Climate and Built Environment
Lecture 4

Need for Shading

When ambient temperatures are within or above the comfort zone, any ingress of solar radiation will contribute to discomfort, and shading must prevent this. If you are located in a climatic condition in which your air temperature is just with in comfort or its going to be above the comfortable range, you might need solar shading devices to cut down any amount of excessive ingress in direct solar radiation inside your building. For climatic conditions which experiences above 18°C throughout the year, solar shading becomes very essential and vital. However, at cool times of the year, it may be desirable to allow solar radiation to pass directly into the room, to provide a useful heating effect. This response can be provided either by the shading device moveable or by it being geometrically selective. Even if you are in a climate in which you experience winter months as well as summer months, you need shading devices to be designed only for your summer months; and for winter months you might want the solar radiation to come inside and heat your spaces or even fall directly on the occupants to improve their thermal comfort. To know how much amount of shading device you need, you must also know about the sun position, because as we just saw in our earlier presentation sun path diagram changes according seasonal variation which is summer & winter months. By understanding this we can be able to choose, if we want a fixed shading or movable shading device. On what type of geometry we need? How much length and depth of shading is required?

Function of shading- solar radiation entering a room can have three effects: 1) Radiation absorbed on the room surfaces will lead to an increase in air temperature. 2) Solar radiation falling directly on to the occupant will lead to an increase in the mean radiant temperature experience. 3) High intensities of radiation from direct sun or even the diffused sky can cause discomfort glare, or disability glare where the occupant's visual performance will actually be impaired. These are the some of the points which indicates why we need shading? When solar radiation has been ingressing into your space; considering if it is during summer months all your surfaces, say if you are having a huge window and solar radiation is directly coming inside during very hot season, all your materials that is present such as : walls, roofs & all your furniture's are going to observe the heat because of the presence of specific heat capacity of each and every material that is present within the space is going to observe the solar radiation and it's going to emit again, which eventually leads to increase in air temperatures. Which might lead to discomfort of the occupants, and it might also fall directly on the occupants which increases your mean radiant temperatures. The high amount of solar radiation also causes glare. You might have observed when you are looking at a hot summer sky, we might suddenly turn and we might see different spots and colours, this is due to the presence of high amount of glare. To cut down glare; and to have good visual comfort, we need to be sensible in choosing what type of shading device we need? The function of shading is to eliminate these three factors or effects.

Solar shading- When sunlight hits a pane of glass, it splits into three components which is reflected, as you see there is a glass and sun rays is being passed through the glass. We might think the sun which is hitting through the glass comes directly inside, but in reality it is not the case. The part of the solar radiation which gets hit is being reflected outside; and part of it is being absorbed by the glass. So the amount of absorption of the glass depends on- the type of glass you are going to choose; and the specific heat capacity of the glass that it can hold. The remaining amount of solar radiation after reflecting and absorbing by the glass is what is being transmitted inside your interiors spaces. Reflected component from the glazing has no thermal effect on the space behind the glazing. It is obvious, if the sun is going to hit a glass and it's getting reflected, obviously the amount of sun which is being reflected will not have any effect of heating your interior spaces. Because you are inside & reflected sun rays is going to go out. Absorbed component within the glazing itself heats up the glass. Heat is transmitted inwards and outwards by conduction and long wave radiation. The amount of heat that is being absorbed by the glass is going to be stored within the glass; and say the interior space is at lower temperature due to heat transfer that is going to constantly happen between two objects to maintain to its thermal equilibrium, the heat that is being absorbed by the glazing is going to get dissipated towards your interior space which is going to add to your air temperature. We need to know how much absorption that glass can take; and you need to choose appropriate glazing depending on your climatic zone.

