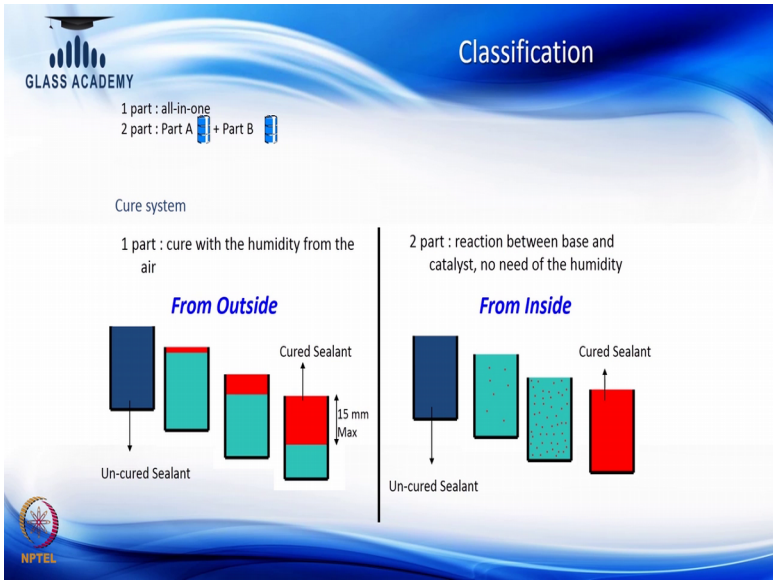
Glass in Buildings: Design and Application
Prof. Ravishankar
Department of Civil Engineering
Indian Institute of Technology, Madras

Lecture - 62
Silicone for Structural Glazing

And, coming into the classification so, we saw the ingredient part.

(Refer Slide Time: 00:22)



So, this sealant is converted in 2 different classified products. So, one is called as 1 part and other is called as 2 part. So, the 1 part is a ready mix you might have seen in the market a 300 ml cartridge or a 600 ml sausage pouch. So, that is a ready mix material.

So, if you see a carpenter or a window sealer coming to our house or somebody sealing your kitchen or somebody coming to your bathroom and doing some joint applications with sealant, you would have seen them coming with a small plastic cartridge under dispensing equipment. So, this is like a small dispenser. So, this is called as an 1 part.

The formulation the ingredients what we saw before, everything is being bundled and put inside the cartridge. So, while packing it is pin packed in certain atmosphere and where it does not trigger any reaction to happen within that particular tube. So, once you open cut it and then apply this reacts with the moisture in the air and start secure.

So, this way the product you know starts curing where reacting some moisture in the air. So, when the moisture enters through the sealant after application, then there is a initial cure which happens on the area, which is in contact with the air. And, you can see the paste form of the silicone is getting converted into a rubber form ok.

So, then the moisture penetrates slightly through, slightly through then you can see that the rubber component becomes more and more deeper so, but with a with a single component the constraint is if you have only and one side exposed cure to the air where the moisture can penetrate. The maximum depth what can what you can do with single part is 15 millimeters.

So, beyond 15 millimeters the reaction will be very very slow. So, you would not get a fully cured sealant to give you the desired from mechanical or the physical properties. So, this can be changed by having a dual you know air for systems by using an open cell spacer or an open cell baker rod. So, where then there can be allowed to pass through from both the ends and then the depth can be increased.

But, essentially for a single seal with a one sided open ended applications like what we do in the weather seals the maximum depth waters you know been can be cured as only 15 millimeters. So, and this cure rate takes time. So, the time it takes to cure 15 millimeter is general thumb rule is 2 weeks' time. So, a 1 millimetre per day is a general thumb rule for joints which are done beyond 10 millimeters, but if you really look at you know in the applications we do not do except on some of the structural joint applications 15 millimeter.

So, what is important to understand is by feeling more and more sealant into a joint for a wider depth using a single point single part; you are essentially not achieving anything beyond 15 millimeters ok. Whereas, this particular limitation or what we call it as the constrain is completely not there for the 2 part. The 2 part it does not require the moisture to you know react and cure it is an automatically, when the 2 components of the sealant like part A and part B they are mixed together. So, there is a catalytic reaction which happens and then the sealant cures only the by-products catalyst. Even on a single exposed joint obligations you can go to a depth of 30 or 40 millimeters and essentially that cures in say 24 to 48 hours time.

