Structure, Form, and Architecture: The Synergy

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Lecture – 10
Learning from Animal's Architecture

Hello, everyone welcome back to online NPTEL course on Structure, Form and Architectures Synergy. Today we will be discussing lecture number 10 and it is all about Learning Lessons from Animal Architecture. So, so far whatever we have discussed in previous lectures we have seen some wonders, some creation by famous architects, our ancient people and structural engineers, so, buildings that we formed over the time.

But now, not only the human architects; in nature we also have some great architects, some birds, some animals, some even small creatures who can create wonders and obviously, from those kind of architecture we can get some idea, we can see their formation, the material they used and how they really built it. So, we can get inspired from them and we can apply that knowledge in our creation, when we decide upon structural form or creating architecture or choosing right material for the right structure. So, let us begin.

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So, this is nice example of nest and it is the (Refer Time: 01:44) nest which, is basically formed with a perfect neating of the grass and it is something hanging from a branch of the tree; where like the threat like other animals, other predators cannot reach to that part.

So, in this lecture we will get to know about such more from different you know birds or maybe; it is the small ants or maybe it is some other animal. So, regarding this particular nest I will also show you like a nest that I have during that particular portion. So, why they built? It is pretty similar. The reason that is why we built our architecture or buildings.

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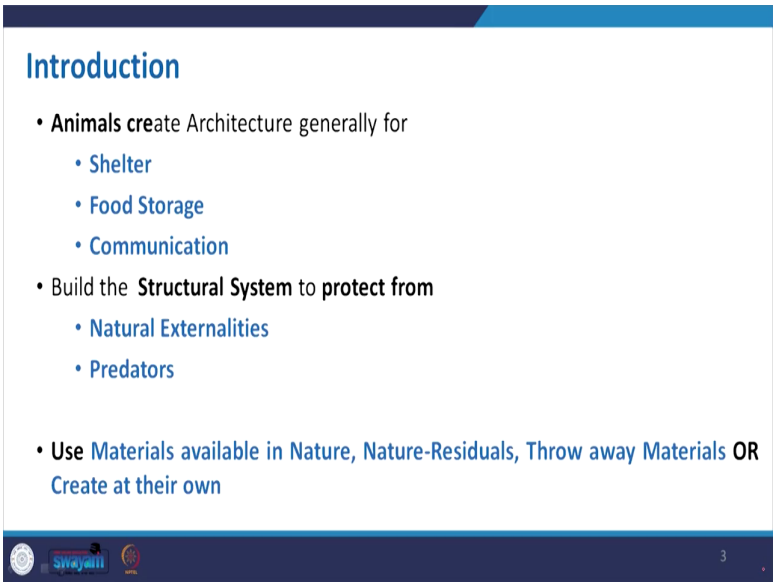

So, preliminary for getting a shelter then sometimes for the storage they need specially for the nursery, for the you know the kids they have to feed them they sometimes also need a storage and also sometimes for the communication; to make that nest to really make it attractive to their mate. And, also they build the structural system in such a manner, that which will resist the external you know load like the wind pressure or sometimes it may be the rainfall some natural you know cause that may disturb their nest so, they decide the structure on that and also choose the material on that ground and also to protect from the predators.

Now, the come to the material so, they use the material which is available in nature that in the earlier slide, we have seen that they have used the green grass which will again you know get harden and it will change color in presence of sun light; sometimes it may be nature residuals that you know the fallen branches, leaves and other residuals through a materials.

So, sometimes you just throw the you know material as waste it may be the ware, it may be some other stuff that normally we through to the dustbin or you know open space so, which will be used.

So, that is why we can say that they can create good best out of waste kind of product and sometimes also they create the material at their own, so, like the spider they just use from their own you know their saliva or something they just extrude from their body and then you know they create the material for their shelter or the nest.

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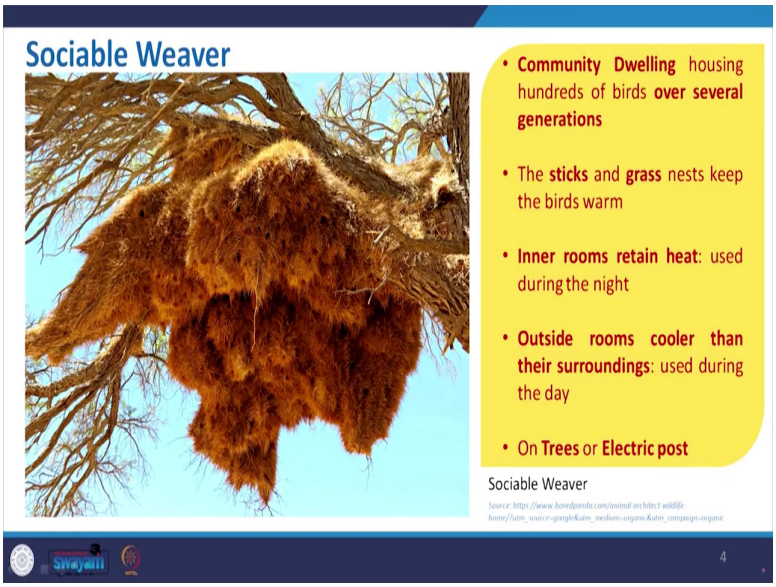

We start with sociable weaver; so, you can see in the image so, it is a huge structure and normally it is being made with like some grass or some winds like; materials, sometimes to give the stability they use the stick and here why it is called sociable weaver, because its not a

single nest so, they believe in community so, this represent a community dwelling like a mass housing and where they can stay over period of generation.

