against the span. Say example span by 90s, span by 240s, span is the span of the panel, then we have whatever the allowable as a deflection. Say mullion if they say you know not more than 20 millimeter, so a deflection should not exceed 20 millimeter, it should be design in a way, it should be below 20 millimeter. So, like in this case is a allowable may be like 20 millimeter, but the maximum defection they are getting is 11.8, so hence it is safe.

Considering all the factor loads you know, whatever loads they apply. So, it is like calculating a simple simply supported beam or a column right. So, run through the program you know or even manually also you can do, but people nowadays do not do too much of manual calculation, they always go with the softwares available, this gives you complete detail. So, we start the reverse, the substrate first, then design of mullion following with the transom and other things.

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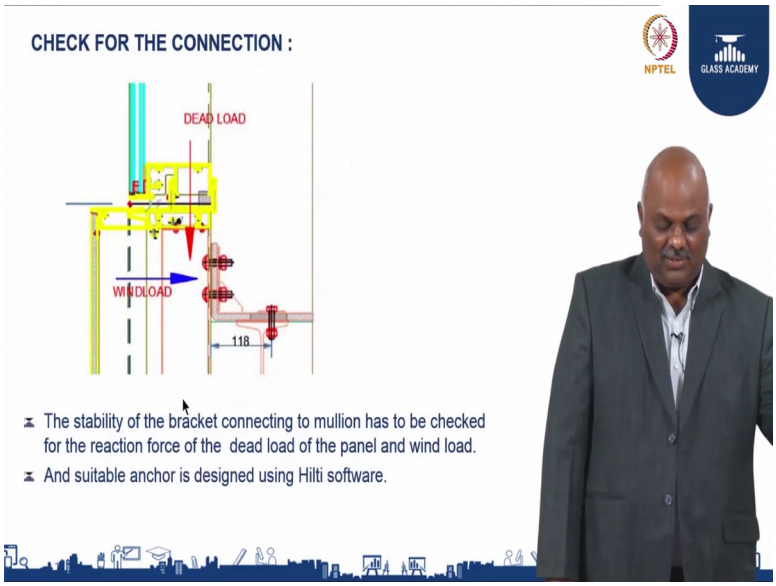

Once you pass through, then you just design your bracket system and anchors. So, what are the bolt sizes you need, and what are the loads it is going to take care of. You can see you know basically what the bracket system what you have should restrain a wind load as well as a dead load. So, like example, these two bolts here they act in shear, but the same time this bracket here, this bolt will go into shear as well and as well as uplift.

So, you have to design and combined the combined forces. Sometimes you know you will see both under tension and compression sometime, so those sort of things have to be studied properly, before you will engaging on design. So, you start with the substrate, then you design your glue thickness, which is the (Refer Time: 22:34) thickness, then you design your mullion, you run through the system. So, complete system will be run through, I mean how to be checked properly in a proper way.

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Yes, now with this, I will like to wrap up, what we have. We can see you know some buildings have (Refer Time: 22:54) here, they start coming with various forms; I just collected this images just to 2 days ago. You start to see different forms of facade they are still alive, you know even this buildings what you see here like 100 years or you know these buildings are available still. I just got this small image of Madras in 1940, and now what is Chennai look like.

These are all metal, you see these are all free form metal, they are stain aluminum panel, these are free from stainless steel panels. So, different forms you know different view, you know like this again you know with (Refer Time: 23:31) on this full with glass whatever we see, we have color glass, so where we are heading, what we want to do.

So, basically we are standing an invention as well as bridging over from the past and whatever we learn, so now we need to understand going into future, how we are going to act upon to design systems and facade, which can take care of the environment, which can take care of a well being. So, this is where the time is spent now. Yes, we have a lot of ideas; we have gone through various phases of transformation.

Now, collectively you have to decide and design systems, which can be good for the environment, as well as our livelihood, as well as our future we should not you know design systems, which are not user friendly, which are not giving comfort rather put more attention towards comfort. Doing too much is not good, too little also not good. So,

be active and choose systems, choose material, which are viable, which are good. And we are seen throughout the presentation, what are the different materials available. The choice is ours, what we want to do, how we want to do is they should we all have to make.

But, on the same breath, do it right. Do it right, not only just simply considering like this is a design it has to fit in the building, but also put more effort to understand, how I am going to build it, who is going to build it, in what form it is going to get done, how safer I can design it quality. So, understanding about facade you know, it can be not just simple like this half-hour or 1 hour or 2 hour briefly, it is too elaborate, however the basic fundamental idea is to understand the facade.

I hope, this brief would I given you some insight about the facade, and how it is being done.