Structure, Form, and Architecture: The Synergy

Prof. Shubhajit Sadhukhan
Department of Architecture and Planning
Indian Institute of Technology, Roorkee

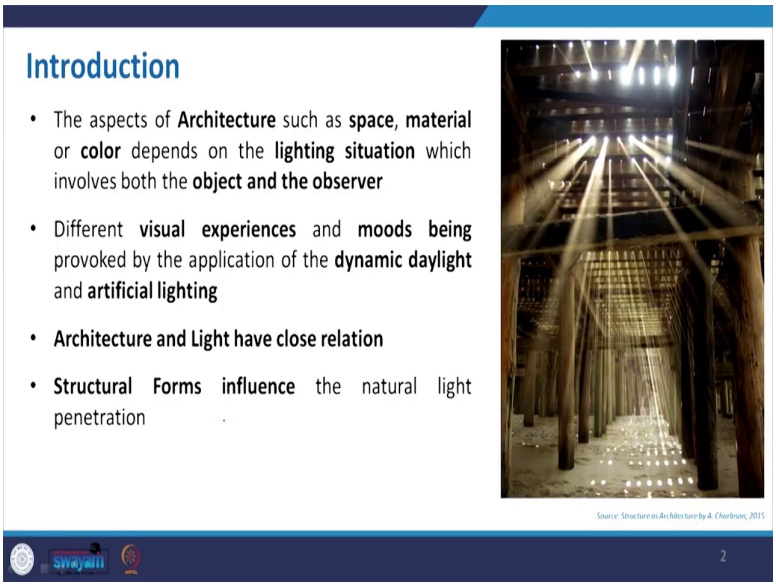
Lecture – 35
Structure and Light in Architecture

Hello everyone. Welcome back again to the online NPTEL course on Structure, Form and Architecture. Today, we are at lecture number 35 and this is something interesting that we will discuss in this lecture. So far whatever we have understood about different structural form, different requirement, even recently we have covered the structural form and structural arrangement for like seismic prone area, windy area and their different consideration.

Now, in this lecture, we will be focusing on the structure and light in architecture. So, there are some structural arrangement, structural form which will help to allow daylight and the natural light alternatively we can say to create some beautiful form and architecture. So, in this lecture we will be discussing on those kind of structural element and also is go through some of the examples.

So, let get started.

(Refer Slide Time: 01:28)



So, at the beginning if we just try to again recap what is the architecture and then the many definitions will come into picture, like it is a articulation of space, sometimes it can be represented by the texture, different component of design, the color and then the is shape space. So, like that here what is written in this slide the aspect of architecture, the aspect of architectures are such as space, material, color depends on the lighting situation and it is obviously, true and we all accept that.

In absence of light, we cannot actually see any objects and even we can change the color of the object with some lighting because of different filtration, nowadays even we know these things. This is available in our smartphone devices, different photograph that we take and then we apply different filter different toning, so by which are the changing the color of the light and the intensity we can really make a change in the outcome. So, as true for this case where

the light, then the object and observer these three parameters we will determine how we can perceived one structure.

Next like different visual experience and moods being provoked by the application of dynamic daylight and artificial lighting and definitely it has a relation with your visual experience. Say if it is too much glary, if too much light is coming in a summer day along with all this light and other thing our perception we feel it little bit warm whereas, a very dim light, very shallow opening will give us sense of something very close and dense and this is related to the daylight.

But when you consider the artificial lighting then also if we go to a restaurant, We definitely do not expect a very high exposure or very you know light like maybe which is very much required in operation theater, maybe a dim light maybe a different tint of your leash radius or whatever the color that we prefer these kind of ambiance in the restaurant and the party area will change the ambience. The same form same infrastructure will look in a different manner. So, light and architecture have very close relation. So, that is already been experienced by all of us. So, in absence of light we cannot see anything, in presence of light depending on the intensity, depending on the direction, depending on the color tint of the light we visualize the object in a different manner.

Now, if that is true that they have the relation so, so as too with the structural form, so different structural form that may facilitate to welcome the light inside a structure. So, here you can see in this image. This is a wooden structure, a very simple structure where you can see these columns and then beams and then at the rooftop, there is some kind of you know percolation, there is some perforation. So, these perforations, through this perforation the day lights are coming inside and that is creating shade and light ambience which indeed giving a different experience than if we just cover it up with some opaque material.

(Refer Slide Time: 05:15)

Now, let us experience a few more with some images. So, in this is somewhere very simple structures where you can identify this column and beam and this whole opening been just covered with some frame and the glass and then basically it is maximize the light. So, the whole floor being in the daytime and this is looking at this, so this outside this is basically the courtyard. So, from courtyard, so this with the reflectance with the indirect light; so this whole area is under light so, this will give some different feeling of like the vastness and all. Along with that it will also help to do some kind of saving in energy point of view.

(Refer Slide Time: 06:12)

Coming to the next one again this is a structure where different shade being created with a [FL], where this being created with some kind of you know square and rectangle and the interior you can see that a nice texture being created whether it is on a circular column or even on the floor. So, this dark and light dark and light; so, this create a different ambience. It is very simple with the structure where some perforation being made some kind of [FL] form being created and with the daylight this is creating definitely a very nice you know ambience inside the structure.