Transmitted component of radiation that penetrates through the glass raises the temperature of the surface behind it. A transmitted component is what contributes majorly towards the air temperature. The transmitted rays of sun is the one in which it completely penetrates through the glass and falls into your interior spaces is what is going to add up to air temperature. It might lead up to good amount of thermal comfort, because in places which demands for passive heating you might wants this to be very high. So your spaces can actually absorb sun, & heat up the space for you to be less dependent on room heating. But if you are located on a space in which the demand for air-conditioning spaces, this becomes an additional load for the air-conditioners. The proportion between the three components is determined by the angle at which the solar beam strikes the glazing is called angle of incident; and by the type of glazing. This depends on what angle the sun is being located in relevance to your glazing. If you know which position your sun is being located you can cut down the sun when it is harsh and take the advantage of the sun during the winter months. It also depends on type of glazing system you are going to use. For most types of glazing, the transmitted component is very small if the angle of incidence is larger than 45° from the normal to the glazing. If the angle is more than 60°, most of the radiation is reflected. Depending on the angle, if the angle is at 45° glazing at normally, but if it is more than 60° the most of the radiation gets reflected because of its high angle. So angle of incidence is very important to choose your type of glazing. These are some of the examples where you need to keep your shading, if there are two components of glazing system and then you keep your shading inside or exterior. If it is kept inside, this sun rays is going to fall on this glass system gets reflected, absorbed and then transmitted rays has been cut down. But if

you keep your shading devices outside, the instant solar radiation most of it will get reflected, and the amount which gets absorbed in relevance to keeping the shading device inside will be much more lesser. If it is a mid plane, it acts as an average keeping the shading device inside or outside. The advantage of keeping the shading inside is it gives the occupant's control. When you want your sun to come in, we can go close to the window and open the shading screens. But when you keep some fixed shutters outside, and if you want the shading to be opened you need to open the window and then only you can open it. So it gives lesser occupant controls compared to keeping the shading inside.

Exterior Shading Device

Exterior shading device is primarily used to control the amount of radiation penetrating to the interior of the buildings. For example operable that can be raised or lowered. The exterior shading element which you are going to keep outside, say like wooden shutters or wooden louvers , which can be moved up and down or sidewise; mashrabiya are one of the examples of external shading devices which we might have noticed in Mughal architecture. And even in history of architecture, you might have noticed a different fenestration panel which is being kept out and it can be closed & opened, or moved also. Two basic types of exterior shading device are horizontal and vertical. It can be rolled up, or moved up, or it can be kept like windows & shutters which can be opened on vertical planes as well. These are some of the shading devices which can be used. This is horizontal single blade, this usually doesn't restrict any views & this is like a fixed shading device that we might have seen in all our windows. This is like a sun shade which is being projected out with the same masonry elements. Out stringer system, it's ideal for southern orientation. This also does not restrict any views. But it can allow the penetration of some of the solar radiation inside if your space needs such type of design. Horizontal & multiple blades is also ideal to cut down harsh solar radiation in the directions like south side. One disadvantage of this can be reduction in the views compared to the other two options that we just discussed. It can further reduce the ingress of solar radiation, but it will have lesser amount of views. Vertical fins are usually ideally for east & west directions in which sun is going to raise and when it is going to set we will have lower angles. To cut down the lower angles, it's ideal to go for vertical shading elements. Vertical shading elements also further reduces the view. The slant or vertical fins – depending on the degree of the tilt of your building; if your building is not facing towards true east or true west, if it is tilted then you might have to tilt your shading devices to adjust & reduce the thermal ingress. Egg-rate is the combination of horizontal and vertical fins & shading system. This happens when you have higher amount of solar radiation, when you need to cut down all the solar radiation completely from your building. It's also restricts the amount of views that you are going to have compared to single shading system or solar shading that we saw earlier. This is also ideal for east and west.

As we can see in this image, this overhang has been designed for mainly to cut down the summer shading. So June 21st 73° of instant solar angle is going to happen at noon. This overhang has been designed in such a way; there will be no sun penetration or infiltration

inside your space. But when you consider March or September 21st, which is the equinox, the sun angle is much more lowly compared to your summer solstice which will help in ingressing of instant solar radiation during an equinox season, which is during fall or spring. During the winter season, when it is December 21st, the sun is at very low angle, like almost 27 to 30° noon which is the highest angle the sun can achieve during December 21st. this type of overhang has been designed for sun to reach within the space throughout the floor. This can give you an idea how long your, how deep your room has to be located, so the sun can penetrate throughout your floor. For example, when you look at this image, if this room is twice as dimension of what it is now, the sun will penetrate only for half the portion; & other half the portion will be very cold. You can actually design your proportion of the room based on the sun angles. Here, even thermal mass for the floor is being used. The thermal mass is one which has high specific heat capacity and it can reduce fluctuation between the day and the night. The thermal mass can trap the heat which is being incidentally falling on the material and can trap it when there is lesser temperature on the inside it can emit out. When you are using high thermal mass you need to cut down the radiation that is going to fall during summer seasons. This is ideal for windows that are facing southern direction.