So, that is something really a good lesson from this kind of structure and if you look into the system that there are small holes these are nothing, but the entrance to that nest and you know that overall feeling the insight as because, the material used which is not, which is a bad conductor of heat so, maintaining the inner temperature they actually store it. So, normally during the night time they can definitely, get some cosines inside that and they used to leave and thousand and thousands of birds they can stay together in this and normally they make this structure, which is like some height may be on tree or sometimes may be some post so, this is example from sociable weaver.

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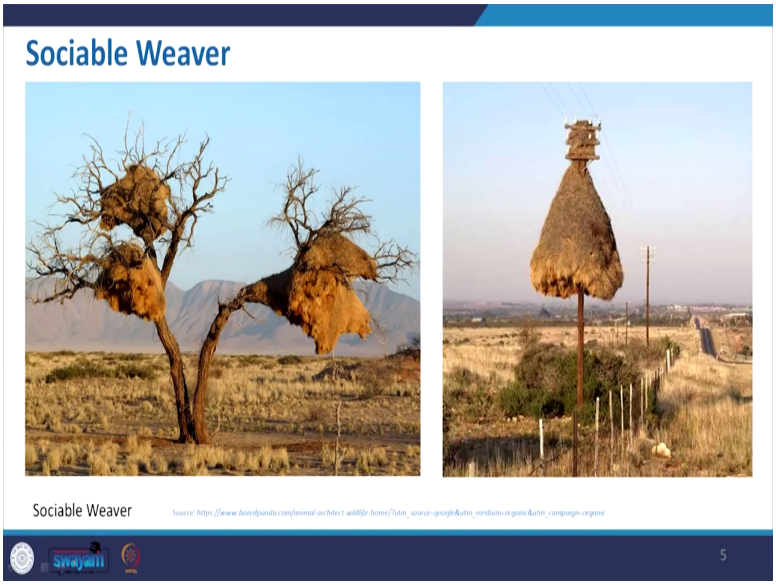

So, these are another two pictures of that, one they build it on tree and other one on the post. So, they build over the time and you know again it is representation of something where; they show the community dwelling or the housing. So, this kind of you know architectural features to create the mass housing can be you know, derived from this kind of concept and so, far the material is concerned they really, built it in such a manner with you know multiple layers of this grass and stick so, that they can also maintain the temperature fluctuation, which is also essential to protect them from the you know external you know like may be the wind, may be the heat that can disturb their you know inhibitors.

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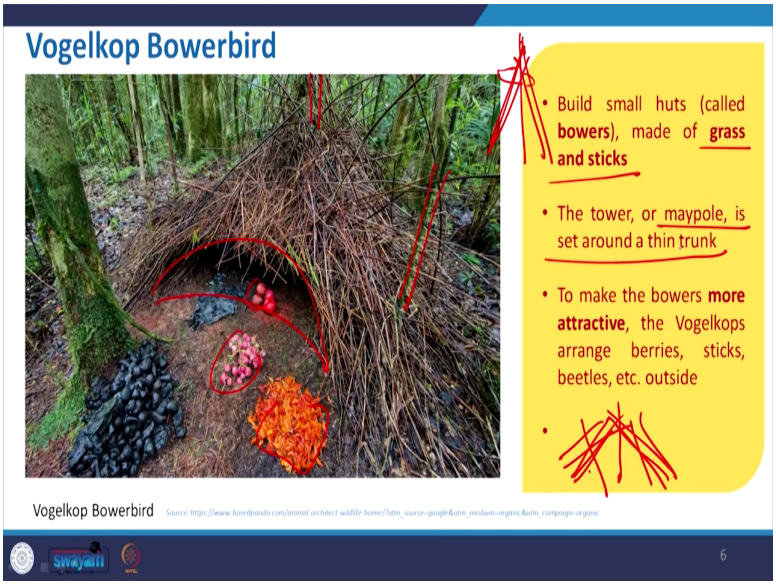

Now, move to the next one this is the Bowerbird and here you can see that this is just a pile up, of something. So, what is new in it? But, if you see that they nicely create some space in between so, its all started with stick and then just they placed it in a manner all these stick they used the friction to you know, lie them one after another so, that it will be stable. So, this

tent like structure if you notice that there is a small you know, branch and here also you can see in this picture that on which they just put the stick and grass to you know tie them up. So, this is being created, but more importantly here if you see those you know berries or some flowers or other thing which is giving a contrast.

So, this is something like ornamentation to this so, normally in this case like the male bird they build this structure. So, and make it attractive to communicate to its mate. So, this is again a structure, where this is build by a bird and you can see the effort like it takes time; so, it is made of grass and stick and stick its making this structure.

So, again I we can you know match this structure with the (Refer Time: 08:39) structure, where we also get this kind of tent where different sticks are tied up and then a membrane like materials is you know then put on top of it to you know protect it.

Now, again as I mentioned that they make all these structure along the thin truck on so, and then they make it attractive.