So, the rate of cure for the 2 part is much faster than the 1 part. So, that is the only difference between these 2. So, for a project which are of large scale and where you do not have a space to keep the panels for cure. And you want to move them out faster in day or 2. Then 2 part is one of the you know preferred product used by most of the high end and you know fabricators or the facade manufacturers, because they want the panels which are done today to be dispatched or you know ready for instruction tomorrow.

So, this can be easily achieved by using 2 part, other than essentially between 1 part and 2 part there is no change in terms of design. So, it can also happen that the broken glasses in an unitized system on a facade needs to be fixed using 1 part, because sometimes 2 part is not possible to be you know applied or done though there are some new products, which have been introduced by some of the manufacturers have come in to do that, but essentially if you look at most of the times. So, 1 part is always used for those applications where, you cannot move the pump to the site or do some applications with 2 part.

So, the design in terms of the load or the capability for both is different only the cure rates are different. So, now, we are going to essentially look at one of the application called structural glazing.

(Refer Slide Time: 05:25)

So, what is structural glazing? It is the method of retaining glass to the frame using silicone on all 4 sides. So, any load coming on to the glass is transferred to the frame

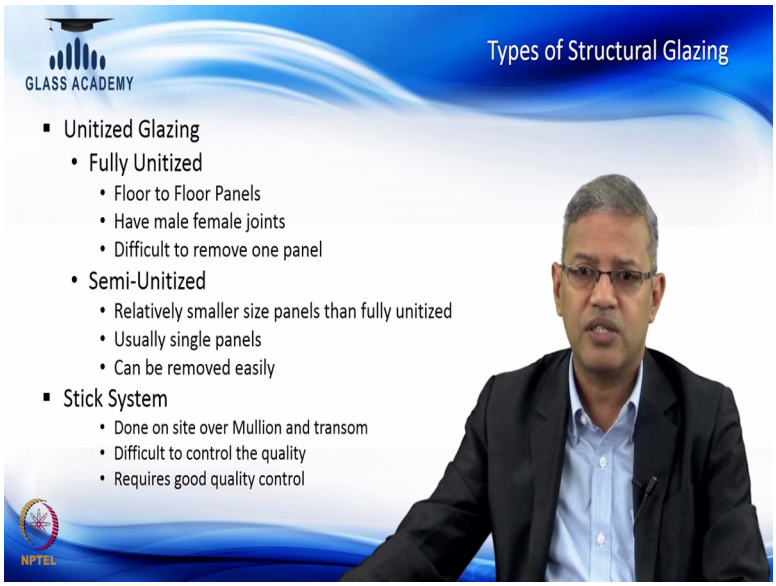
through the silicon. So, we are going to talk about this in detail and essentially if you look at a picture like this like a building, where in the areas where you can clearly see this is the area where, we are talk going to talk about the facades is the structural glazing part. So, this is a curtain wall. So, in India probably still some when I say curtain wall most of the people might think that this is a mechanically fixed system.

So, what is interesting to understand is the glass can be fixed to the building in different ways. The way we are talking about here is using a silicone sealant to burn the glass with a frame. So, this is one of the very proven technology very energy efficient you know method, and it has to go through a series of quality check for doing the application. So, which we will you know which I will take you through.

So, other than that silicone can be used for various other applications, it can be used for fixing solid materials like composite panel or high pressure laminate or thin stones. It can be also used for you know elastomeric coatings can be given on the rear facades, where you want a good excellent waterproofing to be you know part of the facade. So, it was also we have got insulation blankets, which are very very thin amount of insulation blanket we can achieve very high insulation.

And, also what is also essentially understand is there are some new technologies coming up which can give you a clear crystal clear method of bonding a glass to the frame or in a fin or could be in weather seal or on the point fixing, where there are essentially a clear technologies, which are coming into picture, where you can avoid drilling a hole in the glass in the some sometimes in the facade.

(Refer Slide Time: 07:24)



So, on the essentially coming back to the structural glazing part the way the silicone is applied on a facade today is characterized into you know classified into 2 types; one is called fully unitized system and semi unitized system. So, the fully unitized system is normally these frames are floor to floor in height or could be you know different dimensions where multiple panels can be put in one frame.