(Refer Slide Time: 06:51)

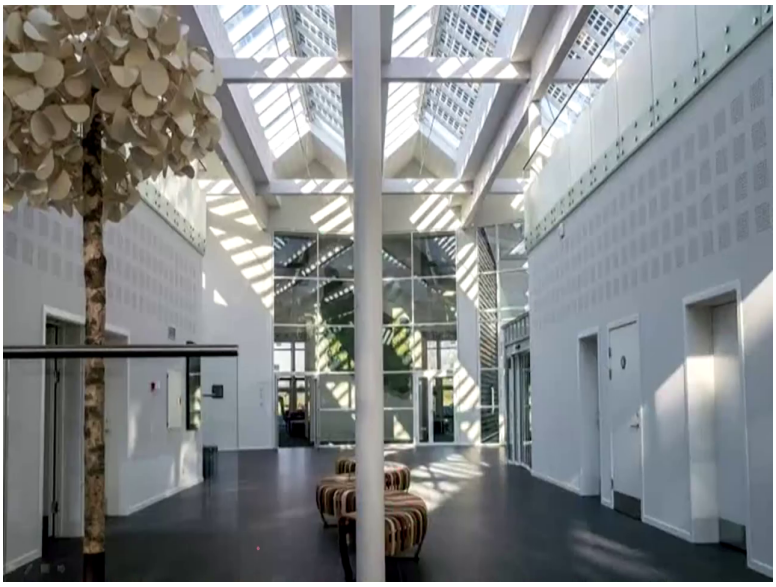
Then, moving forward to this one where this is a swimming pool and where the roof been covered with some kind of structural arrangement where you know with the inclination, with the sun. So, there is a indirect light penetration not the direct one not the direct layer here also the application of [FL] by which the light can easily penetrate and this whole area is given a dramatic feeling, which is also one of the point of appreciation; in this case where this whole area in the daytime is being illuminated.

Now, the question is if it is so, then what will be that case in case of the heavy rainfall or maybe like there is heavy dust. So, definitely for that this will not be really a good option, but wherever the option is there, we can still maximize the daylight. In terms of making things beautiful, if we place in order, we will get a better result along with that some saving on energy consumption as well.

(Refer Slide Time: 08:01)

Now, this is another one this is very beautiful example, I liked it much. So, with this small opening you can see that how this light being reflected from the ceiling and create some nice ambience in this particular corridor. So, with direct light to this surface and then the reflected light which create a different gradient at the rooftop. So, in this image this gradient is giving some you know different feeling and this light and shade is giving adequate lighting to work in the daytime and this is creating nice environment.

(Refer Slide Time: 08:41)



Coming to this example where the truss the member, like this you know line that angular member being repeatedly used and that is been covered with a glass in order to stop the rain water penetration to the building, but this is giving enough indirect light, of which is refracted from this ceiling and then it is creating nice environment. So, this is another application where this the structural form that the system the arrangement that been picked up which maximize the penetration of daylight.

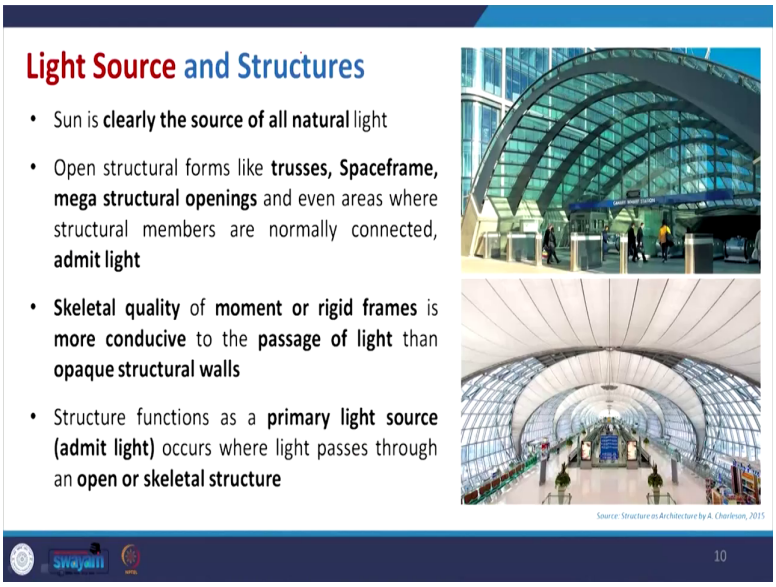
(Refer Slide Time: 09:27)

Coming to this, this is another example where good building this particular dining area and this is the kitchen area being illuminated by the daylight. So, what exactly it has been they in this; you know example what the architect has done here that put some glass in this particular cover. So, which will allow this building to take the light inside at the same time it will protect the building from the rain or such you know dust from the outside. So, this is another application and again with this white color and this with reflectance, so this is giving a sense of you know gradient. So, it is giving nice experience.

