Structure and Architecture
Lecture 8

Works of Felix Candela

Felix Candela was a spanish Mexican architect, he studied at the Madrid school of architecture, where he was born. He was famous for the development of Mexican architecture and structural engineering. He was also famous for development of thin shells, made of reinforced concrete known as 'Cascarones'. Let's have a quick look at his early life and career. Felix Candela was born in Madrid, Spain in the year 1910. He graduated in the year 1935 from Madrid Superior Technical school of architecture. He then travelled to Germany to study architecture further. There he developed a very keen sense of geometry and started teaching other students in private sessions. He always had a keen mathematical precision in his drawings. He also started teaching other students in private sessions during his study in Germany. Later, he moved to Mexico after the Spanish Civil war.

Looking at what he is famous for, he is famous for thin shell structures made of reinforced concrete called 'Cascarones'. Cascarones are basically reinforced concrete structures which are extremely efficient in a dome or shell like structure. Let us look at the efficiency of these structures and let us look at why they are very efficient here because the shape pretty much eliminates all the tensile forces in the concrete because we know that from our earlier episodes or studies that, concrete itself is very bad in tension. That is why we require an element called steel which is to be reinforced with concrete so that the reinforced concrete itself as a compound structure and becomes capable of handling both compressive and tensile structures. Here, this type of a thing Cascarone structures eliminates the tensile forces completely. They have been making concrete more efficient in taking loads. It is like an arch shaped structure. In an arch the tension element is completely lost. All the forces are completely compression forces where the load transfer is from one element on the top to the next element on the bottom and then it just transfers all the way to the boss. Whereas, none of the elements actually carry any tensile force. Similar thing is what happens in these cascarones. Around 1950, Candela's company went to design laminar structures. Candela did most of his work in Mexico throughout the 1950s and into the late 60s. He was responsible for more than 300 works and over 900 projects in this time period.

Let's look at one of his famous works, his first and famous work is called the ' Pavilion of Cosmic Ray's, it's located in South of the National Autonomous University of Mexico. It is in the same good condition as it was proposed. The Pavilion is a very thin reinforced concrete, double curvature structure. The first curvature here is the one which you see here. This is the first curvature. The second curvature is the one you see here. This is number 2. This structure is curved both on this axis and at the same time it is curved on this axis. Due to the very thin

reinforcement concrete and its double curvature, it is based on a structural principle or a mathematical component called the Hyperbolic paraboloid. That is the concept on which the structure is based on. Pavilion of Cosmic Rays was proposed using a double layered curved roof warped structure instead of a cylindrical structure which war originally projected by Architect Jorge Gonzalez Reyna. The initial projection of this project was a cylindrical structure in which like a walt like a structure itself has half of a cylinder and this half a cylinder has a single curvature. This was what was proposed by architecture George Gonzalez. But later Candela came and changed the form to a hyperbolic paraboloid. He justifies the construction of a Hyperbolic paraboloid in a geometric trace since it would provide the stiffness, strength and stability necessary. He is talking about three major components here; stiffness, strength and stability. There are three different things. Often stiffness and stability are confused with one another but then Candala clearly differentiates these three things and thinks only the use double curvature, the one curvature over here and the other curvature here, only by the use of two curvatures in the single building is able to achieve all the three components which he mentioned. Stiffness, strength and stability. The shell is 12m long and 10.75m wide. The cover of this laboratory specializing in the measurement of neutrons should respect the condition of not to exceed 15mm thick its highest point, to fulfill its role optimally. Access is via a reinforced concrete staircase, leading to the first bay of the building where there is a lobby that connects to an external cubicle and two laboratories. Here are some of the pictures of the Pavilion of Cosmic Rays. We can see the staircase at the rear end of this picture. There is a closer view here, there is a staircase made of reinforced concrete which leads to the laboratory on the top. This is the setting of the university and we can see the frame of reference where a little Pavilion is placed over here.

The Pavilion consists of foundation based on isolated footings, which leads to two bays from three rigid frames with reinforced concrete columns that clearly divides the space into two. There are three frames, which clearly divides the space into two. The one space over here and the other space is over here. Clearly, there are two bases formed from the three rigid frames with reinforced concrete. The Laminar structures or the three concrete shells derive their stiffness and strength with respect to the geometry they acquire by allowing tangential stresses, that makes bending so small i.e considered negligible. There is practically no bending that happens on the structures because of tangential stresses which the whole structure allows for. That is why the bending stresses are considered negligible in the structure and that is what makes the structure very stable.

