Glass in buildings : Design and Application
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Lecture – 60
Structural Design of Facades

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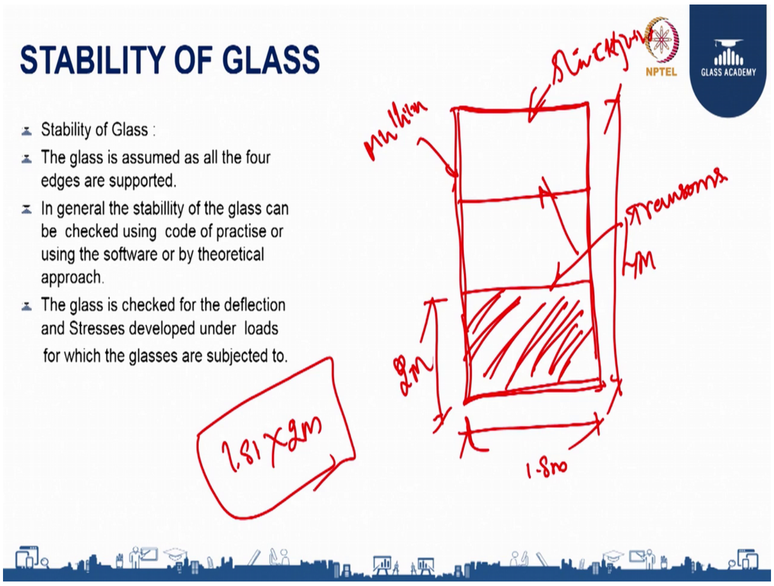

Then let us start with the Design of the Glass. So, in especially in the glass design the panels the unitized is let me clear here that I will be talking about only the unitized system designs. So, the same concept is applicable even for the stick system or the semi unitized system, but the same concept cannot be applied for the point fixed glazing or any other systems. But, here they say that all the following calculations which will be shown or will be shared is applicable for the stick system, semi unitized system or unitized systems. So, let us begin with the stability of the glass, if the floor to floor is 4 meters height.

Let us say it is 4 meter height floor to floor and the panel width is 1.8 meter and we have a transoms here and normally this will be called as the Mullion, this will be the stick joint these will be the transoms. So, if this single glass is about 2 metres the stability of the glass can be used, using the code of practice that is a s t m 1300 or even by the software can be used or even the theoretical approach also can be followed. Especially, this glass is considered as one glass panel, this is the whole unit is one unitized glazing panel, but here this is the one single glass. So, this single glass will be of 1.8 by 2 meters, if we check this using the STAAD pro.

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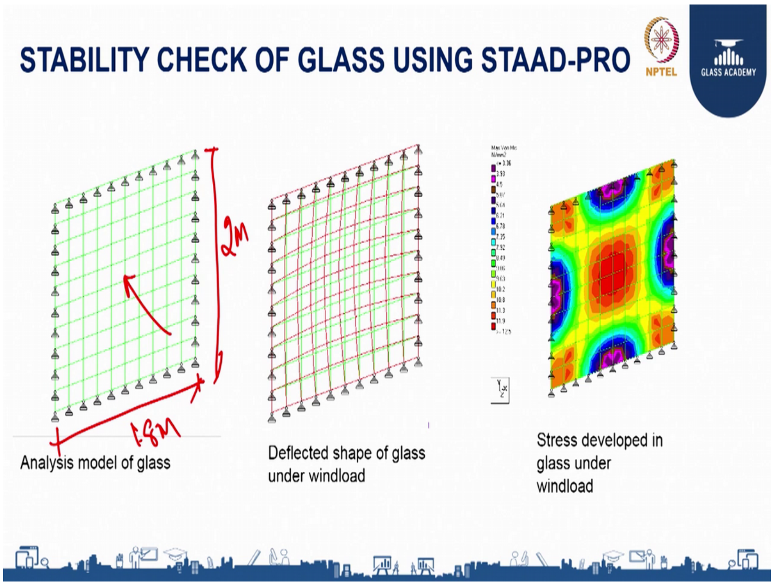

So, the same model can be used it is 1.8 meters and this is the height of the panel and since all the structural sealant will be applied this the all the sides of the glass panel will be supported. So, that is a reason this will be considered as all the four edges are supported and applying the wind load on this the whole glass panel, we can always check the deflected shape of the glass and at the wind load. And if there is any live load acting then we can always apply the live load as a point load and the check the deflection and the stresses also can be checked using the same software any finite element software gives with this results.