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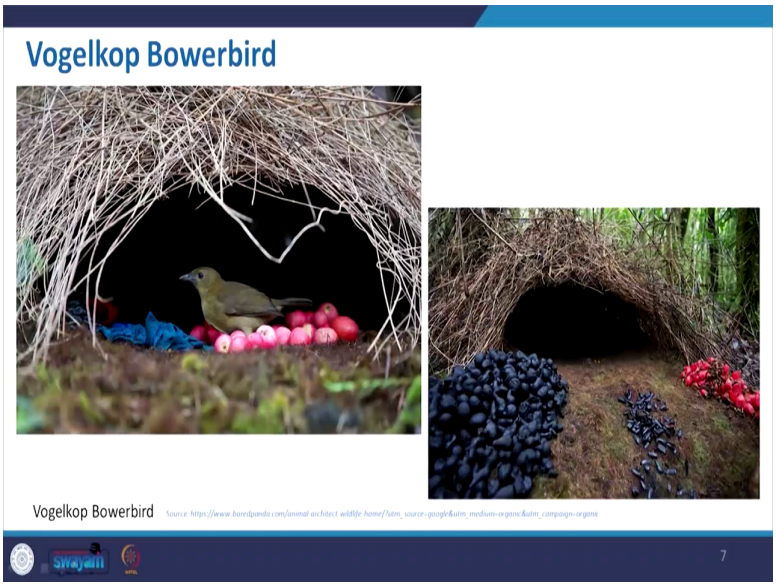

So, in next picture it will be much more clear. So, they nicely create this space. So, is not the pile up; so, normally this structure you can resemble with when you go for a you know bonfire or something so, we just pile up the street, but nicely created this structure which is also giving some you know strength it will not really break up and you can see the knots, not the knots is like how they placed all these stick criss cross so, that they will be sticked to each other with friction.

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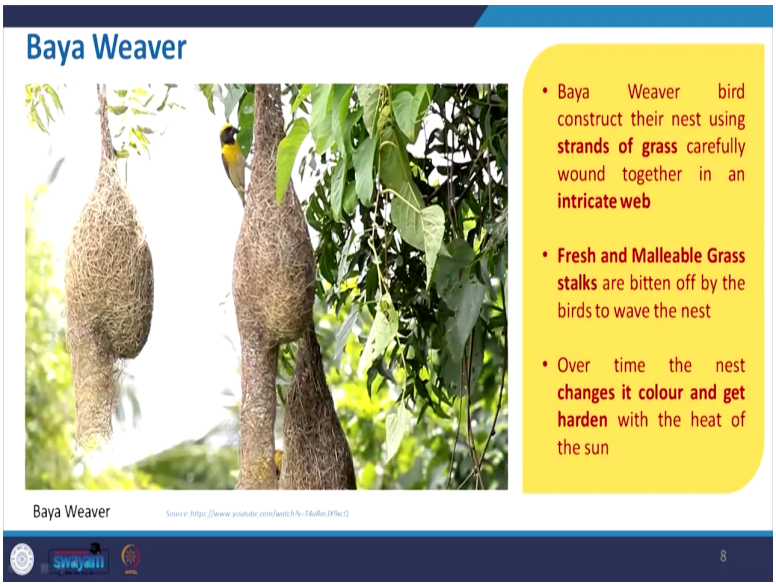

So, move to the next example, this is at the opening slide also i have shown this is a nest and very nicely built and it is again the formation, the formation is created with the reasons so, this is the entry from the bottom and specially this is built on a tree branch where it is a hanging structure and this is made of the grass so, that the entrance from this will help them you know to protect against the predators like the snakes or other, other you know ferocious animal to go inside and this is the portion if I make a cross section of it so, this is the chamber where they lay eggs and the kids grow up.

So, they are netting it very carefully and here they use again the grass and when it is new the fresh and malleable grass stalk, they use to built it; in that picture we have seen the color is green and then over the time it dried up and it give the strength and this all you know grass

acts as a fiber, which is also considered to be good attention so, they change the color and get hardened.

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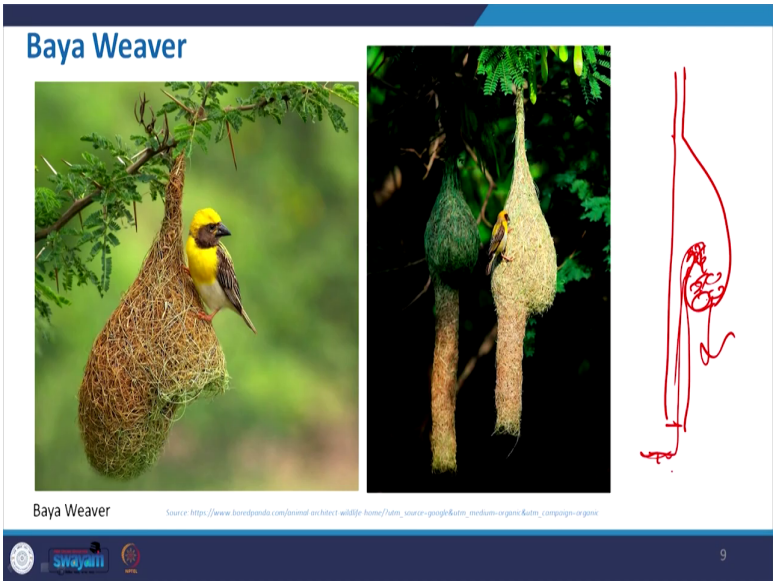

This are two pictures of the same kind, but more than that I have one of such.

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So, you can see this the pretty similar to that and this is a original I have collect it so, here you can see this is the bottom portion where I can put my finger up, ok.