(Refer Slide Time: 10:16)

Now, this is the example from the Louvre museum. So, here also the interior story, the in interior space of this building is really getting the maximum of the daylight with this you know steel manures, steel frames and along with this glass covering. So, which will protect from the external rain or maybe the wind, but at the same time it will have a direct connection with the outside environment. So, this is creating a nice sense where the structure being used to welcome the light.

(Refer Slide Time: 10:55)



Now, coming to the light source and structure; this is very important and so far whatever I just told about, it is all related to the daylight or the natural light and the source is sun basically. But in this context of the source, the structure as a source of light refers to the type of structure which will allow direct light penetration, the maximum light it can penetrate. In many cases it may happen that the structural material that we use of translution type where a diffuse light can you know enter.

Say for example, if we consider the membrane, in membrane structure depending on the translucency of the you know the membrane we can get some diffuse light, but in the system wherever a system being lined, they join together or creating with the cross kind of material it will be more effective. So, here in this what is mentioned, the sun is the clearly source of the natural light, open structural forms like trusses, space frame, mega structural openings and

even the areas where the structure members are normally connected those areas can admit light if we can do it in a nice manner.

In this context, definitely in order to get the light inside you have to have some opening. So, that is why let the skeletal quality of moment or rigid frame. So, where you just make your structure with beam and column, and the rest of the things you can either fill with the masonry wall, but that will reduce the opening percentage of the facet or else you go for the know you know structural glazing with the glass like this building the way we can see, so which will allow more light to pass on. So, that is why the skeletal quality of this rigid frame is more conducive to you know allow or you know passage of conducive to the passage of light then opaque structural walls.

So, in a high rise structure, what we have seen that in order to make it more resilient to the lateral load; if we can go with the shear wall, so which is basically a very solid and opaque screen which will definitely protect in that sense, but that will also block the view. So, in that case if we cannot go alternatively with some frame or super frame that may really help.

So, we will be discussing on high rise structure in some upcoming lectures of this course. There will see that how alternatively we can even make our high rise building structural like structural resilient to for this kind of lateral load without compromising the opening for the building opening to the outside of the building.

Now, again the structural function as a primary light source basically which will allow like the passage of the light occurs where the light passes through an opaque skeletal structure. So, it is better to have a skeleton structure like making of the space frame, making with some whole truss, something like this arch form where the covering will be done with some glass material or transparent or translucent materials. So, that will help to welcome the light.

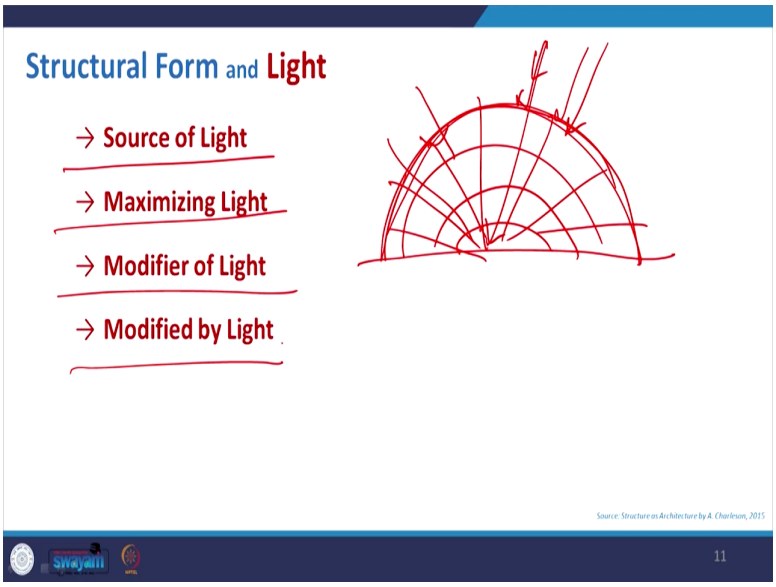
So, here you can see two images where this particular space is being formed with this frame where the arch frames being made as a structural component and then this being connected with again steel and being covered with a glass. So, that will protect from maybe the direct

heat this will have this property of the structural you know which will not allow anti glare glasses so, which will remove like minimize the glare as well as it will give the adequate light.

Down this example is from your Bangkok airport. So, where you can see the waiting area this is being illuminated with the daylight which this again your you know some kind of structural arrangement with the steel frame and then the glass combination. And this application is not, it is only used for this airport most of the airports that we can take the airports in India international airport or maybe there are examples where this kind of waiting area and where you have some kind of you know transition. So, those areas being highly illuminated with the natural light with the truss frame or maybe the space frame and that is basically giving a nice experience of light and shade along with the energy efficiency.

Coming to the structural form and light; so, if we can classify the structural arrangement which will direct to that you know allowing the light and all, so we can specify it in 4 different ways.

(Refer Slide Time: 16:32)



One is the structure as a source of the light, then the structure used for maximizing the light where the main the whole structure probably we are making to you know get the light inside maybe a glass house concept where we need to have this kind of structural composition where the inside will get the maximum light form your the natural sources.