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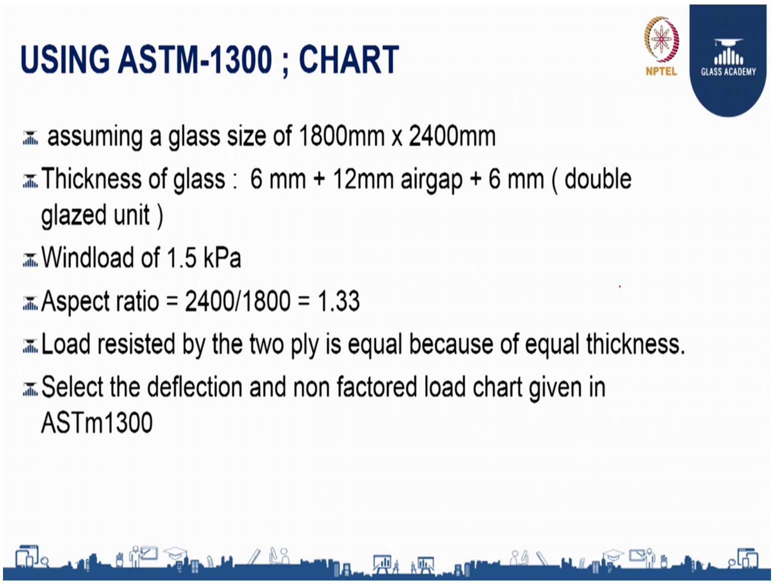

So, using the chart that is the first method and this is the second method if I will be explaining how we can determine the glass thickness or the stability of the glass using the American standard that is A S T M 1300 using the charts given in the code. Assuming the glass size as 1.8 by 2.4 meters and thickness of the glass is 612 and 6 and let us assume as a wind load of 1.5 k P a.

So, this the aspect ratio is the bigger side of the glass size by the smaller size which will be equal to 1.33 and the load resisted by the two place, that is the 6 and 6 m m will be equal because of it is equal thickness. So, the deflection the and the non factored load chart for the 6 m m can be selected and it will be something like this.

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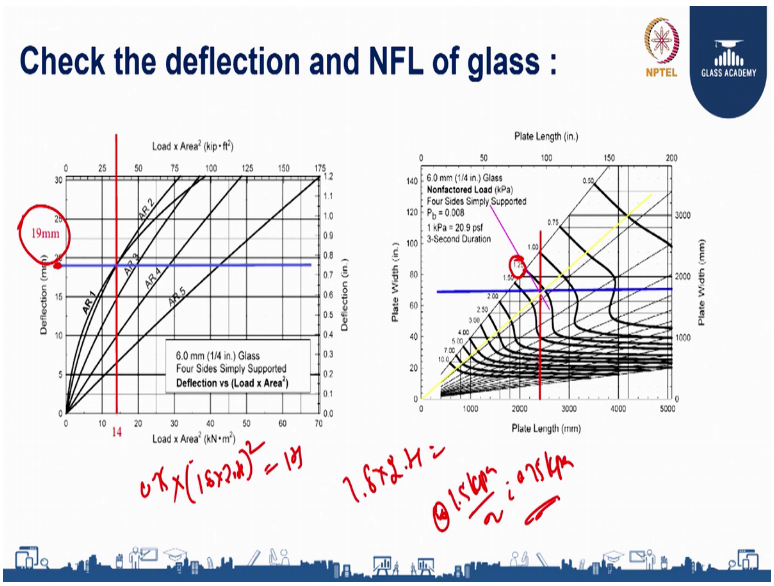

So, this is the load into area square so, where area is your glass area that is 2.4 and 1.8 that is 1.8 into 2.4. So, this will give you the area and the load shared by each glass ply that is 1.5 k p a divided by 2, which will be equal to 0.75 k P a. So, the 0.75 into your 1.8 into 2.4 whole square the value whatever you get will be 14.

So, draw a vertical line on the 14th the on this bar chart and then the same aspect ratio 1 on the curve, where the intercept point is there draw horizontal line. So, the left hand side value whatever will be shown that is the 19 m m is the glass centre deflection. On the same chart for 6 m m thick glass that is your 2.4 meters width draw a vertical line and the width of the panel is 1.8 meters draw a horizontal line, where the two intersect draw a cross line from the 0 of the chart and then draw a perpendicular. So, the line wherever it intersect it is1.25 so, the resistance of the 6 m m glass glass resistance will be the non factored load for 6 m m glass will be 1.25 k P a.