So, this is the entrance and if I really want to cut it so, I do not want to cut it, here if you see this is basically this portion is very solid and they have a you know line chamber. So, from top it is something like that so, where they put eggs and all and as because, this protection being taken. So, it will not there really fall down. So, when this you know eggs they matured and then the kids they you know, are ready to fly away then they go out from that.

So, this is the mechanism and with this particular netting is very nicely netting and you can see that, how much dedication and how much time it requires and they make it the similar kind of materials. So, they are very choosy about which kind of material to be used so, it is not whatever available so, they choose it and its all uniform thickness so, you can see that you

cannot really pull this grass so, I just put the pressure, but then also it is not coming out so, this is a very good example of this and like definitively it will sustain for some duration and whenever they do not really feel like this is safe so, they make it empty and then they build again.

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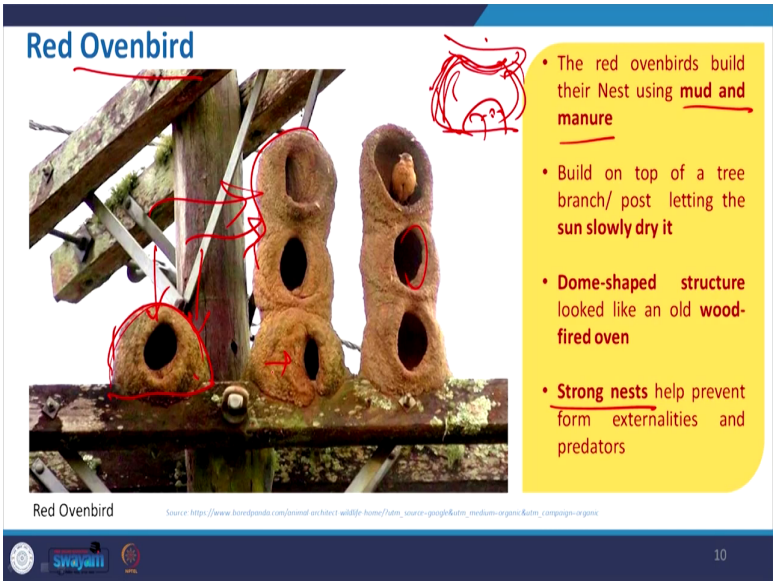

Now, move to the next one this is red Ovenbird; the you know, this Ovenbird the name also has some justification so, this time it is not the grass so, they used the mud and manure and they just you know, create the structure, and then dome like dome shaped structure they create and you know over time with sun light it dried up and give a solidity and you know some stability to the structure and with some small opening.

So, they can create multiple counter for the multiple you know user so, in this case mud and manure used and the acute dome structure; here you can see it very clearly where load can be

distributed, even this kind of you know shape is also we have seen that it is good for resisting against the wind so, this is another good structure they made and in this case this nest help them to prevent from the externalities and now, why it is called oven if you see this particular structure?

So, it is earlier days now, we are using LPG gas and other you know inductions, but earlier if you see in steal in rural area so, they make a some you know oven made of mud so, after burnings so, it get the strength it hardened and they use it for the cooking and all.

So, this is the similar kind of structure coming up and on that ground so, they used it and here if you see the material they have chosen this mud is basically, having some you know it is something laterite kind of things so, a reddish mixture and along with other ingredients so, they give the strength of this particular nest.

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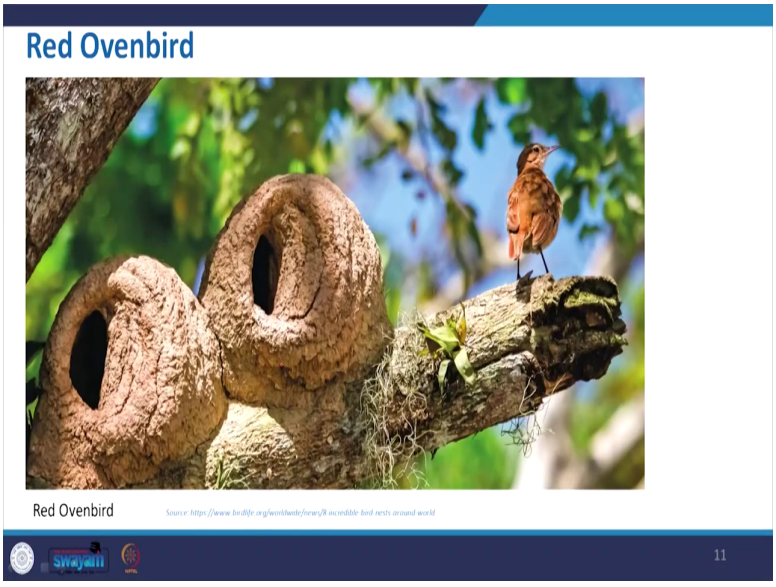

this is a closer picture of the same here you can see that, how you know stable and strong it is looked like, it is made on the you know on a branch which is giving some kind of base and the earlier it was on a particular post.

So, depending on the availabilities so, normally in the urban area where like availability of trees are less so, they do it on some abundant or something, where there is a minimal reach or no reach by the people so, they build their nest on that. This is the Swallow bird nest; and it is very common nowadays we see. So, here they made it with the mud and the saliva they create.