Then the modifier of the light sometimes we may use some structural form or structural material which will modify the light. Modify the light in the sense like it may be due to the reflectance of the you know light or maybe it is due to some filtration. So, whatever the light form, so that will be little bit filtered to that structural system and creates some different ambience. So, we will see the example in this category as well. And then the modified light, modified light is basically modified by light. So, if we now look into this you know structural

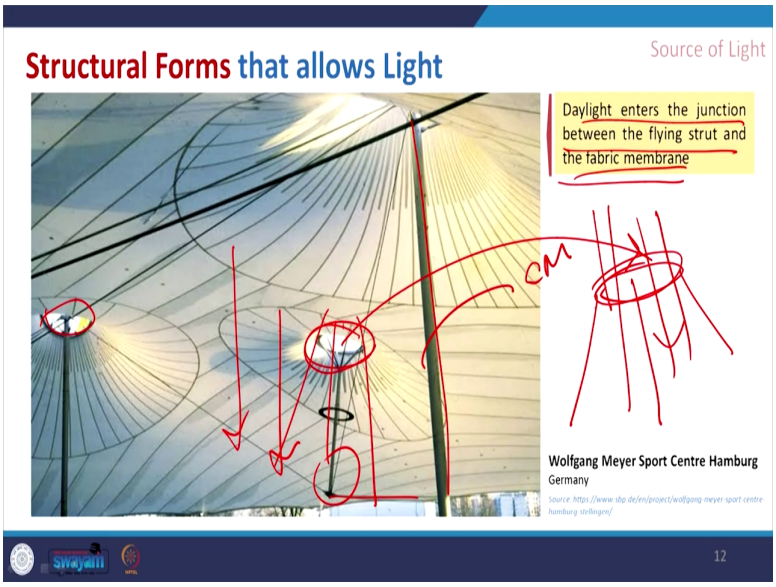
form that will allow light or that is welcoming the natural light to the inside of any architecture.

So, we can broadly classify them into 4 category, the first category that you can see in this slide that the structure as a source of light. So, some structural arrangement like truss or space frame which will allow direct light to come inside or make you know that will help to you know create environment like the airport I have shown and there will be more example to come then there is another structural arrangement which can maximize the light. So, the objective of those structure is basically to maximize the daylight penetration. So, like in a glass house where you create a dome like structure or wall like structure where this is basically some kind of you know steel frame and that being actually repeated and then finally, what we get this particular form which is full transparent, so where the light can easily penetrate. So, we use the maximum daylight.

Now, when we call this the penetration of the light, so many a times we will avoid that glare, we only get the diffused light or maybe sometimes the direct light if we can you know allow that. Then the modifier of light sometime the structure being used to modify the light it will create it will help to create some light and shade combination which enhance the quality, the visual quality of architecture that we have discussed the different visual quality at the beginning of this lecture. Maybe the first week, there we have first week lectures that we covered based on that the visual quality.

Now, the last but not the least is the modified by light. So, sometimes the structure in case like whatever the form the texture, the position this kind of visual appearance will be modified by the light. So, with the direction applied, with the amount of light and intensity, so that can be also one of the component that structure getting modified with the light. So, now, we will focus on each of them and try to understand that with some example.

(Refer Slide Time: 20:20)

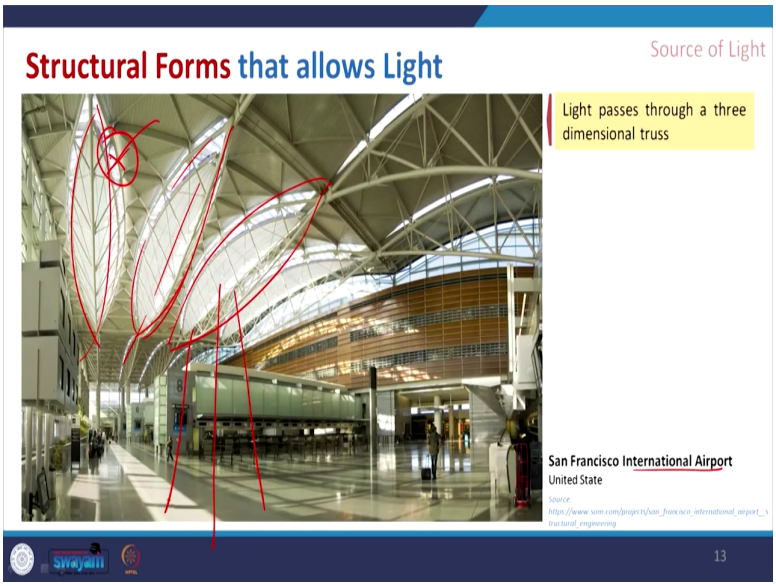


Now, in this category where the source of light, so this is one example from sport center where now in this is the you know time you can easily identify this structure, and yes I guess all of you got it. So, this is your tensile fabric structure. So, these are nothing but the you know compressive mast and this is the membrane which will be giving tension.

Now, the point is with this translucency of the material it will allow light inside is one portion, but if you see that particular joints where this you know floated members is getting attached or maybe with the mast. So, this portion is allowing the direct light penetration. So, this is very useful. So, this portion is basically a conical shape and this being attached with this. So, this portion will allow light to go inside. So, this portion is you know allowing light directly inside. So, day light enters the junction between your flying start, so this portion and also the fabric membrane. So, this is one of this such structure where this can be done.

