**Course Name: Architectural Approaches to Decarbonization of Buildings**

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**Lecture 3**

Dynamic Envelope - Case Studies Part 1

Well, dear students in our last class we saw how facades can be important in reducing operational energy and we saw how dynamic facades something which is a new concept can actually be so helpful in reducing operational energy and operational carbon by allowing the user to control what gets inside the building in terms of enhancing indoor thermal comfort and day lighting as well as generating solar energy. Now, let us look a little bit in brief about know how in what way this building can have a dynamic facade and then move on to some case studies. So, there are normally four ways in which the elements on the facade which result in a dynamic facade it can operate. So, what are the ways in which it can operate? It can operate as a in a rotational manner. So, what do we mean by that? If you look at this, this element which is here actually rotates along this axis, along this axis this element seems to rotate. So, if you see along this axis this element rotates.

So, the axis is here and the element rotates along this axis. You could also have a folding or a flapping one. How it folds itself. So, this is an example where it will fold or flap or it will move.

No, it will fold itself along this axis. So, horizontally or vertically. So, it could be even horizontally also it could fold itself. Or it could be a moving one where it slides up and down or slides sideward. So you can see here it slides along the sides or it can move up and down.

And then you have scaling. This is more like an origami. So you have a scaling type also. So, these are the primary ways in which, these are primary but these are not exhaustive. You can be very creative in how you want the element outside to fold or unfold itself to allow solar radiation and day lighting and also capture of solar energy to happen.

All three or two can happen. So, it is up to you as an architect to be creative to allow

these things to happen. So, you can have, here it's a little bit more clear, you can have a case where you can have a rotating type where this element rotates itself. So, this element along an axis can rotate itself. So, you could have a rotating one or you can have a rotating horizontal vertical element also where it rotates along this axis.

So, the element keeps rotating. For example, if you want solar radiation to fall, then on a particular day, it could be like this. After some time, once it rotates and comes to this, then the solar radiation would be, it would fall better on any of the surface depending upon the direction of the sun, the movement will happen. It can move even diagonally, either through rotation- it can move diagonally or you can have folding types horizontal folding type or you can have a vertical folding type where it folds itself and shrinks itself and you have diagonal. So, these are only the basic classification which may be difficult for you to perceive or understand in this manner.

But what I will do is, I will bring in some case studies for you to demonstrate how these have been used on the facades. So, that is what we will be doing also in the next two classes. So, this is a case of a building which is, called the Bund Finance Center. This building is a very peculiar building, -the facade keeps changing throughout the day. You could just sit outside the building and just watch the facade which kind of sinks.

So, the Bund Finance Center is located in Shanghai, China. Now, this has three overlapping or moving layers of stainless steel pipes. So, you have three layers. This is layer 1, this is layer 2 and this is layer 3 of steel pipes. Now, this was the inspiration for this is the movie or theater curtains as you just think of the falling of a curtain at the end of a performance.

So, it is derived more from that or inspired more from that and the slowly rotates around the building. Now, a major, this is on a, for a mixed used centre. This mixed use centre was designed by Foster and Partners and Heathwick Studio and this is along the Shanghai waterfront. Now, the The building is covered or it is encircled by this three layers of curtains which slide one over the other and it adapts to the changing use of the building. So, it is made up in three tracks.

and of layers it has about 675 tassels of these magnesium alloy. The exterior is covered with three of these curtains or vertical golden bronze colored pipes. And these, hang from the third floor and move along tracks which are powered by electric motors. So, each day for many hours these layers slowly rotate around the building to a musical song. So, if you actually see these are the pipes.

This is layer 1, this is layer 2 and the layer 3 is outside of this which is not shown in this

picture or here you can see layer 1, 2 and 3. Now, from the third floor this overhangs and this length varies. For example, at this stage this is the length and here you can see that this layer gets elongated whereas this layer gets shortened in this picture, in the second picture. And this causes the movement of these three layers one over the other to a piece of music and it creates a very fascinating impact. It looks like a gold finish of draped pipe.

So, it looks like a vibrant gold color screen on top of a curtain which is constantly moving and consciously or subconsciously this also helps in cutting solar radiation inside the building. So, So, this building is one example where dynamic facade is taken to its full spirit because these three curtains slide one over the other. They are dynamic with respect to each other and also with respect to the facade. Next example we will see. The Kiefer Technic showroom.

Now this Kiefer Technic showroom is a exhibition space along with the office building. So there's office building and the exhibition space in it and it has a dynamic facade which responds to the outdoor conditions. It optimizes the internal climate because it allows each user of this office to control or personalize their own spaces with appropriate user controls. The shell construction of the front elevation, it consists of solid brick walls only with reinforced concrete ceiling and floor. And it has stainless steel encased concrete columns.