So, they take the frame in the horizontal direction put the glass in a double sided tape to hold it in place and apply silicone around the perimeter. And, then allow there to cure and after it has cured this frame is moved to the side and fixed. So, this is called as fully unitized system. And, essentially these are done in a factory atmosphere, where there is a clean and dust free room is maintained with temperature control and the advantage is you do not see any grid work done on the building except the fastness part. And, this gets clamped onto the fastness and then you know there is a male female join which are again fixed onto the building and you can do the you know the completion very fast.

So, you need a capability to do a fully unitized system at factory and you also need a good capability to handle these large units, which are much heavier to the site and fix them. So, but this is essentially available in India there are many top class facade manufacturers today, who have successfully doing many projects using fully unitized system. The second system which is also predominantly common and used in India is

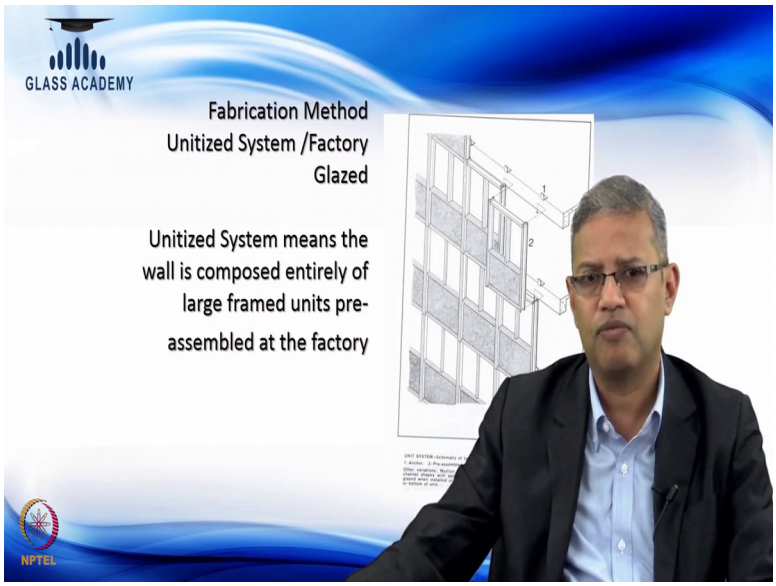
semi unitized system not only in India, these are the 2 systems which are being used worldwide is you know fully unitized and semi unitized system.

The semi unitized system will find a grid work in the building. So, which is we already put on the building. And, essentially there will be a sub frame in the factory and individual glasses will be bonded to each and every sub-frame. This sub-frame will be then fixed to the mainframe. So, again it is not only glass you can use different materials to bond silicone to the frame. And, this subframe can be then moved to the side and fix to the mainframe and you get a externally what you see is a clean good facade. And, also there is one more system which is being also used for some of the applications essentially on a fin you know total vision system, or a fin system, or a 2 sided captive systems, it is a stick.

So, again in the glass will be mechanically held by other systems and the silicone will be used to bond either 2 sides. And, this is again lot of quality control needs to be done, because when we are going to apply silicone at side you know the side conditions, where the side conditions are not always dust free, or not clean, or it is not essentially you know maintain with the temperature is hot humid dust. So, we need to ensure that the proper cleaning is done before the sealant is applied. And, the sealant is applied properly with the right temperatures and also the quality chicks of these needs to be done.

So, this needs lot of quality control. So, essentially somebody is doing a 4 sided fixing for a broken glass again it requires a vigilant mechanism to monitor. So, it is not generally advisable to do this as a system for a whole project, if your broken glass is here and there where we can access it is a quality control, then this is one of the methods which has been followed today for bonding the glass, but not for the complete project ok.