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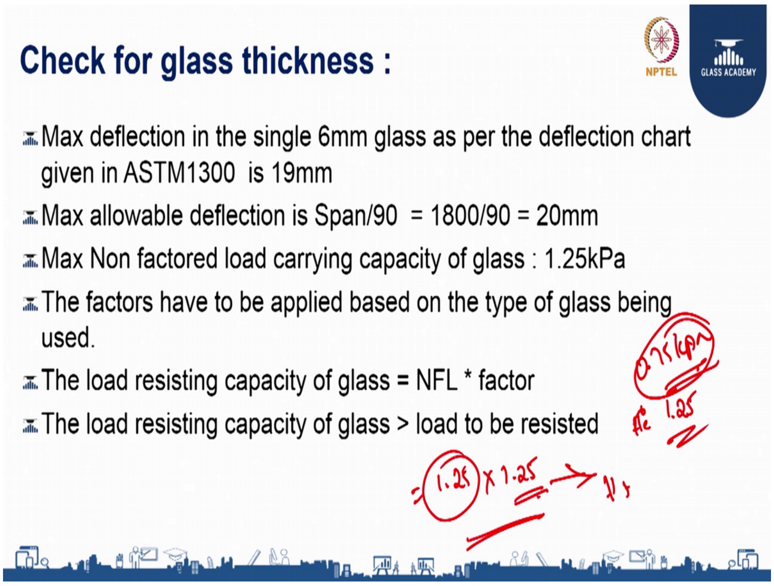

So, depending on the type of glass being used, that is whether the glass is annealed glass or heat strengthened glass or the tempered glass. So, the factors will be given in the A S T M code. So, those factors have to be applied for the non factor load, this is just the non factored load that is the glass resisting capacity. So, for that when once the glass is processed so, that the strength of the glass increases so, those factors we have to consider, let us say if it is heat strengthened glass, it is 1.25. So, the load resisting strength of the glass will be 1.25 into 1.25 that is this N F L we derived from the previous this chart.

So, hence this 1.25 and the factor is 1.25 because of the glass processing, that is the type of glass heat strength and glass. So, this value has to be greater than the load which has to be resisted by the glass, that is in this case this will be 0.75 k P a whatever the value will be derived. So, this value has to be more than the load generated. So, hence we can define if the glass satisfy all these that is the deflection criteria, the stress criteria or the load resisting criteria. So, we can assume or we can tell that the glass specified or the glass being used is safe for the module and also for the wind load generated.

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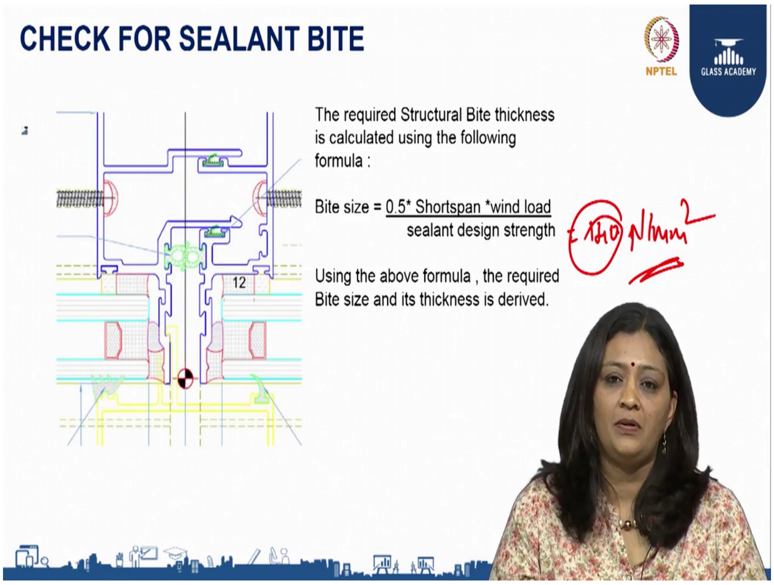

Next let us go to the Sealant Site requirement. So, the sealant bite thickness which can be calculated by using the following formula that is 0.5 times the short span into the wind load divided by sealant design strength. So, the sealant design strength is this is the standard that is 140, that is N per m m square. So, using this formula we will get the bite size required for the panel required for the panel, which is customised or which varies as per the project to project.

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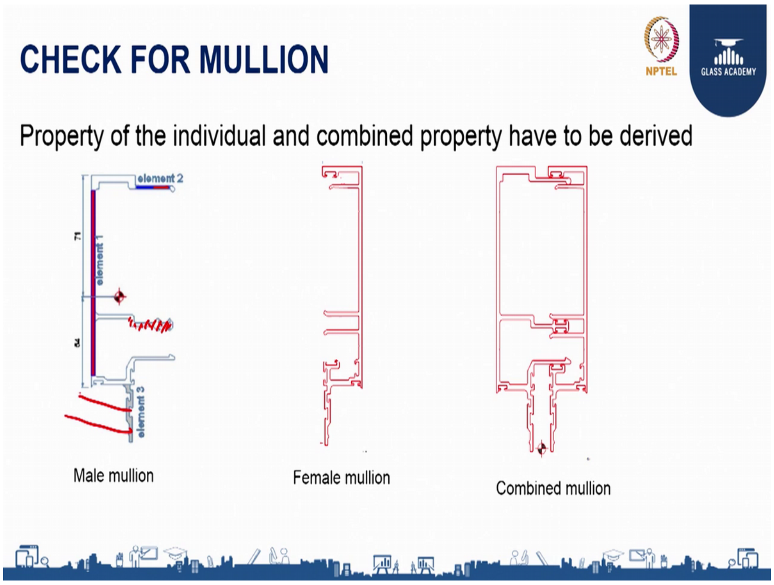

So, let us go to mullion design in this case in the unitized panels there are two components that is the male mullion and the female mullion. So, these two mullions are combined together to form as a single mullion.