Internal shading devices that we usually use in our homes are- blind screens that is internally located and it can be controlled by each and every occupant depending on their need for solar radiation, day lighting levels & ventilation levels. Comparison of both the shading devices- External shading devices are the most efficient thermally because they intercept the solar energy before it has entered the room. Its effectiveness depends on its type and placement relative to glass, when radiation strikes a shading device. When you are considering two shading devices, external becomes much more effective because you are cutting down the sun at its source itself. And you are not allowing the sun to penetrate on your interiors. This becomes much more effective when you are comparing with internal shading device. A part of it is reflected outwards from its surface, and another part is reflected onto the glazing. Remaining part is absorbed by itself, causing it to heat up. When the shading is kept on the exterior, lot of shading that is falling on the shading device will get reflected and there will be another part which gets reflected into the glazing by small opening that you are having on the shading devices. The small amount which goes inside will be absorbed by the glazing system; it will lead to heating up of your glazing or your windows. Thus, even if energy is absorbed by them, it is not trapped behind the glass. The disadvantages of having to be weatherproof and far more difficult to control from the inside. Thus when your shading is kept outside the heat that is being absorbed in the glass, it's not been trapped between the glass by heat transfer, conduction & convulsion. It is usually emitted towards your interior space. The room will get start heated up and controlling this external shading devices is not as comfortable as controlling your interior shading devices.

Internal shading is thermally effective. In such a case, radiation strikes the glazing with no interference, penetrating into the internal space, causing the shading elements to heat up, and from there the heating up the room by both long-wave radiation & by conduction.

When you are keeping the shading devices internally, the sun that is striking the glazing system; very small part of it will get reflected and some part will help in heating the glazing system as well as the shading device, which transmits the heat that is being absorbed in both the elements into your interior spaces in the means of longer radiation and conduction. Radiation emitted by the shading device itself is already of the long-wave type, thus it is trapped by the glazing in front of it in the same way as any other long-wave radiation from the interior. There will be some amount of heat in between the shading device & your glazing system in the air present between these two elements. It will get trapped as long-wave radiation. It is generally much cheaper to install and it is easy for users to control. But it's less efficient for reasons outlined above. It's also vulnerable to damage. When you are keeping it inside one advantage is, it gives good control for the occupants; if you want to have a good view you can immediately go and open it, or if you want ventilation or day lighting you can control the shading devices according to your needs. But when you are looking at thermal effectiveness, it is less effective compared to external shading devices. Because it is going to absorb lot of heat on your glazing and it is going to emit towards your interior spaces rather than reflecting it outside, when you keep your external shading device.

This is the comparison between interior shading and exterior shading. When it is exterior the incidental solar radiation gets reflected and part of it from the shading is also being sent out, and the heating up of the glazing system is considerably reduced. But when you look at the shading device which is being kept on the interior you will observe lot of incident radiation has passed through the glazing system. And there is an air gap between the internals shading device and glazing system which traps the long wave radiation and has higher air temperatures. This internal shading again starts reflecting the heat inside by convection or long wave radiation which leads to increase in your air temperatures. For typical solar gain factor for external white louvers is 12%. Whereas typical solar gain factor for internal white louvers is 46%. Which means your external shading can be much more effective compared to internal shading devices.

Design Strategy for Shading Devices

The design strategy of the shading device will depend on the size and orientation of the window openings. Shading devices can also affect the building appearance. Although the design of external shading devices involves a number of factors, the following recommendations are generally applied to all the designs: use fixed over hangs on south-facing glasses. So when you are situated in a location which demands for solar shading devices, it is ideal to have it external because it will be much more thermally effective. And when you are having externally solar control or solar shading devices, you need to look into lot of different factors such as: where it is located? To which view it's going to get oriented? Which direction it is facing? And how much amount of incident angle of solar radiation is happening in relevance to which space you are going to design it for? If it is a south - facing glass, it is ideal to have fixed overhangs. Limit the area of east & west glass. Vertical or egg-