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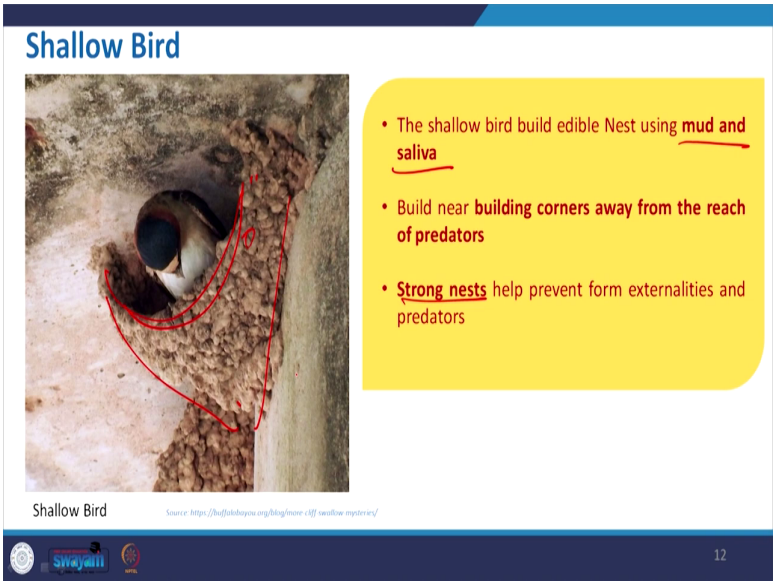

So, normally again they choose some corners. So, may be like in a building where like there is a very rare reach below the cornish or at the corner or sometimes, even below the flyover, so, they used to build this kind of structure where they can lay their eggs and they can stay for

this. So, this is again a important structure that built based on the material mud and saliva they mix it in a proper manner and they over the time they made it. So, this nest also prevent them from the externalities and as because, the position if you see that the creatures like the snakes and all they cannot climb on the surface, vertical surface so, they create this structure also very rough you know in this manner.

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So, that again it is giving a natural finish; this is another example of them where you can see the multiple such you know swallow bird nest are formed just at the below the roof top so, again there is no reason to get the rain inside it and at the same time it can be you know very safe, out of the reach of like the people or maybe this is something where like people do not really clear in a daily basis.

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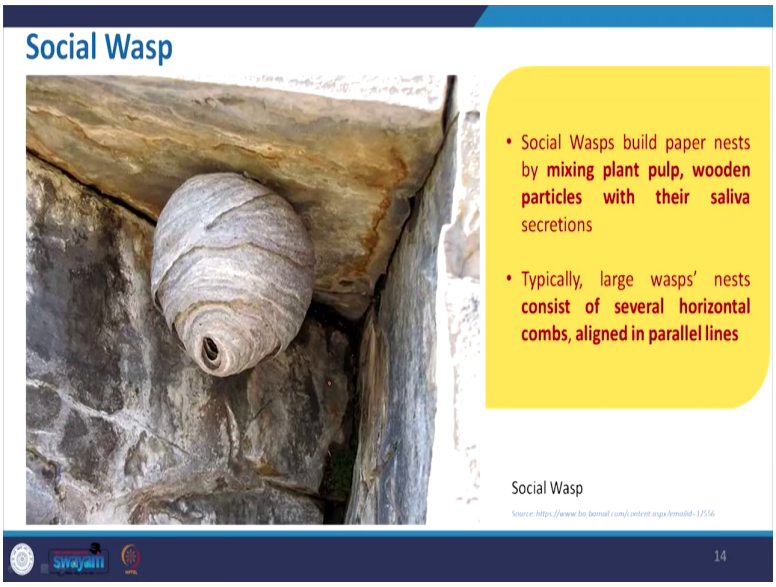

So, now, for birds we move to the Wasps. So, here it is basically a nice you know structure made layer by layer. So, it is basically the social works which build paper nests. So, why it is called paper if you really have a chance to look like the real one so, it is giving a you know feeling of a thin paper, handmade paper so, it is basically a mixing plant pulp, wooden particles and also the saliva secretion. So, they made that material and they built it over the period.

So, if you see that this is the outer look of that it is just the envelop, but inside it they have different cells; the main purpose for this nest is creating to lay the eggs and then they wait till they just get matured and they come out from the eggs, not for the storage unlike like in for the beehives so, they use it also for the storage of honey and like pollen.

So, in this case is basically it is consist of several horizontal combs aligned in parallel lines so, what exactly that will be clear by the next slide.

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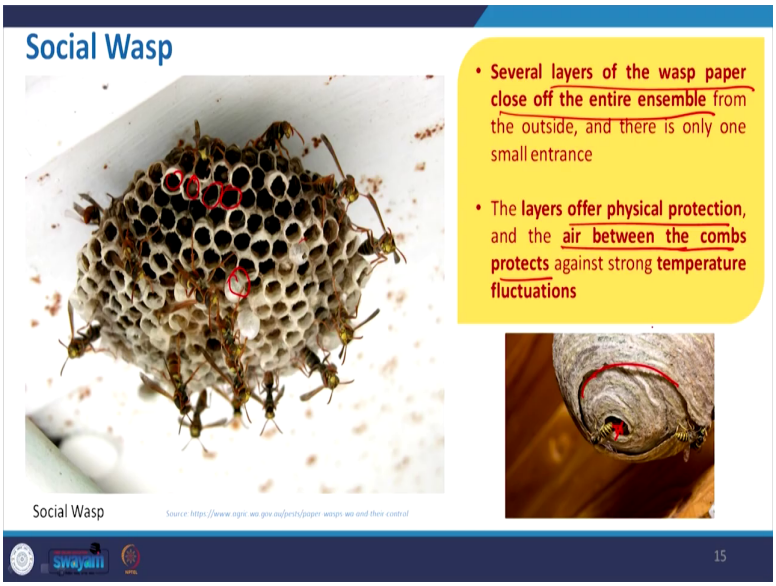

So, this is the you know when they start creating it so, you can see the cells it is the similar to the honey bee so, they create 1000 and 1000 of such cells together and they put the legs and they seal it with the same paper, you know kind of you know finish.