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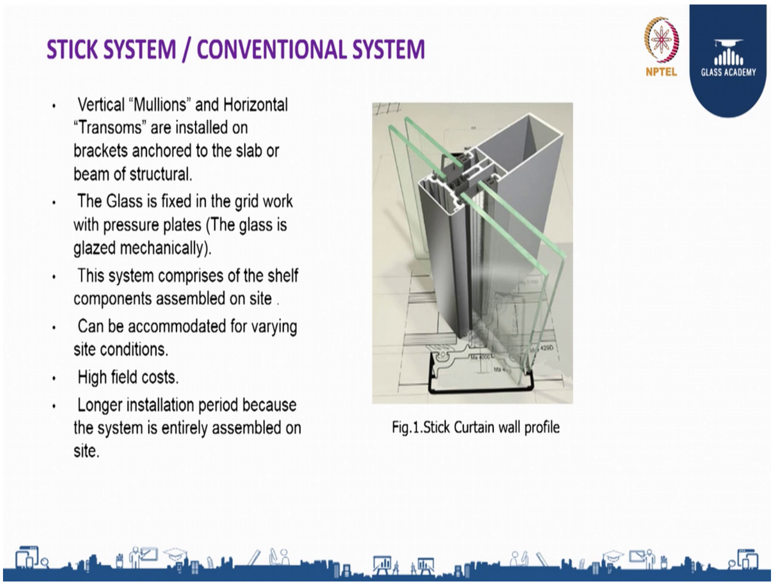

But, whereas, in the stick system if you see; the stick system will have a closed profile as shown here that is it is a single profile.

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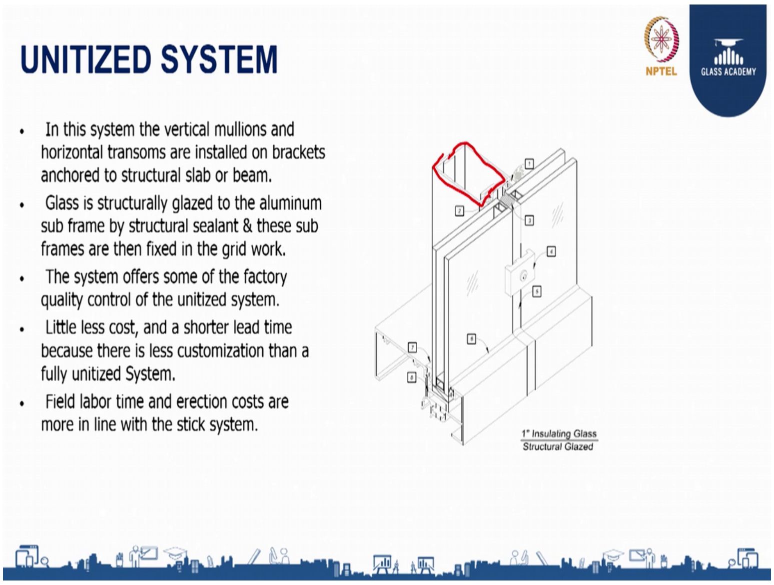

But, where as in the unitized system it will be two different profiles, that is this is one profile and this is the second profile which will be coupled together to form a the single rectangle mullion. The first thing what we have to check is since these are the open sections, we have to check the element 1 that is this wall and the element the 2 that is the load being transferred onto this element and also the load 3 that is the element 3 that is if here the glass will be held here. So, that is why we have to check these are the main checks and also along with that if the profile has the inner arm also even this arm also.

The length and thickness whether it is required or whether what is used is safe under buckling or is it safe to transfer the load, that is the first check what it has to be done. The same the checks are applicable even for the female mullion and the both are then checked as a combined mullion.