Let's move on to the next project. It's called 'L'Oceanografic'. It is an oceanarium situated in the east of the city of Valencia, Spain, where different marine habitats are represented. The Oceanographic is the largest such structure in Europe with a surface of 1,10,000 sqm and a

capacity of 42,000,000 liters. This is a building, this is how the building looks. Look at the use of thin shells called 'Cascarones' and look at the way he has arranged all these Cascarones in a spiral fashion and the striking use of glass with respect to the water, the reflective blue color of the glass with respect to the reinforced concrete, naked color of the concrete is clearly amazing. These are some of the pictures of the interior of the structure where he tries to use different kind of support systems for the roof. Look at how complex the structure systems are of the interiors. This is the basic shell structure without the glass roof. This how the building looks like if there are no glass enclosures provided for the building and on the bottom picture you see the glass enclosure provided with the setting and on the picture on the top we can see how the point where the structure meets the ground. There are only few points where the structure meets the ground but still, the whole structure, the whole concept is able to hold the entire structure in that entire area by very minimal number of contact points. This is the structural drawing of the building. These are some of the other buildings designed by Candala.

Works of Ero Saarinen

Eero Saarinen was a Finnish-American architect. He studied at the Cranbrook Academy of Art. He was the son of an influential Finnish architect Eliel Saarinen and his second wife, Louise. He became friends with his fellow students such as Charles, Ray Eames and with Florence Knoll whom he later collaborated with to create furniture.

We shall take a look at the early life and career of Eero Saarinen. He grew up in Michigan where his father was a teacher at the Cranbrook Academy of Art. He took courses in sculpture and furniture design there. He then studied sculpture at the Academie de la Grande Chaumière in Paris. He went on to study at the Yale School of Architecture, he completed his studies in the year 1934 and he became a naturalized citizen of the United States in 1940. Saarinen first started his design career in the field of furniture design, he received his first critical recognition in the field of furniture for a chair he designed together with Charles Eames in 1940. They received the first price for the chair. The one on the left here, this chair is called the Womb chair and this chair on the right is called the 'tulip chair' and this is from a series called the pedestal series. The first major building which our architect Ero was the Crow Island School. The school has four wings emerging from a central building with common rooms. This design allows each classroom to have its own courtyard and each wing to have its own playground. The aesthetics and the form became a template for mid-century schools. Although the planning or educational system itself did not catch on but the aesthetic and form definitely did catch on and it became a template for mid-century schools later on.

If you look at the building here, take note of the way he uses bricks as very strong elements here. The way he uses brick, the way he positions windows horizontally and the planning itself,

like we saw here, it has four wings emerging from the central building, which means that you have courtyards for each of the classrooms and a playground for each of the four wings.

The next famous building that we are going to look at in Ero Saarinen's career is the GMT Technical Center. GM is General motors. The original idea of an office block was abandoned during the planning phase. Any office block that was designed at that particular point of time followed an architecture called Modern architecture and this modern architecture had very strict rules on how a building must look, how a building must feel like, the concrete, the glass, the way it is created, the idea of an office block was completely abandoned. The eye-catching accent was now placed by a large fountain and silvery water tower in an artificial lake which is created here. This is the artificial like and there is a large fountain or water tower placed here. The picture on the right here, shows the interior reception where the the receptionist's table is custom-made. We can also see a staircase in the background. The furniture piece was designed by Ero Saarinen himself. This is another winding spiral staircase which you see in the interiors of General Motors technical centre. Situated on a square mile of the countryside, this extraordinary assemblage of twenty buildings is a sizable man-made lake complete with fountains and a handsomely modeled stainless steel-sheathed water tower called ' a coordinated research town' and also called an 'Industrial Versailles'. Particularly noteworthy is the use of walls and panels of vivid colors as enlivening accents inside and out.