But the facade consists of aluminium posts and it transforms with protruding bridges for maintenance with the facade. Now the sun screen operates on electronic shutters of perforated aluminium panels. So, these are the aluminum panels which will move or which can be positioned based on the requirement of the user. If the user wants more sunlight, this flap can be made to fold itself- allowing daylight or solar radiation as need be. Whereas if the user does not want more solar radiation, the flap is made to slide down, so that the solar radiation falls on this panel.

If on this panel solar pv would have been placed, then this building would have also functioned itself to generate solar PV. So, here if you look at the overall building facade, this facade will change continuously every day and the facade is never constant even throughout the day. Over the whole day the facade looks different because of the way the panels are made to react to the outdoors. So actually it shows a new face every day. So it's more like a dynamic sculpture.

More than a very airy or open showroom or a park, it behaves more like a sculpture which keeps changing throughout the day. So this building is clad in the entire south part. It is actually a showroom. So they have cladded this showroom on the southern side with

a wall or a layer of white aluminum louver panels which will open and shut and this is controlled by an electronic device- electronic control and horizontal hinges control it. So, the result is that the building has a very has a facade which will gracefully move and morph itself with its folds depending on the lighting requirement and the warmth solar radiation warmth of those need those who are inside.

And there can be so many infinite number of patterns that can be generated with this facade. If all the panels, I will number this picture for ease of reference as we speak. So, this in you can see in figure 1, the entire facade has become opaque. So, it is an opaque facade. where nothing much is known or seen.

Whereas, if you see in figure 2, based on the users inside, the panels are sliding and they move. The panels are made to move to allow whatever the condition the person inside wants. Whereas in figure 3, it looks more like a musical piece where and also it looks more like there is a need for controlled ingress of solar radiation or lighting levels. Here you need more because the window size becomes large and here the window size is less and this happens because of the hinge here which is electronically controlled as shown in figure 4 and you can see in figure 5 how this the window is completely exposed and the panels are folded to their maximum whereas they could also be partially exposed windows. So, it creates a very dynamic and an interesting facade to be seen from outside also not necessarily only from the inside.

We will look at yet another case study which is the Galleria city centre department store in South Korea. Now this is a double skinned glass facade. It has an outer shell and an inner skin. And both these outer shell and the inner skin feature linear or long patterns from the vertical mullions. The layered profile generates three dimensional depth effect.

And based on the viewpoint this keeps changing. So the building has a reflective appearance which is monochrome during the day. So, this facade openings can be strategized to bring necessary daylight into the building While the outer laminae, they can block the direct sunlight from entering the building. So, it comprises of this building facade comprises of layer 1 and layer 2 and the reaction of layer 1 and sorry not this layer 1 and layer 2. And the way these layers move here, you can see the three dimensionality of the building over here in that area.

As I take you through the other facades, you will be able to appreciate the three dimensionality better. This is the building. You can see that there are also colored lights which add more to the three dimensionality so from the outside this building. It looks like a dynamic two layered facade and it is intended to stimulate a user's experience The skin has patterns of vertical mullions making the building virtually scaleless in its structure

providing no clue of how big it is, how many floors it has and it's kind of a illusion which is created and this results in a seemingly alteration of scales and the creation of double images. So, none of the images is permanent in this building.

Sometimes because of by virtue of the facade movement, sometimes by virtue of the lighting. So, during the day the building has only one color. It has a monochrome reflective appearance while at night Because of the way colored light is used, soft colors are used to generate waves of colored light across this large scale illuminated surface. And lighting design is also another important component of this building. And computer generated animations specifically is designed for this building and there are various themes which are related to the in the department and the lighting relates to those themes- say whether it is fashion or events or art and public life.

So, overall, this building looks more like a piece of art which responds to the function inside. We will see yet another case study, one that is called as One Ocean. So, In the previous class, we saw the case study where the building looked more like a piece of sculpture and the building had multiple colors also ingrained in it. So, it was a good combination. It very well combined aesthetics as well as functionality.

Here we see the One Ocean. This class we will see One Ocean which is a thematic pavilion expo of 2012. Now this is very popular and known for its fish like appearance, fish like characteristics which is created by a facade system which is extremely technologically advanced. The facade system is made up of glass fiber reinforced polymers and it is able to get morphed into a number of animated patterns. It has a number of laminas and the integration of these mobile laminas on the building's facade creates multiple experience. So, this is called as the ocean and you can experience the ocean in two ways.