(Refer Slide Time: 10:42)

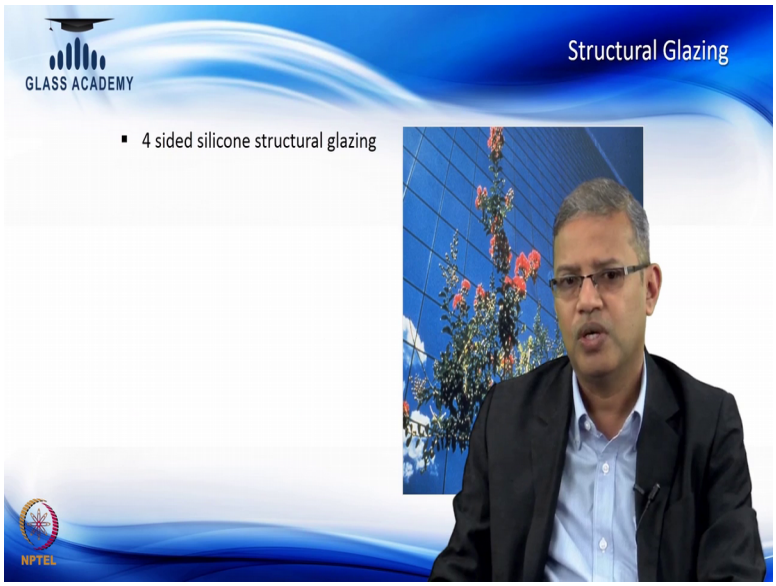


So, this is showing you the picture on the fully unitized system, you can see there is a larger frame with multiple parallels in one frame ok. It is fully unitized and this is semi unitized where in there is a single subframe. Where the glass is bonded and this is then fixed with the main frame using mechanical plates because the glass has bonded with the subframe using silicone sealants.

So, the case histories what it has been shown here or all the projects, which are done with a fully unitized system and you can also still see some of the systems have a 2 sided mechanical capping, because of the requirement and an architectural feature or sometimes they are also designed to take the loads. So, what is essentially a critical to understand here is, you can also see these are the projects which are like the world's tallest towers standing today; which are the it is the finished structure Burj Khalifa has been done with such a system, and also the top wave type a 101, which has got lot of earthquakes and tycoons or typhoons.

So, and also you can see the climate like Malaysia, which is similar to what we have in Indian coastal climates again the Burj Al Arab. So, these are all the cases which have been standing tall for 10 20 15 years you know and then these are proven that the technology what has been used or the product is really working.

(Refer Slide Time: 11:58)

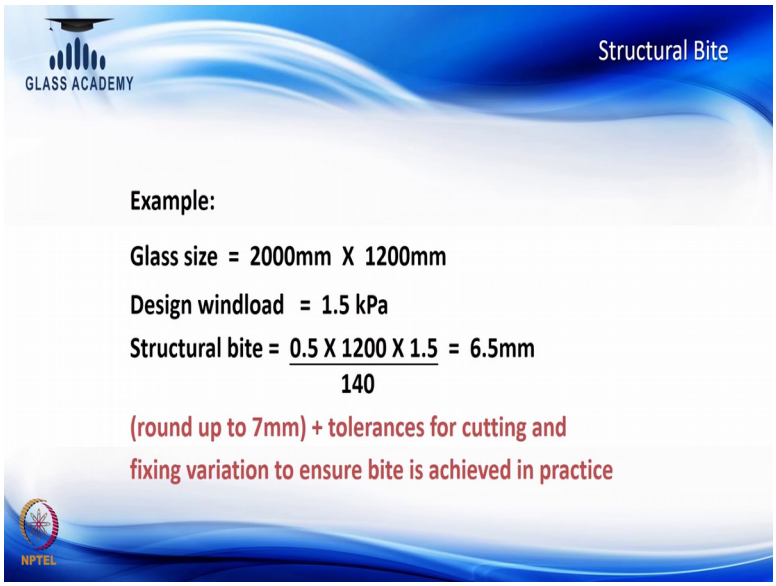


So, what is the difference you saw from the previous picture to this picture is here you do not see any mechanical fixing or an aluminium, which is holding the capping, which is holding the glass from outside. So, what does it essentially mean is all 4 sides of the glass is bonded using silicone sealant. You can get a completely clean facade by using this technology. So, you do not need to have an additional mechanical feature to hold them.

So, you can you have what you have to do is we need to design. And, then apply and then install. So, what is possible is these are the new trends and you can see in India many many many projects, which have been done using this technology in last 15 20 years. So, I want to quickly take you through one of the important slide on this particular application is a dissection of an structural joint.

So, this is the glass and this an aluminium. So, the glass is bonded using silicone, which is applied behind the glass. So, this is called a structural silicone and this is what we have been talking about so far. So, any load coming onto this glass is transferred through this silicone to the frame. So, the contact width between glass of the frame is called as structural bite.