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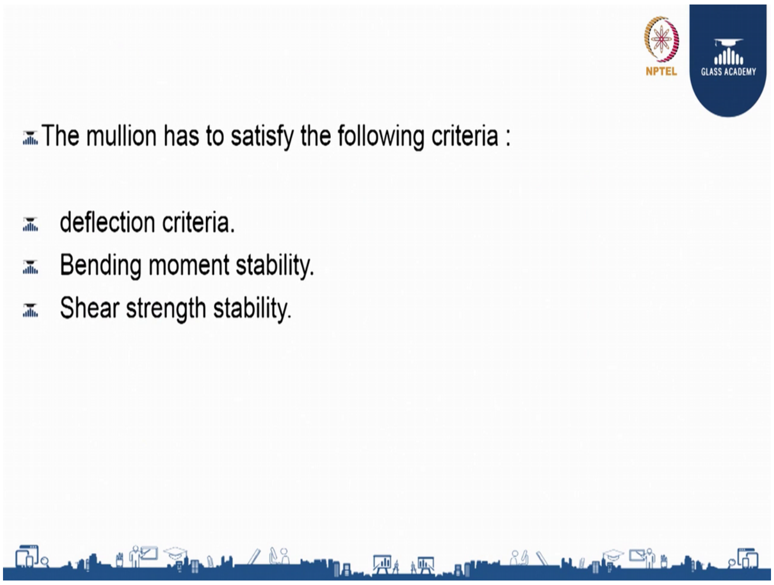

So, when it comes to the checking or the structural stability of the mullion. So, the first combined mullion will be checked for the deflection criteria and the bending moment stability and the shear force is it safe to carry the shear force. Individually both the male mullion female mullion have to be checked whether, individually whatever the load been transferred onto the mullion and that is the male mullion and the female mullion based on their distribution factors based on their inertia.

We have to check individually the male mullion and the female mullion whether they are safe to carry the loads. And after that the combined mullion has to be checked for the combined load transfer also, that is your moment and the shear forces combined we have to check all the three factors.

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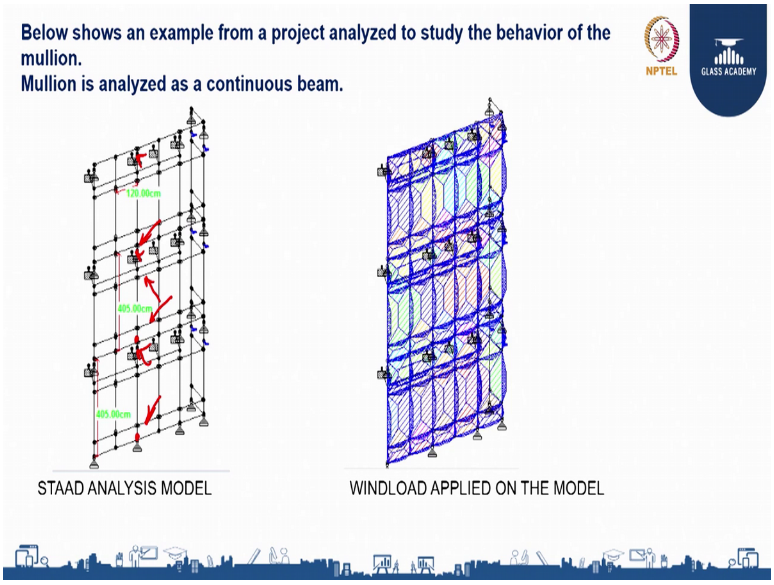

This is just a case study where in it has been where in the STAAD pro or a finite element analysis was used to analyse the stability of the mullion. Where in the panels was 1. 2 meters actually the panels was 2.4 meters we have a dummy mullion here, let us not get into that, but the panel is let us assume the panel is 1.2 metres by 4.0 metres height.

So, this panel has a dead load bracket here and these are the transoms this is the stick joint and this is the transom these are the stick joints and this is the dead load and the wind load brackets for the panels. So, the same the three panels have been modelled using the STAAD as per the actual and then the wind load has been applied perpendicular to the facades or the elements.

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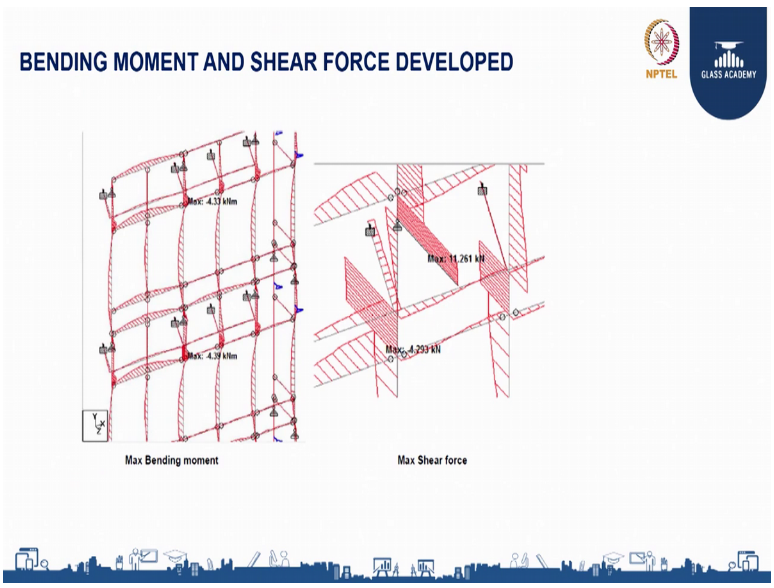

Then the bending moment and shear force has been taken from the software, that is after the application of the wind load, the dead load of the glasses and if any live load is acting on the facade.