crate fixed shading can be considered if the shading projections are fairly deep or close together; however these may limit views. If you are having large openings in east & west direction on places like tropical climates we are going to experience prolonged harsh solar radiations on your west directions. It's ideal to have good amount of external shading devices both horizontally and vertically. One of the examples that we saw for that was the egg-crate shading device, which can be installed on east & west windows. It can effectively cut down the ingress of solar radiation, but it has disadvantage of reduction in views. North-facing glass received little direct solar gain; usually no shading is required to this exposure. Northern side, usually sun rises in the east, and sets in the west towards the direction of the south, so northern side doesn't actually get lot of direct solar radiation. Ideally you might require only shading, may be to protect your spaces during heavy rainfall but not actually for direct sunlight. Interior shading devices such as venetian blinds or vertical blades do not reduce cooling load since the solar gain has already been admitted into the indoors. However these interior devices do offer glare control. We might have observed in the offices, they might have blinds or a Venetian device which doesn't actually contribute to any reduction of mechanical air-conditioning loads, but it just controls from external glare which is happening due to higher amount of harsh direct sunlight. To summarise, finally shading and solar control devices have a great potential for architectural expression, adding to the texture and modulation of the façade. They also have the potential and should respond to the orientation of the façade, thus visibly reflecting the building's place in the natural world as well as its urban setting. From the exterior of the building, its shading is also very important in articulating your façade design or elevations, and it can also tell which space is being more used, and which is being less used from look of the exterior of the building itself because of having sensible sharing devices.

Shadow Angles are formed by sun shading devices or projections on a wall exposed to the sun. Different designs of sun shading devices from different shadow angles. The performance of shading device is specified by two angles: a) Horizontal shadow angle; & b) Vertical shadow angle. You need to know how much horizontally sun is going to come? & how reflected sun is going to come inside your building which will demand to know about horizontal solar angle (HAS) and vertical solar angle (VSA). For a climate which is being experienced in tropical, for example in Chennai we might ideally need to know both horizontal solar angles and vertical solar angles to cut down any solar ingress inside your space. These angles depend on the position of the sun and the orientation, where the window is facing. If you are facing towards the north there might not be need for having any solar device or minimum solar shading device will be required. But if you are facing east or west direction of your building, you might need both vertical & horizontal shading devices. If it is towards the south you might have higher amount of horizontal shadow angle, which will demand for higher or longer shading device on your horizontal plane. The horizontal shadow angle (HAS) is required for (or cast by) vertical shading devices. It is the horizontal angle between the normal of the window pane and the azimuth of the sun. So, HAS = Wall azimuth – solar azimuth. Solar azimuth is, how we just saw from the true north to the angle

of your building from the central focal point is azimuth. And wall azimuth is the same in relevance to the location of your window opening. Horizontal solar angle is a deduction of wall azimuth from the solar azimuth. The vertical shadow angle (VSA) is required for (or cast by) horizontal shading devices. Due to the presence of horizontal shading devices, how much angle of shadow has been cast is called vertical shadow angle. It is the angle between the ground line and the altitude of the sun. As you see in the picture, this is the horizontal shading device; and this is the line which is being cast. Sun will enter after this point, so this angle is called vertical shadow angle. Whereas when you have fins, this is called vertical shading device, the sun which is being protected because of the presence of vertical shading devices will contribute to horizontal shadow angles.

Design requirements – requirement of shading largely depends upon the climatic conditions. According to climatic zones, there are three categories of shading requirement: Complete year round shading; & complete year round shading but only during major sunshine hours. If your location is going to experience seasonal variation, you might want shading device also to act seasonally. But if your climate is going to act completely the same throughout the year, you need to have fixed shading devices or no shading devices at all, depending on the air temperature levels your locality has been experiencing. Shading during summer months only, in places like lower Europe, like Italy and Spain, has good amount of summer months, but it has extended winter months. You need to calculate your shading device only to shade for your summer seasons.

Shading requirements in different climatic zones- for hot & dry it is complete year round shading. For warm & humid climate it is complete year round shading but design should be made such that ventilation is not affected. Because of the presence of the high humidity levels you might want to keep the shading levels in such a way it cut's down only the solar radiation but invites the ventilation. For temperate climate, complete year round shading but only during major sunshine hours. Cloud & cloudy you might not need any shading at all. Cold & sunny- shading during summer months alone. Composite climate - shading is during summer months alone. This is to given an idea of what type of shading you might need for different climates. So these are different climatic shading devices that can be given for different sun angles- overhang, projected fins for summer sun and winter sun.