The next famous building that we are going to look at in the architecture career of Ero Saarinen is the 'David S.Ingalls Skating rink' inside the Yale university's campus. This skating rink is characterized by a sweeping domed roof that was designed by Eero Saarinen. He graduated from the Yale university as well. This rink was lovingly known as the 'Yale Whale', probably because of the shape of the roof of the building, the colour and the striking contrast this gives with the sky above. Though the rink is seemingly heavy and brutal. It is truly a tensile structure. The main structure comes from a 290 foot long central arched backbone of reinforced concrete. The central arch is this one which acts like the backbone and from there we have subsequent structural systems that carry the entire load of the structure. You can see the central arch over here and the subsequent structural elements in this picture.

The next famous building that we are going to look at is 'MIT Chapel'. MIT Chapel is situated in Massachusetts Institute of Technology in Cambridge. It is a non-denominational chapel inside the campus. Even though it is a very small building, it is noted as a successful example of mid-century modern architecture. Through the sheer manipulation of light and the its focus on the blazingly white marble altar over here. This created a place of mystic quiet. The exterior of the building is very simple with brick as a material, with a cylinder that's supported by small arches at the base of the building. Small arches that you see over here and it is surrounded by a small thin concrete mount and it is surmounted by an aluminium spire on the top here. Its completely

windowless, it has only one opening right in the middle which provides light directly on this altar, blazingly white marble place that creates the magic. From the outside, the chapel is a windowless brick cylinder set inside a very shallow concrete moat. It is 50 feet in diameter and 30 feet high, topped by an aluminium spire. Saarinen chose bricks that were rough and imperfect to create the texture effect. Look at the texture that is created on the wall here when there is light being focussed. This texture was created specifically by Saronen to get the textural effect.

Next important building that he designed was 'St.Louis, Gateway arch'. The Gateway arch is a 630 foot monument in St.Louis. It is clad in stainless steel and built in the form of Catenary arch. It has many accolades to carry for itself. It is the world's tallest arch, world's tallest man-made monument in the Western Hemisphere, Missouri's tallest accessible building. It is the centerpiece of the Jefferson National Expansion Memorial. A soaring curve in the sky that links the rich heritage of yesterday with the richer future of tomorrow and brings a 'new purpose' and a 'new sense of urgency to wipe out every slum', that is what the building is described as. Here you can see the picture of the arch in twilight and the reflection of the Gateway arch on water and here you can see the Gateway arch in the backdrop of Jefferson National memorial.

The architectural study about Eero Saarinen is never complete without the study of the 'TWA Terminal'. The TWA terminal is also called the Trans world flight center, although it has opened in 1962, it was abandoned later. The portions of original complex have been demolished but the Saarinen designed head house has been renovated and is partially encircled by a replacement terminal building. The building that you see here is shaped like a bird taking flight. The bird with the beak, its two legs, claws, wings on either side, ready to take flight. How interesting is this form especially if you want to design an airport terminal building? You take the inspiration from a bird just when its about to take flight and then you design beautiful buildings with that as an inspiration. This is the bird's view from the top angle. You can see the beak, the two wings of the bird, the tail of the bird, you can see one of its legs here, the other hidden by the body and this is how beautiful the structure looks. It is so beautiful that, both the interior and the exterior were declared as 'New York city's landmark' in 1994. It is called the Grand Central of the Jet age and it is also called the 'Monument to human throughput'. The prominent wing shaped thin shell roof over the headhouse or the main terminal is the one that catches the eye of any observer. The unusual tube-shaped departure-arrival corridors were originally wrapped in red carpet. Tall windows were used to enable expansive views departing and arriving jets. The concrete shell, which inspired Saarinen to develop curved-edge ceramic tiles conforming to the curvilinear shapes. This design, this building straddles many architectural styles of the future, such as; Futurism, Googie and Fantastic architecture. This particular architectural style which Eero Saarinen followed is also called neo structural

expressionism. Let us look at some of the pictures of TWA Terminal. These are the interiors of the building and this is another exterior where it is well lit and you can still see the logo of TWA on the right side here. The furniture on the left was again designed by Eero Saarinen himself. Look at the bold use of colours, red and white in the interiors. The picture on the right top, is the narrow passage we were talking about earlier which was red carpeted completely. If you look at the interiors of this building, look at the sweeping curves and the straight lines on the picture here. This is the kind of architecture that creates a sense of greatness in every person. The moment you enter the airport terminal, you see all the sweeping curves elegantly designed staircases, handrails, furniture i.e when you get inspired to life itself.