As per the specification requirements the maximum bending moment developed has been taken derived here and which is always directly given from the software and also the shear force developed is also given by the software. So, we have to check the moment that is the bending moment developed and the shear force developed for in the mullion that is the bending moment will be resisted by the mullions. So, the same we have to do the checking for all the deflection, the bending moment and the shear strength stability have to be checked and then after that if all the individually we have to check the male mullion stability and female mullion stability and combined mullion and then for the combined loads we have to check.

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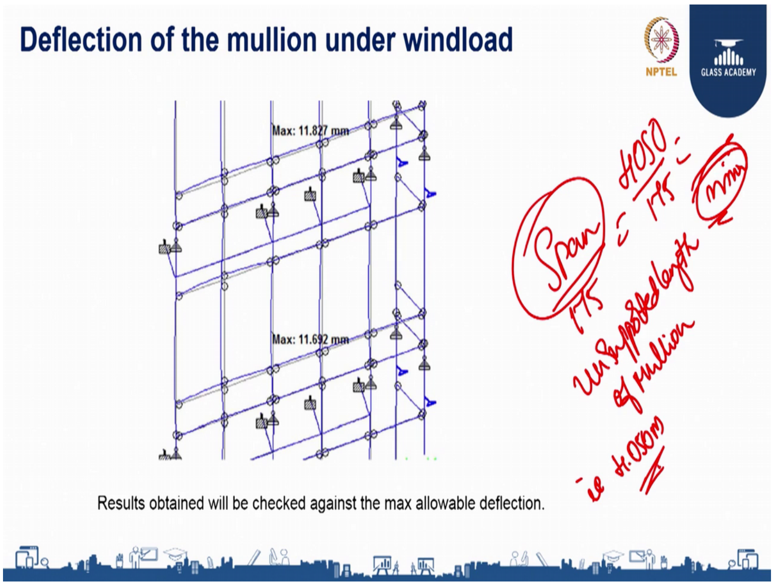

So, once all these satisfies we can always tell that the mullion is safe against the wind load or the loads being transferred, how we can derive the deflections or how we can say that the profiles, which are being used is structurally safe. So, the results have to be compared and as per I as per I S 8147, the deflection in the structural glazing or in the unitized panels is considered as span by 175 where the span indicates as the unsupported length of the mullion.

That is in this case we have the bracket at every floor height that is at 4050 meters. So, the span will be considered as 4050 by 175 whatever it gives the value in m m that is the maximum allowable deflection in the mullion. So, the deflection in the mullion has to be limited because, has to be within the value specified as per the code. The deflection cannot exceed or should not exceed even though if the deflection exceeds the span by 175, but it should not be too high because it directly depend the on the it will have an effect on the glass also.

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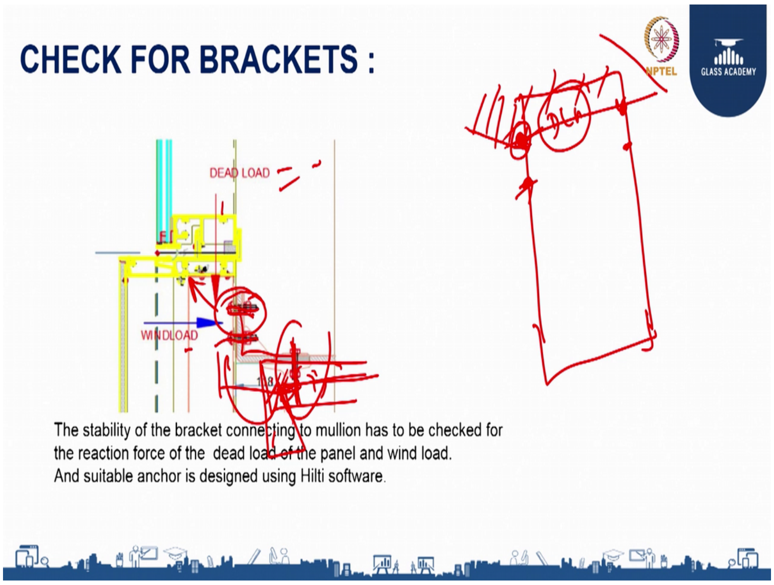

Next let us see the design of the main supporting structure or the brackets design, which will hold the panels the stability of the bracket connecting to the mullion is has to be checked for the dead load and the wind load. So, when the panel is the unitized panel will always be hanged from the top, it is this will be the dead load brackets. If you have any brackets here that will be completely the wind load, wind load brackets, which will only resists the wind load, but mainly especially the dead loads will be carried only at the top that is at the slab level the slab or beam whatever the main supporting structure level the dead load brackets will be provided.