Even the application of this membrane structure is mostly used in your stadium and in the stadium we also get some kind of diffused light for the spectators.

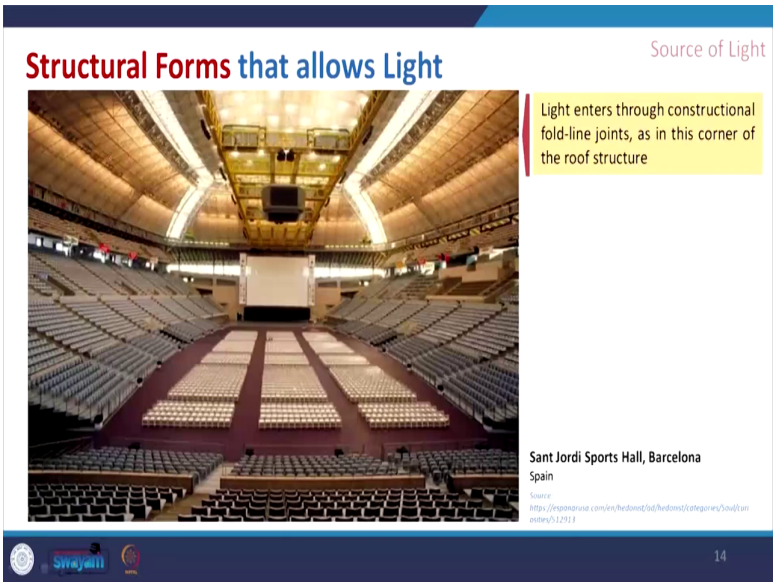
(Refer Slide Time: 21:55)



This is another wonderful example from San Francisco international airport where the whole structure is being made with the truss frame and in this you can get a very nice combination. So, this kind of folded, this boat like structure is also giving a sense of a petal and this is giving a nice view of the roof as well as essential functionally it is giving some light inside.

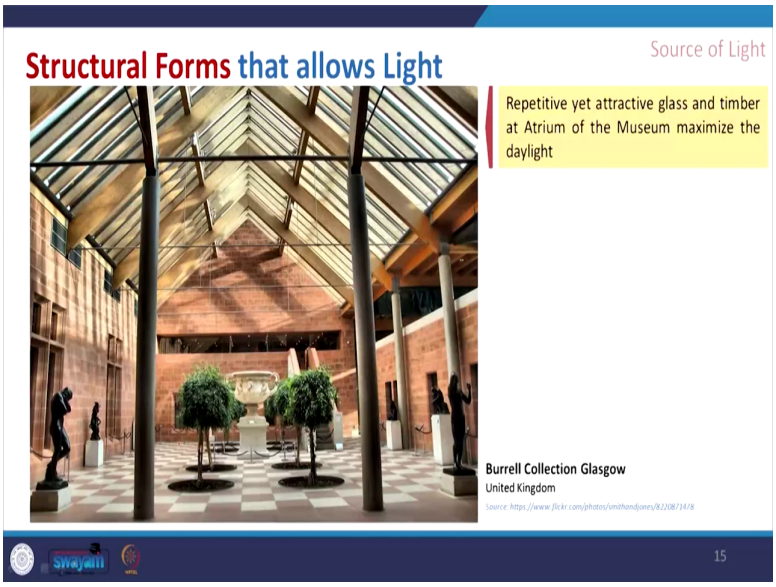
So, all these opening, so if you see these details, so this form allow the light to enter and then the area being illuminated. So, light passes through a three dimensional truss that we have discussed in the truss section and this is how this being done.

(Refer Slide Time: 22:42)



Coming to the same category now here it is a sports hall in Barcelona, where at the corners you can see that the arrangement of the truss in such a manner that will allow daylight to come. Along with the artificial light definitely whenever at nighttime we will not really you know get light, but in the daylight system we can easily see that how this can be used very effectively.

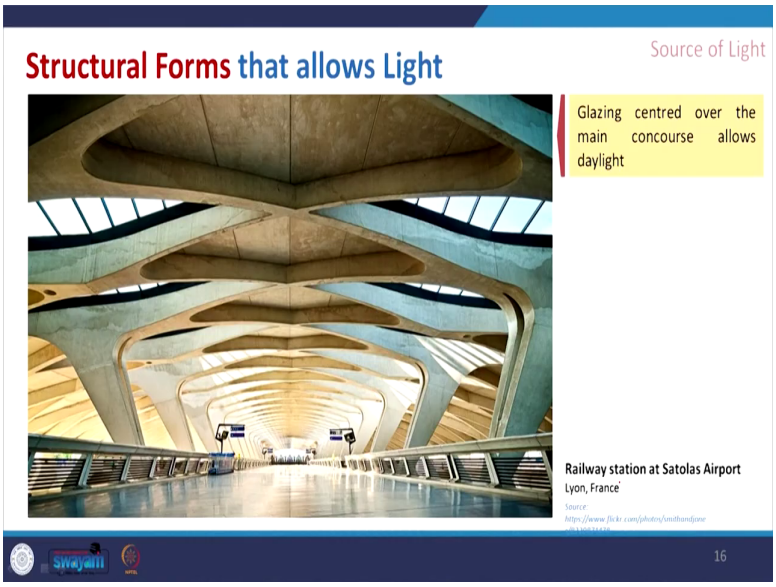
(Refer Slide Time: 23:14)



Coming to the, you know Burrell Collection museum. Here also this peach roof where the different wooden members is being repeatedly used and then it is covered with a glass material and that is creating a very nice environment at the atrium. So, this is another example where the structure being used as a source of light. So, if this could be alternatively done without opaque or the flat roof or maybe the opaque peach roof, so this kind of interesting environment will not be created. So, this application of your using structure in the manner where the you know light can penetrate and create this kind of beautiful environment is always you know appreciable job.