So, this is being created again with some wood particles or saliva and the other plant pulp and they seal it and then after that they wrap it and they have very, you know tiny opening to reach inside to that and whenever they just matured, they just break this itself and then they go out.

So, several layers of the wasp paper close off the entire ensembles. So, that it will not open to the external you know environment and also not open to the other predators; which may kill or may eat their eggs. So, this is something really very important and then also the layers of physical protection they provide and also they protect against the temperature deviation so, the you know gap in between two such layers is giving up void, which will maintain the temperature.

So, temperature fluctuation will not really effect the growth of the eggs and that is why, they build this structure and the organization from this you know the cells one after another those chambers is really giving some idea to you know build our you know design maybe, we can treat it in the plan a group of such you know rooms or class room or else it may be something sometimes, we can also treat it in the elevation which will have a similar and repetitive architectural treatment.

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Now, as I discussed that this is the similar kind of you know approach, but this time it is the honey bee structure and we all know, how beautiful they make it and it is basically the comb they create with regular six side that is hexagonal cell; which they actually built with the wax they can produce and where they just store larva and also the honey and pollen. So, once they lay the egg and they seal it with the wax. So, to protect it still it get mature and the reason behind this hexagonal shape is basically it fit together all these you know, cells one after another it can fit the maximum without wasting much space and with minimal effective parameter, it can give you the maximum area.

So, safe for example, instead of hexagon if I go with the circle so, we can see that when we make it so, there is a gap and that is not really effective utilization of space whereas, when we make it an as you know multiple you know 1000 and 1000 of such you know worker bees,

they are making this structures. So, they just follow it on that ground. So, they can easily link up one after another to create it.

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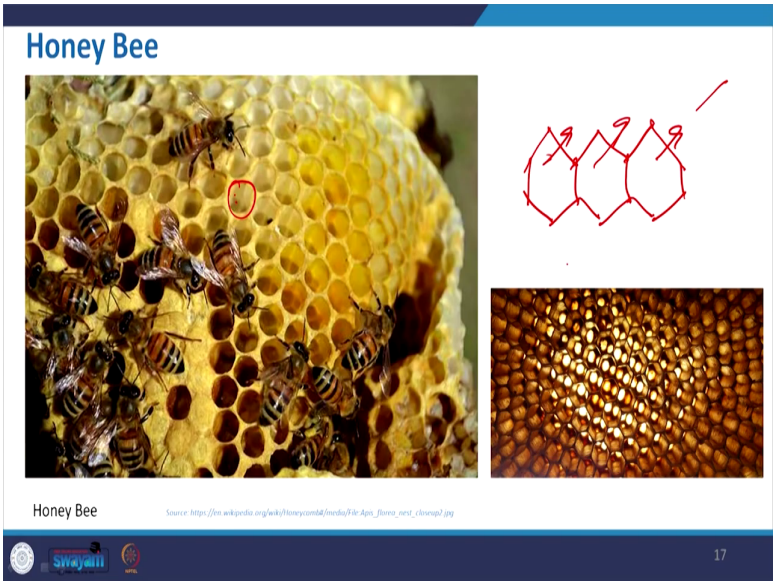

And, here you can see the details; this is one example of this you know empty honey bee structure, which is very perfectly built with this is very light and when they put the honey and then the eggs so, they sealed it.

So, again I am showing you the reason of this, so that you can see automatically it giving a cluster. So, this is something where also we have you know since some of the buildings, which also formed it. So, create multiple (Refer Time: 23:05), it may be a hotel room, creating the view, so, again it is maximizing the space whereas, the other form is not that much effective than this one. So, that is why these being chosen and again these structure you

know helps us gives some idea to the form the hexagonal form that we can create, which will be easy to put such many regular shapes one after another to build the huge structure.

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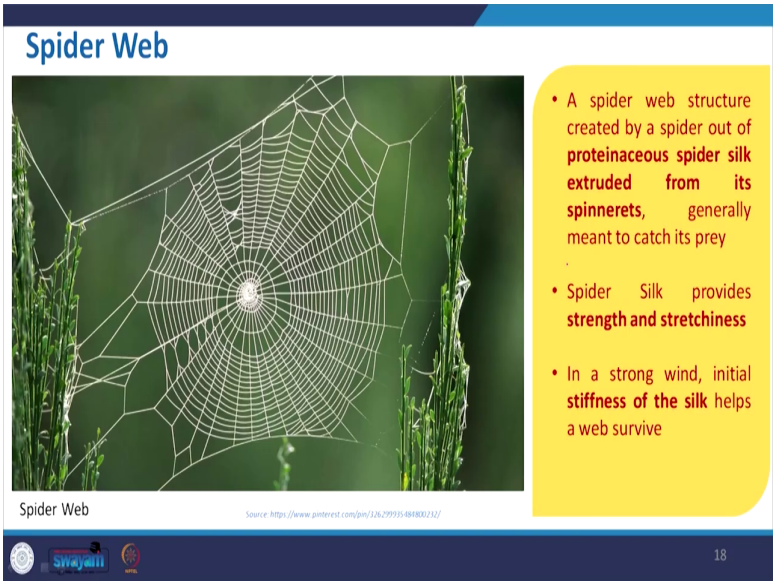

Now, this is something really you know interesting and we all I guess I am sure that like me you also like the series of the spider man. So, there we know the reason like this is the power that one can, you know create the spider web which is having the strength, it can elongate and its probably it has been like the reason they create it; with the spider silk they just you know produce from the mouth and this is giving like a cable or rope netting structure, where some of you know the portion is tied up with the available support and then they build their with the precision.