So, this bracket has to be checked for both the reactions that is the dead load and the wind load and these will be the completely dead load of one panel which depends on the type of glass, the thickness of the glass and the profiles used. We have to always calculate the dead load of the complete one panel and then the wind load.

So, the supporting structure can be any the steel or slab or beam it can be anything. So, based on that brackets will be provided the brackets will be anchored onto the slab or the beam and in turn the bracket will be connected at site to the mullion through bolting. So, these bolts have to be checked for the resultant force developed by the dead load and the wind load and the bolt grade have to be specified and also the eccentricity develops a moment on to the anchor.

So, the moment has to be considered and has to be derived and the what is the required anchor to resist the dead load, wind load and also the moment caused by the dead load and also the wind load due to the eccentricity which has to be checked. So, normally the anchors in general practice the Hilti, there are many brands which can be used such as commonly used will be Hilti or Fisher or Mongo there are many types of anchors. So, we can use and all these anchors softwares they provide the softwares to calculate the stability of the anchors and we can always use those.

So, based on the edge distance criteria and all those things if we input then and the reactions so, the feasible anchor which has to be used for that project for those panels, who are depending on the wind load specified. So, the anchors can be calculated ok.

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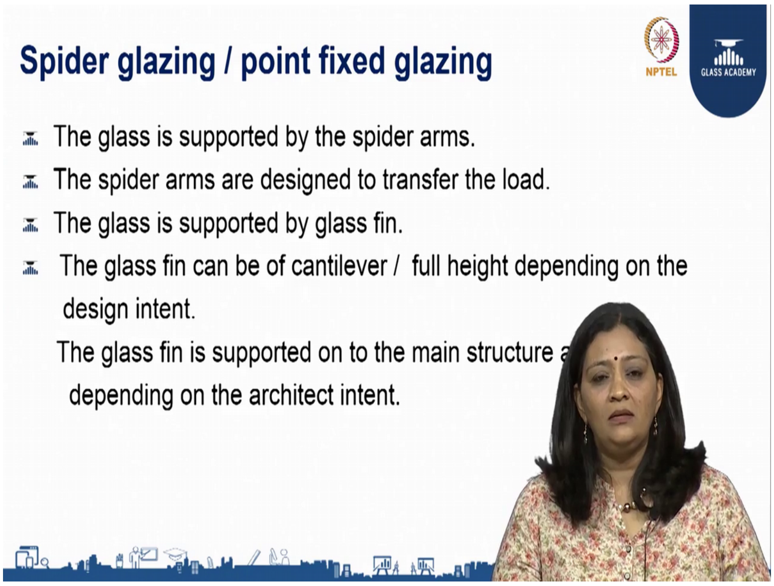

Let us go so, with the Spider glazing or the point fixed glazing. So, the glass is in this system the glass is supported by the spider arms, where the spider arms are designed to transfer the loads. So, these spider arms especially will be supplied from the suppliers or we have to design, what is the kind of spiders is required based on the glass panels, the wind load, the span and all these are the designing factors for the spider arms.

So, these spider arms are in turn supported in the glass fin. So, the glass fin can be of half length glass fin that is as it behaves as a cantilever beam or it can also be as a full height depending on the design intent or the opening in the building where the spider glazing is proposed. So, the glass fin will be generally supported on to the main structure and the glass fin will be hanged from top it will not be support it will be supported at the bottom, but it has to have the moment in the at the bottom.

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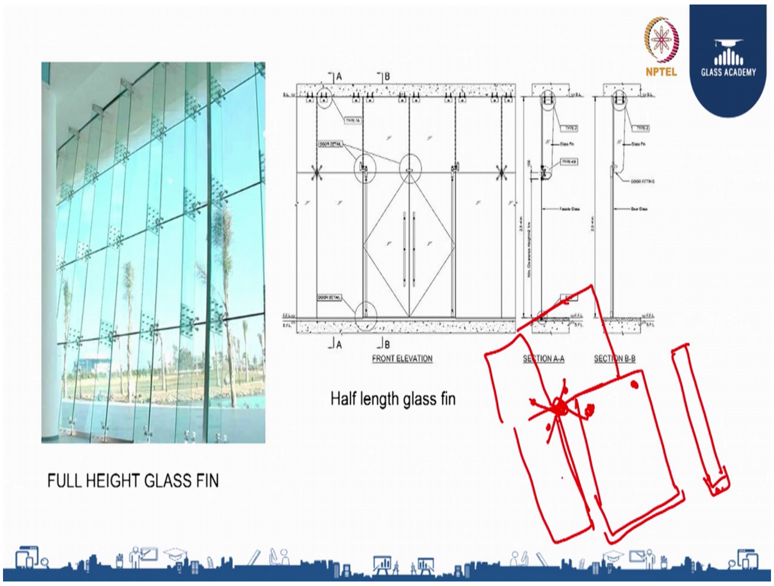