Coming to the another example this is the railway station in your you know France, the you know Satolas airport.

(Refer Slide Time: 24:10)

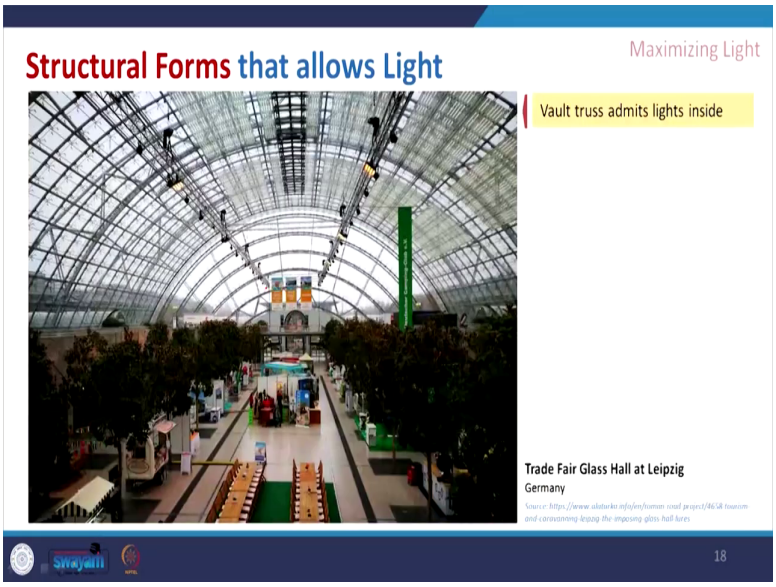


So, in this case you can see that the structure is nothing but a frame again, but this time it is made of concrete or the steel and this is designed in such a manner that the place the gap between these two portal is being covered with glass and that is giving the enough light to you know luminate this concourse level.

(Refer Slide Time: 24:43)

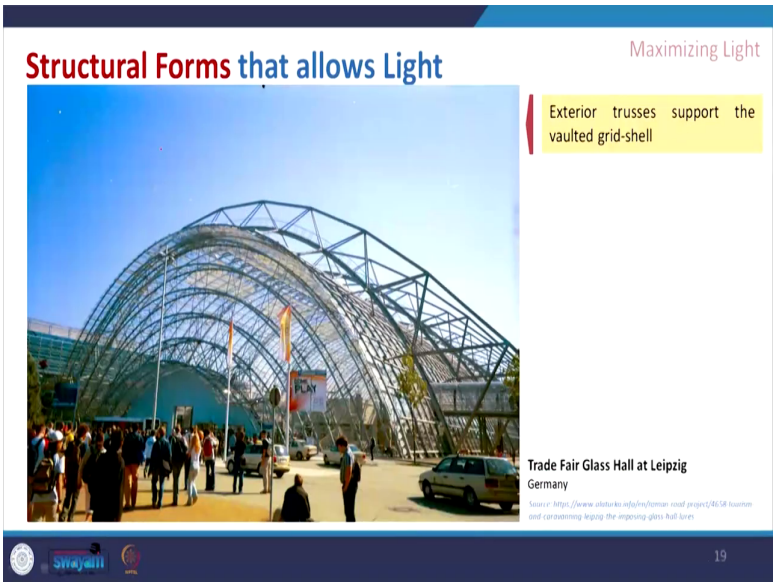
This is another view of the same where these being taken from this direction. So, the glazing centered over the main concourse allows daylight and this is really that arrangement is similar to the petal arrangement that we have seen in the San Francisco International Airport, here also in this railway station we get this ambience.

(Refer Slide Time: 25:05)



Coming to the next category that maximizing the light. So, this is the Trade Fair Glass Hall in Germany. So, in this case also this vault being created with your steel members and then that being supported outside, by some kind of space frame that you can see that how the structure being supported externally with this members.