So, normally it has some additive property which will actually, you know catch the other insects or something. So, some like some you know other flies or mosquito or some other

creatures; if they somehow come in contact to this so, they will you know be obstructed to that and then spider can easily store their food with this nest. So, in this case basically, the spider silk which is basically proteinaceous silk and they have the spinnerets so, there from there they actually create the structure.

So, this particular spider web they are good, you know having good stiffness and also they are having this strength and stretchiness. So, it will have some property we can when we put the pressure it will elongate and then it has the property, elastic property they can get the retain the original shape. So, that is why it is giving a good you know example of the how structure can be built specially for with the rope and other cable suspended structures.

So, it is having that same concept and they built it at their own and in this case they produce the material for their construction.

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So, you can see that again where ever it is beyond the reach and some the area, where it is not being really regularly be used so, they create it very beautifully and netting it with perfection and there are some main anchors to that wave and then they built it the other support; like this all links are being made and so, they also follow the geometry so, depending on the spider category they also go for different kind of spider waves.

So, this is another good example from animals architecture, which we can also get some clue where like this can be used in our building structure; for specially cable suspended where like we build the tensile structure, like may be something with a very thin material and we can create that overall you know outcome we will produce and there also we can get this kind of you know cable suspended structure, which having tension to manage it.

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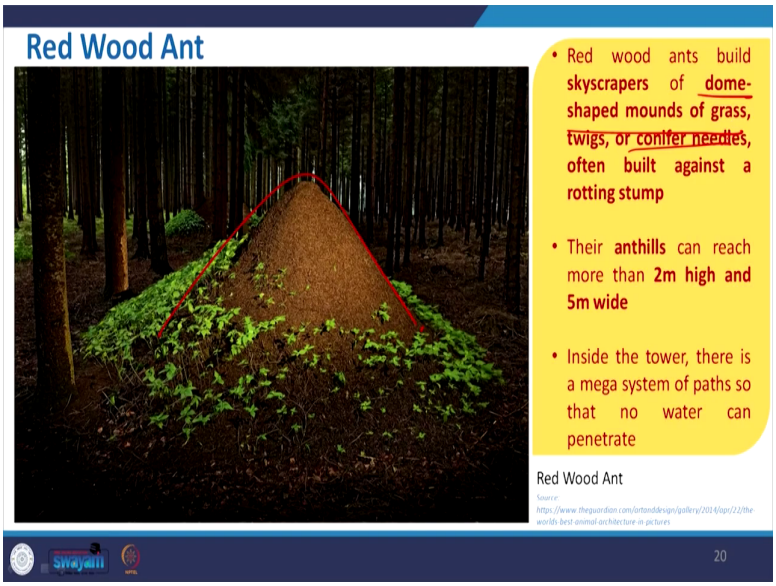

Now, come to the even smaller than that is the some red wood ant and they pile up so, this mound kind of structure normally we have seen in the forest area or sometimes even the area is having some humidity, just after your rainy season so, this being created. So, this is again a skyscraper a compared to the scale of that particular animal, which is also known to you know carry almost 30 to 40 times of their weight the building materials so, this is the skyscraper dome shaped mount of grass twigs then conifer needles and then again they use some other, you know wood dust or whatever the residuals they can pile up so, they create this mount with proper ventilation and this ant hills.

So, this is hill like structure so, its referred at ant hills can up to 2 meter and 5 meter wide and depending on the side and the nature so, it can also vary so, inside the tower there is a mega systems. So, we can only see this mound, which is not looking very decorative and all, but the system inside is really making us wonder like; how this can be you know built and function fulfill the function as per their requirement.

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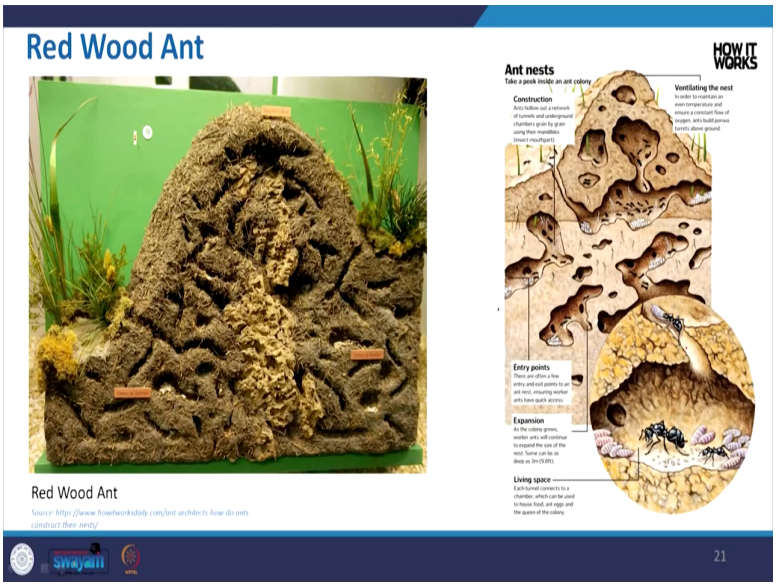

So, here you can see this two you know image that I have taken from the source so, here they have divided the whole interior space into different segment. So, somewhere this is the chamber, where they like leave they just put eggs some where they put some storage so, they prepare everything. So, in this case if you see this are the entry points and how will they built it up so, that even if there is some rainfall so, something will be protected.