So, this shows the full height of the glass fin, this is the glass fin full height of the glass fin and this glass fin since the glass fin comes only for a span of 6 meters. So, this glass fin is connected with a splice connection. So, this in this glass fin is approximately 12 around 20 metres. So, which has two splice connection and this is the glass bottom glass, the bottom glass will be normally supported by the u channel.

So, the bottom glass will be will be supported by the u channel, that is this is the glass which will be supported by the u channel which will have the movement. And the glass the spider arm will be fixed here; the next panel will have the same arm. So, one spider will have will be holding the four glasses so; that means, each one spider will have to carry the dead load and also the wind load being transferred from one single full panel.

So, this is one more example, where in the glass fin is half length. So, this is the half cantilever glass fin where it spans only until here, the glass fin is supported at the top and this glass span is supported through the spider arm and it is supported at the bottom the u channel.

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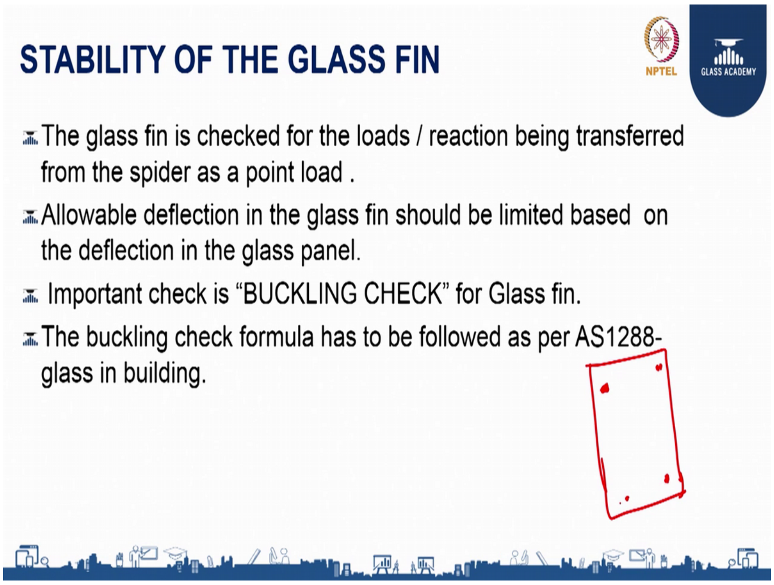

So, the stability of the glass can be used as I said in the previous methods, that is using any finite element softwares. So, in the finite element software the glass panel can be modelled like this and it with the whole and these points have to be supported and do the plate analysis. So, which gives the a result of the deflection and also the stresses developed in the glass under the wind load and also the dead load.

So, the allowable deflection these reactions which are developed have to be transferred onto the glass fin again and then the glass fin has to be checked for the deflection and also the other stresses developed in the glass fin. So, the very important or the critical check for the glass fin will be the buckling check. So, the since this is a plate element and it is very fragile and also the glass fin is a very you know the thickness is less and also the depth of the glass fin will be the load being transferred onto the glass fin will be quiet critical.

So, it tends to buckle so, that is why the buckling check for the glass fin is very important. So, the buckling check formula has to be followed as per the American as per the Australian standard it is A S 1288 glass in the building. If what will be the deflection of the glass fin when the horizontal that is the when the buckling length is reduced that is by providing a horizontal glass fin or if there is no horizontal connection at all between the two adjacent glass fins, then what is the buckling strength of the moment carrying capacity of the glass fin. This can be derived based on the or the formula given in the Australian standard 1288.

Here, you all might think that, why suddenly we are switching from Indian standard to Australian standard. So, the since the Indian standard is the Indian code of practice is in is dated back in 1976 and still the up gradation of the code is going on and the Indian code for glass first of all is not very clear and it has to and there is no specification has been specified especially for the glass fins check. So, hence this has to be followed as per the Australian standard A S 1288, which is worldwide which is a common worldwide practice. And thank you all for this presentation and you can always contact me through the glass academy if for any further questions.

Thanks.

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