(Refer Slide Time: 25:28)

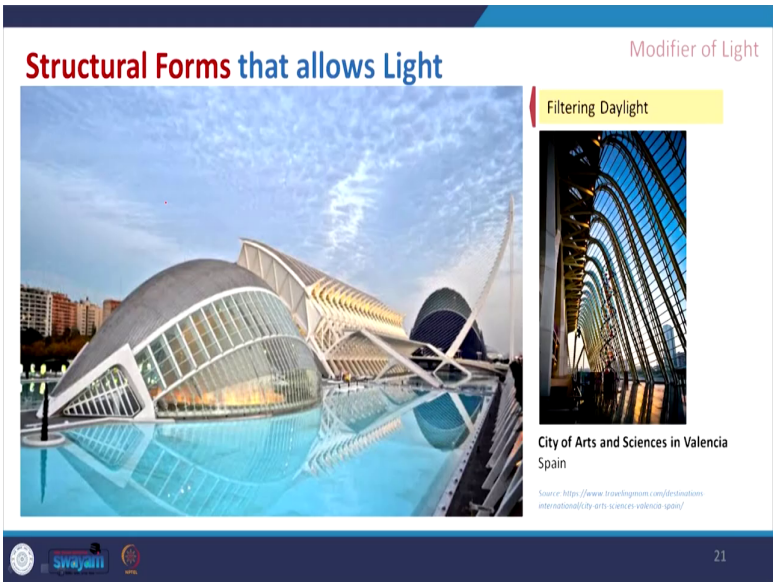


But here you can see that the whole structure is visually very light and also it will maximize the daylight penetration. This is similar to the example that we have seen in case of your Louvre museum.

(Refer Slide Time: 25:52)

So, in this it is a same concept of maximizing daylight.

(Refer Slide Time: 26:01)

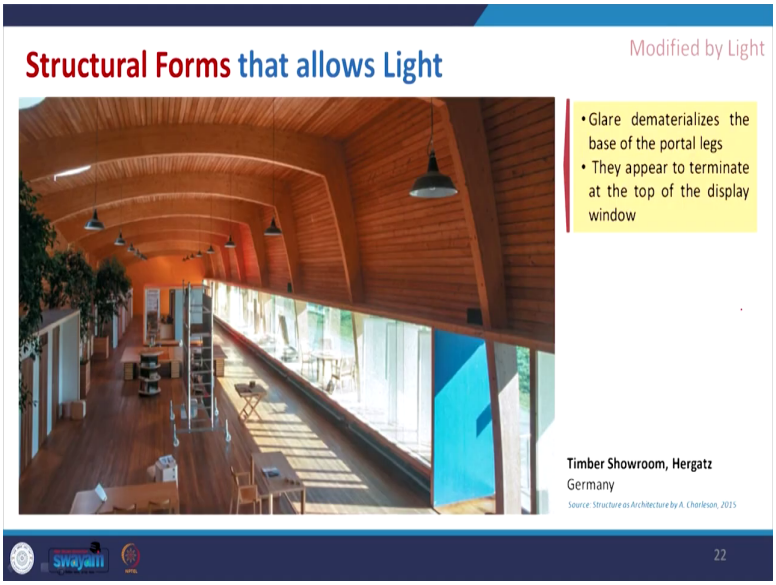


Now, coming to the modifier of the light. So, here it is basically allowing the light, but creating those kind of brief pattern and these you know lines is generating some kind of shade in a continuous spectrum of light and then that is creating some shadow see then shadow on the surface in the interior which is basically nothing, but a filter. Now, this filtration is through the members sometimes this filtration may also be done with the changing material with a colored glass, but in point of structural point of view we just obstruct it with different pattern of your structural arrangement.

So, mostly what we have seen is related to the skeletal to structure and the space frame. So, these are being very much useful material to do this. Mostly in the station area if you see many of the, you know Indian railway stations or maybe in abroad the stations where this kind of platform we get the use of the truss and portal frame where the light being created. In the same context even if you see some of the factory they are the not skylight there is a term terminologyuse. So, they have made this kind of truss system.

So, here the light can penetrate through this surface and then it will allow this kind of truss is allowing the north light truss is allowing the sunlight to enter in the functional area and then the adequate illumination is being accept. So, illumination is the lighting you know whatever the level of the light that is referred to that.

(Refer Slide Time: 27:58)



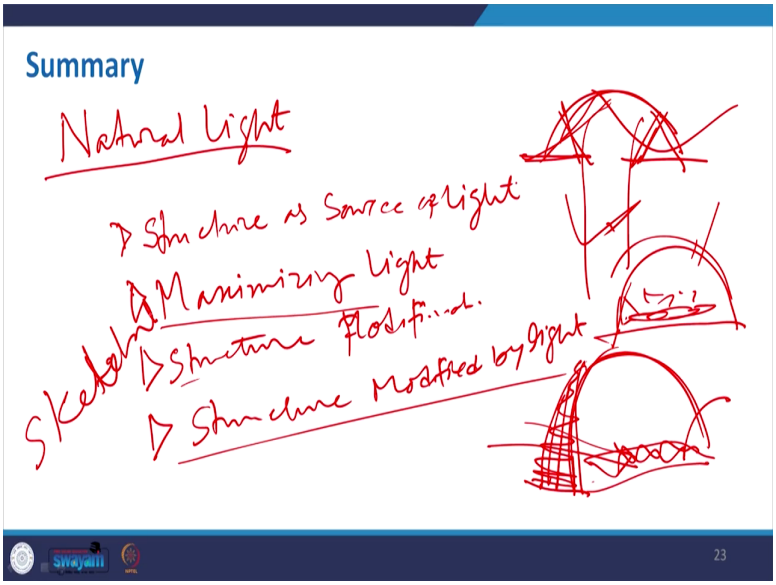
Now, coming to the last category of that and I have picked up only one example but there are many where we can have this kind of devices. So, this is the example from city of arts and science in you know Valencia Spain.