(Refer Slide Time: 13:19)



So, this needs to be calculated and this is calculated based on a formula which is again designed on a rigid plate blending theory. So, how you when you bend the rigid plate. So, what does the trapezoidal distribution of stress coming out so, based on that the formula has been developed for this technology and this is proving out to be the successful formula for last 45 years.

The thickness of this particular silicone is called as glue line. Function of the glue line is want to gun the silicone into this joint and second when there is a thermal moment happening between the glass and aluminium, this glue line accommodates that thermal movement ok. So, this takes the load and this takes the movement. And, what is that you see here is also a spacer tape. So, the function of the spacer tape is to provide the gap and also the keep the glass in place till the sealant cures, you might have seen in many applications where there is a single glass being used and there is a double sided tape has been applied. So, essentially you can see that the adhesive would leave the glass in no time ok.

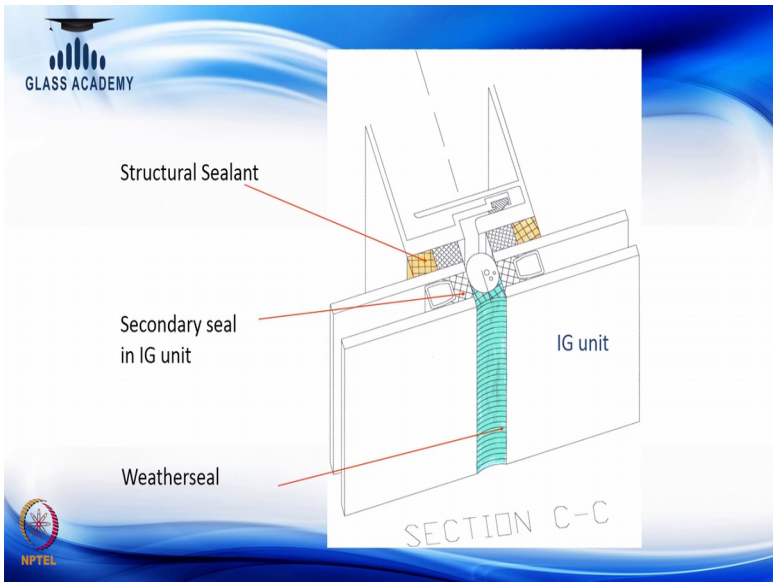
So, what is holding the glass permanently to the frame is silicone. So, we need to understand this is the product which is going to be holding that for the long term. So, this you may not see from outside because nowadays people use performance glasses, people also use double glasses. So, what we generally see from outside is the weather silicone. Again, there is a minimum joint design required for weather seal in terms of the width

and depth and this is what is you know really providing against a watertight seal ok. So, the essential components what you see it is glass aluminum whereas, there are 2 types of silicone is being shown here. This is called as split joint design, where the silicone has applied from inside there is a spacer and somebody also can use a baker rod here and this is the weather silicone.

So, this is the formula I was talking to you about how we have derived at the formula for determining the structural bite is by you know doing a stress distribution theory using the trapezoidal you know a way. So, here the maximum stress you can see how it is happening around the you know 50 percent of the short side and somewhere here on the long sides. So, the formula comes by multiplying the 0.5 into short side into wind load, which is in the kilo Pascal divided by the sealant design load. In most of the cases we this you know the point phi and sealant design load is almost common, depending upon the glass size and the wind load the you can essentially determine the structural bite.

So, the concept is same for a single and double glass. So, in case of a double glass if this is a double glass which is made from the glass purchases factory, the structural silicone is applied behind the glass ok, inboard glass. So, this is a fixed unit where you can see the sizes of both inboard and outboard DGU is you know glasses same. So, in that case you normally apply the silicone behind the inboard glass of the insulating glass unit. So, this is a spacer tape, again it is a fully unitized system you can see a male and a female joint, and also you can see the weather seal here which is controlled by putting a baker rod here.

(Refer Slide Time: 16:32)



So, there are 3 types of sealants being shown in this picture; one is the structural sealant, second with the insulating glass and the weather seal. Just to give you a few you know idea. So, there are 3 products and they have different application requirement. The structural silicone is used for holding the glass to the frame and any load coming on to this unit glass has transferred through this out of the frame.