One as a endless surface and as a immersed perspective in depth. So, it's a plain profound duality of this building that makes it very interesting too. So, continuous skin surfaces twist from vertical to horizontal orientation and they define all important interior spaces. The vertical cones invite the visitor to immerse into the thematic exhibition. So, this is the building that we have discussed now and you can see that at no point of time would this building look the same.

I will just number the pictures so that you are able to understand it better. So, if you look at picture number one, the building is almost sealed. It does not allow any sunlight or no solar radiation to enter inside and it looks very tight. It looks like a tight or a closed facade. Whereas on picture 2, you can see that the fins gradually open up.

They rotate along while they are anchored at the two ends. They open up and it allows a breeze to enter inside. If you see picture number 3, this is opened up quite a bit. And at picture 4 a part of it is opened up and a part of it is completely tight and shut. We will look at yet another shading system and this rotates in three directions according to the sun's position.

So, Tyler Short has designed this and this is called as the Penumbra Kinetic Shading System. It uses traditional static components that makes the louvers swing out to create the depth that is required to either prevent solar radiation or lighting from entering inside. So, here you can see in these pictures how the vertical fins are beginning to open up to allow partial ingress of daylight and here you can see that if this is the direction of the sun then again it is partial whereas if you see in each here it is almost closed. It does not allow solar radiation if it is. So, when you want complete shading picture 4 happens and this happens because it has elements which close itself beautifully.

And this is how the facade looks. The facade is divided into facade is divided into grids where each of the grid functions independently. So, when you look at this grid it functions independently the know the planks they function independently they move vertically to So, there are a number of ways in which this concept by Tyler Short can be used. So, he was an architecture student. Why is it more relevant to you? Because the one who has designed this was a student. And he developed this alternative to a traditional window shade.

So, he had a mechanical louver system. That moves in three dimension. It moves vertically and it moves horizontally. Diagonally to adapt to sunlight during various times of the day. So at this time you can see maximum sunlight entering in onto picture 3. And gradually maximum sunlight entering onto the various heights.

And look at the comparison between picture 1 and picture 8. In picture 1, it's all almost closed. In picture 8, the openings are completely exposed with a good shading device. So, like a vertical indoor blinds, the conceptual penumbra shading system as it is called. It would hang down on the front of the windows and it can be pivoted left or right to adapt to either the east or the west orientation of the sun.

It can also fold upwards to create a horizontal shading against a high afternoon sun. So, he solved this by having a series of vertical shading lures. that will move independently and pivot itself to maximize solar protection. And when the sun reaches an altitude in which the vertical louvers will be ineffective, completely rotate upwards to act as a horizontal shading element and a light shelf, which will also function to increase day lighting inside the building.

So, this is a concept which was created by Tyler Shelf. And next we have this Penumbra concept itself. So, this project was designed to offer a you mobile kinetic and mechanical solution to an issue which must be impossible to solve with static facades and static architectural components such as a window, operable window with a horizontal shading device because this building and this facade is relevant in terms of its energy efficiency, in terms of its reduction in operational carbon throughout the year. Because it provides shading across a building's facade for a hot part of the day, for a cool part of the day, for a low evening sun, for a very high afternoon sun. So, for all the conditions there is a this building response. Now this design would be able to provide the shade for every time of the day whether it is a high afternoon sun or a low evening sun.

Now the shades can be powered either by hand like this like the mechanical pulley system or in the here you can see the pulley system or you can also in today's day and age have a mechanical system to operate it. So, the functionality of the shade is very appealing, it makes the building look dynamic and yet it functions appropriately as a response to the outdoor conditions and therefore provides maximum indoor comfort based on the requirement of the client and therefore is very useful in reducing operational energy. So, otherwise it would be a very stagnant looking building. So, the things that these building had is a adaptive sunshade. So, it is a penumbra sunshade, which is adapted to change sunlight conditions and innovate the sunshade industry.

It has mechanical solutions for architecture because you can use any of these pulley techniques to control the shades. Or you can have hand and computer powered products. This can be this Penumbra sun shading system. It's your innovation.

I mean you can be as innovative as possible in using it. The concept is there brought out by a student. It is completely up to you how you utilize this, how you take this forward in a very innovative manner. And it is going to yield a very sustainable building. Because you have complete control about how much solar radiation you want the building to have, how much of daylight you want the building to have.

It is useful for any typology of building. You can have it for residence, you can have it for office, for a commercial complex. So, in every way, it is a dynamic building. It offers aesthetic appeal. and it also fulfills the requirement of being very sustainable. So, what we will do is we will stop with this class and we will move on to further case studies in the next class.

So, with this two examples we will close and we will move on to the next class with some more examples.