Now, coming to the last example in this category like the modified by the light, so what a interesting thing that you can see that because of the heavy glare and light, so if you see this picture and if you see the predominance, so this particular frame like this portion is almost you know (Refer Time: 28:42) or almost visually being omitted at this Linton level. So, the glare

dematerialized the base of the portal legs. So, looking at this you hardly can see this portion. So, whatever the highlighted part of this image this is that timber showroom again from the Germany, so they appear to be terminated at the top of the display window. So, this is the display window and this is being omitted. So, again here the amount of light the intensity of the light they are changing the structural arrangement.

So, with that I conclude this particular discussion and what we have learned from this. So, in this specially some of the buildings where there is a public gathering or maybe it is your residential building and you want to maximize the daylight penetration in order to get some you know natural feeling which we can connect with the environment during the daytime and as well as to some extent to reduce the load on the energy consumption. So, you can always make your structured in such a manner make prohibition to get the light inside without compromising the you know to the you know exposure to your rain and dust.

(Refer Slide Time: 30:11)



With that like it is basically I have talked about the natural light and based on the light how the structure is interacting and all, which is being classified in 4 category. The first is your like structure as source of light. So, here it is basically where the structure is allowing the light. The second category that we have seen that the structure is maximizing light, then the other third category is your you know your structure which make the modification, ok, modifying the light and then structure modified by light.

So, in this we have seen the examples of different the airport where like you know the top portion maybe this being exposed to the light and then with the reflectance and also this will get illuminated. In the second category, maximum light is a you know example of greenhouses, so where like all these visitations are getting the maximum of the light through the structure, where like the steel frame being used and then the glass covering being used to cover it.

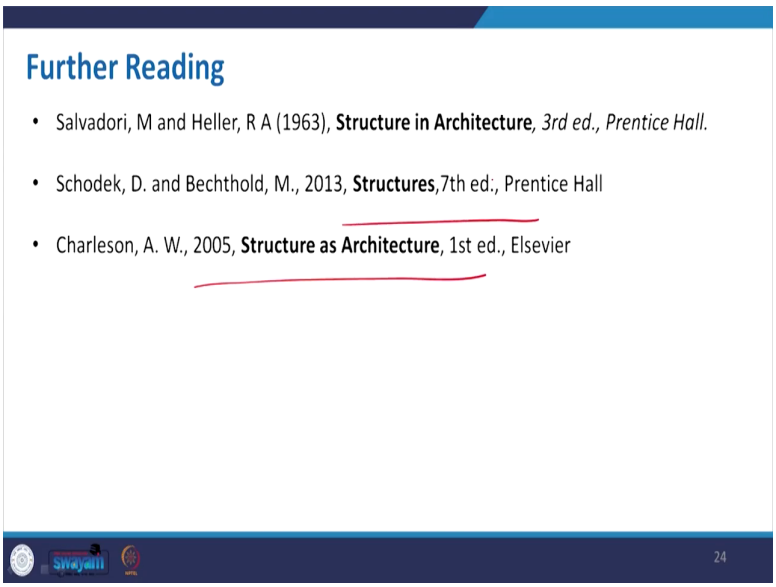
Now, structure which is modifying the light is basically the create the shading devices where instead of single frame we can use some kind of pattern or [FL], [FL] type of things which will you know allow light to penetrate, but that will also create a pattern. So, that is being modified. Then the structure modified in the light it depends on the intensity of the light, the tint of the light by which a structure is looking in a different manner that we have seen in the last example where with a huge glare outside and with this glass what from the inside what we initially in a in quick glance what we see that this particular frame is being terminated here. Though it is having a presence, but again like with the glare it is not that much prominent.

So, with this we can create some interesting structural form architectural ambience that we create playing with the light and the material selection. And in this what we have seen most of the time that this can be created with the skeletal, skeletal structure rather than a opaque structural walls or the masonry wall. So, wherever we go for the now frame beam column structure and structural glazing so, that will help to maximize it. And for the roof covering, for the open public area like airport or the stadium or maybe somewhere is a convention hall in that case we can use the light structure of like space frame or truss to do this kind of arrangement where that will help welcome light in a larger quantity without compromising the

other adverse effect for the opening. So, with this we can really create. So, this is all about your structure and light interaction in architecture.

So, with this I stop here. And these are the study material, you can go through. Already I have given this book references earlier, but then also you can go through it if you can get access to this.

(Refer Slide Time: 34:07)



So, with that we will be looking for something that I have talked about so many times in recent times that we will be discussing on the high rise structure, how this will be designed. So, we will be talking on your evaluation of high rise structural system in my next lecture and we will be discussing on different structural composition. And then we will slowly go with each of the component where for this high rise building phenomena against the wind and earthquake and how different system can resist it.

So, with that I again thank you all to take part in this course. And we will be meeting in my next discussion in the next lecture.

Thank you very much.