The insulating glass sealant is do you know designed to take the keep these 2 units together, whether seal is you know acting as a seal not to allow the water to come in and take the movements. So, any of one of this fail you may have if weather seal phase water will come in, if the secondary seal of the DGU fails you will have a fogging and if this fails you may have this class coming down. So, they are very critical and also in terms of the quantity if you look at normally a glass of 1.5 meter by 2 meter or a 2.5 meter with a windload of 2 kPa, generally the silicone required to supported against windload is hardly 12 millimeters. Such a huge glass a 3 square meter glass what you need is essentially 12 millimeters of silicone.

But, the critical device what is important is designing the product applying it and then selecting them is very very important for this to perform. And, it is like any other thing it is not that is you need to do extra care for silicone, it is essentially important for any manufacturing process that you need to have a proper design, proper product, and proper application.

So, just to sum up what we have seen here is the silicone is taking loads. So, what are the loads it takes up? There are a large area load which comes onto the building, which is called as the windload this is a full area load. So, the wind will be hitting the building either through the positive or the negative. So, the positive is a compression you know and then negative is the suction. So, when the glass is pulled out what is holding the glass to the frame is essentially the silicone sealant here ok. So, this is the sealant which is essentially holding it. So, this has to be design to take against the windload. So, which can be design we have seen the formula.

The second thing what we need to understand is sometimes in the facade we may have provisions not to have the you know we cannot we may not be able to support the weight of the glass. So, which is not a good practice essentially we need to support the weight of the glass as part of the section under setting blocks and using setting blocks. So, if not what happens is this silicone is also have to be designed to take the weight of the glass which is a shear. So, there is a different formula which has to be followed to take the weight of the glass; so, which will depend upon the weight, and the perimeter of the sealant length, and also the sealant design factor for the deadload ok.

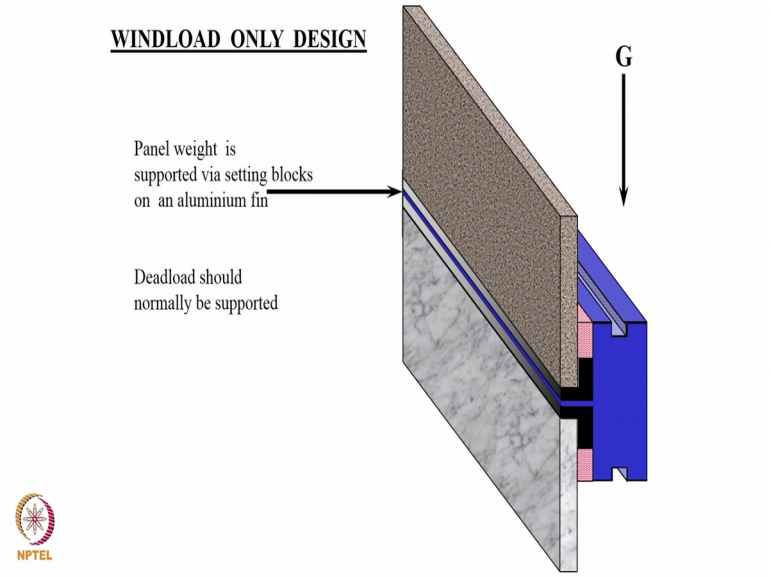
So, it could be possible that in some of the facades you may not have a just straight façade you might you might have an inclined facade. So, you have a deadload support, but this still there is a some angle of inclination because of which there is a load acting on the sealant. So, we may have to determine both windload and deadload see which is more, and we need to see the combined stress, and recommend the bite according to the stress which is acting on the sealant.

So, we saw windload we saw a deadload and also there is a differential thermal movement. You know there are climates which are like you go to Hyderabad, Delhi, Bangalore, Pune, you may have a minimum and maximum which is quite high. Essentially, you may have a minimum of say 15 if you go to Delhi it is minimum of say 5 6 degrees maximum of 45 degrees, this is an air temperature. When you talk about the air temperature the substrate temperatures are much much higher. So, there is a temperature gradient of close to 70 degrees we are talking about. So, there is going to be a thermal expansion and contraction which is going to happen between glass and aluminium.

So, essentially when there is a thermal expansion and contraction happening. The silicone which is a tough rubber, but it is also flexible. So, it has to allow certain amount of movement to happen, it is not like a chewing gum that you need to allow that movement otherwise nobody will go near the building. What we are talking about this the rubber which is tough, but flexible. So, you, but it accommodates the movement.

So, that the glass moves and then you accommodate the movement. So, that it does lead into any failures. So, the silicones do that and there are you know the movement capability has been built in as part of the product characteristics, which is also considered while designing the product for this joint design.

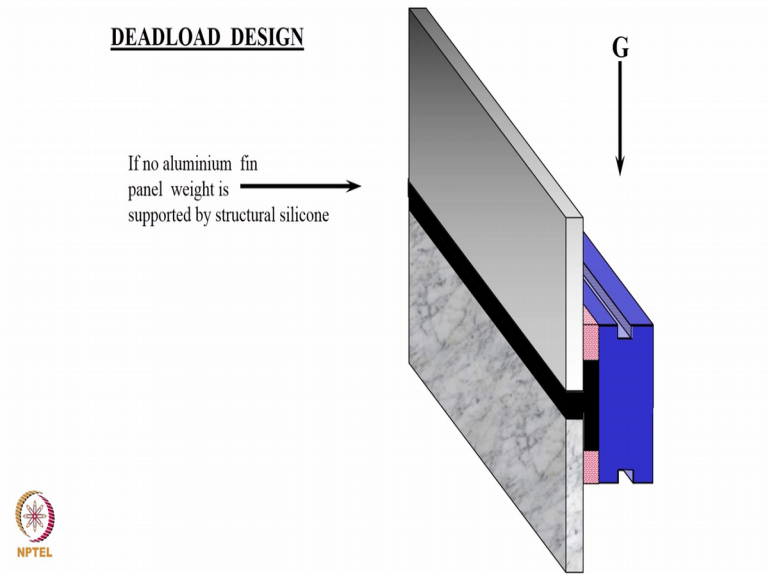
(Refer Slide Time: 20:55)



So, I am quickly taking you through some of the way how do you calculate the bite? So, if you take a glass size of 2000 by 1200 millimeters, and if you see how to calculate the windload is if there is a design windload of 1.5 kPa. So, you take 0.5 into the short side into windload in kPa divided by sealant design load which is 140 kPa you get 6.5 rounded up to 7 and at a millimeter tolerance and always maintain 8 millimeter. So, that your glasses you know essentially designed to take care of the with the silicone to take care of the windload.

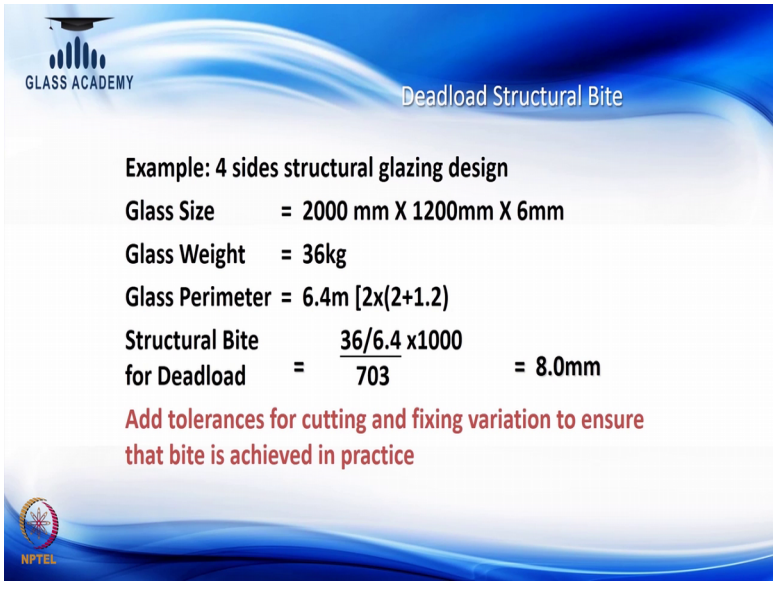
So, when there is deadload support the silicone will take the windload and here the setting blocks are takes in the weight of the glass which is again transferred to this deadload to the section.

(Refer Slide Time: 21:40)



But, in some cases this may not be done this way. So, where the deadload is also taken by the sealant again this is a formula where we need to use for calculating the deadload structural bite, where the plate will act into play. So, here the weight upon you know perimeter into this is the sealant design factor for the deadload.

(Refer Slide Time: 22:03)

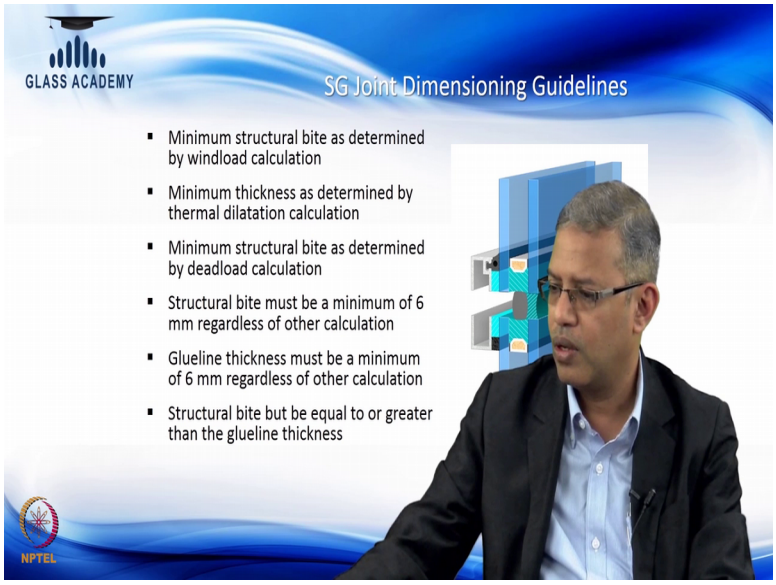


And, an example to talk about is if you have a same glass size with the 6 millimeter thick where the weight is 36 kg and if you apply the you know. So, you have a perimeter of 6.4 meters, and also you have a 36 kg. And, when you do the calculations you are getting 8

millimeters through this. So, we got 7 in the windload and 8 in the deadload. So, we have to use 8 millimeter for this particular glass to take the weight load.

So, whatever is higher we need to do that. So, when there is a particular angle then we need to actually take the angle of inclination and accordingly calculate the deadload size for those buildings which are inclined. So, this is essentially showing you how the movement happens with expansion and contraction, because of the temperature change you can see the how silicone is moving. So, essentially both the structural and the weather seal joints are you know tough, but they can move and take this movements.

(Refer Slide Time: 22:58)



Just to recap on our first part. So, the minimum structural bite has to be always to domain by the windload, also the thickness has to be determined by doing the thermal dilatation calculations. If there is a deadload which is acting on the silicone we need to determine the deadload as per the formula. And, minimum 6 millimeter of bite has to be maintained in spite of calculations and also a minimum thickness of 6 millimeter is made to be maintained regardless of any calculations.

So, the bite should be always equal or greater than the glue line. So, if you are doing an 8 millimeter glue line and your bite comes to 6 millimeter, then automatically to accommodate the you know equal you need to make the bite of first 8 millimeters.

(Refer Slide Time: 23:43)

So, there is a ratio between the bite to the glue line the width to the height. So, 1 is to 1 to 3 is to 1 is the ratio for a 6 millimeter thickness or the glue line you can go up to an 18 millimeter structural bite. The important thing what is also essential to understand here is the structural joint should be easily able to be which up to able to fill into the joint. It should not be so, complex you can show in the drawing, but practically it may not be possible for you to apply. So, such designs are not really a proper design for applying silicone ok.

So, one side should be always exposed to the air for the silicone to cure which I explained in my initial slides. So, these are all minimum guidelines. So, you should always contact your manufacturer or the suppliers representative for any complications or design challenges.

So, essentially this is a technology, which has been used for now 45 years and it gives you an excellent benefit; you get a completely clean glass façade, there is a flexible anchor which is holding the glass to the frame. This takes windloads, this can be designed to take hurricanes, typhoons, it is a flexible anchor, it can take seismic loads, it is UV resistant, it is a long term weather able weather resistance product, it is a flexible cushions. So, it is one of the most reliable method which is being proven for more than you know 45 years. So, it is a proven technology for us to really take that as a right method of doing the glass mixing today ok.

So, this is my first part and I am also going to you know take you through a small video in my now to show you on some of the essential things of how you really apply a silicone into a structural joint. And, what are the quality controls you need to follow while doing this joint application.