So, this all cells how they make it you know with their caliber is really appreciable. So, in this case you can see that the extension then the leaving space so, they go even you know deeper and deeper for making their life safe. So, this is very important lesson so, this is one kind of underground structure they made and this all space are well ventilated, that is another important aspect that when you built your underground structures so, that should have some ventilation.

So, whether it is naturally done or may be artificially, so, in this case this is a natural ventilation and they maintained the temperature, this is a model where it has shown all these you know aspect that is being described in this photograph.

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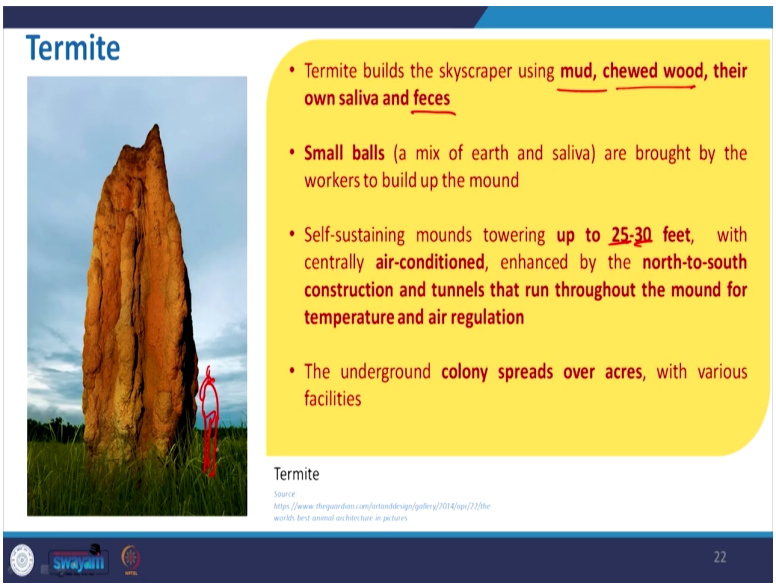

Now, next example is like the huge tower that is the termite skyscraper. So, here also the material they use that is mud, then the chewed wood, their own saliva and feces. So, with that they create this material and they can go up even to you know 25 to 30 feet high so, it is a you can see that our average height may be; 5 point say 5.5 feet and then it is almost 5 times to that.

So, it is a huge skyscraper and also it is self sustaining mound. So, this staring up can hold a million and million of the termite along with some of you know the area that they built underground so, here itself the self sustaining mounds towering up to 25 to 30 feet and it is

air conditioned and the tunnel, they create they are actually maintaining the temperature and the flow.

So, this is very important relation and the underground colony spread over acres. So, if we only see this is something we can also say for comparison like ice berg; so, basically only a few portion that we see as a super structure, it is not all they built below the ground and they can really create again a good underground infrastructure, which being clear from this.

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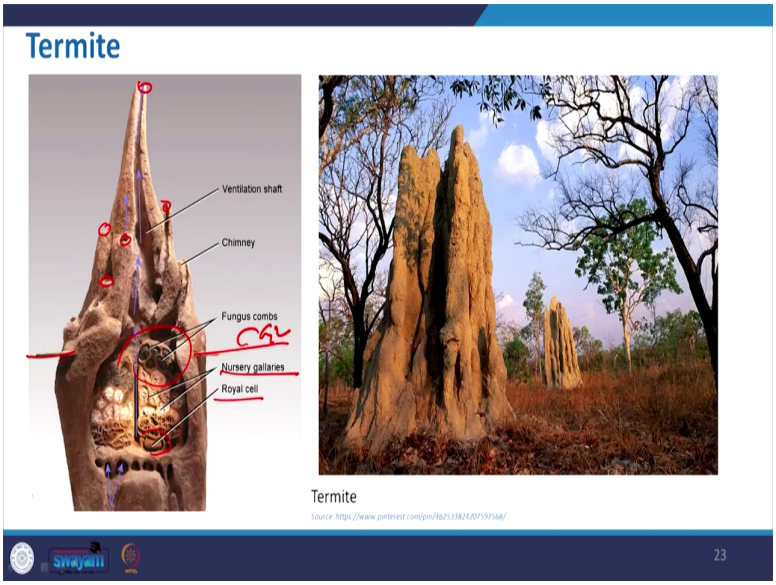

So, you can see this is basically the ground level. So, on top of it you can see some of the pores so, these are mainly made for the circulation of wind, which will really give the ventilation and inside that they have multiple such chambers, where they grow the nursery so, you can see the nursery galleries then there are some royal cells, where normally the queen

will stay and then also they you know cultivate some of the fungus and other combs there which will be used.

So, this is another example where you can see the shape of this is really high and how they have created so, if you see the close loop they will there will be the whole like this and they create in a multiple manner. In Australia and those places it is being observed in a grate; even in India if you go to like the forest area and all in south if you go to Coimbatore and then you go to Coorg; so, you will find these kind of a structure or where like it is being made by the termite.

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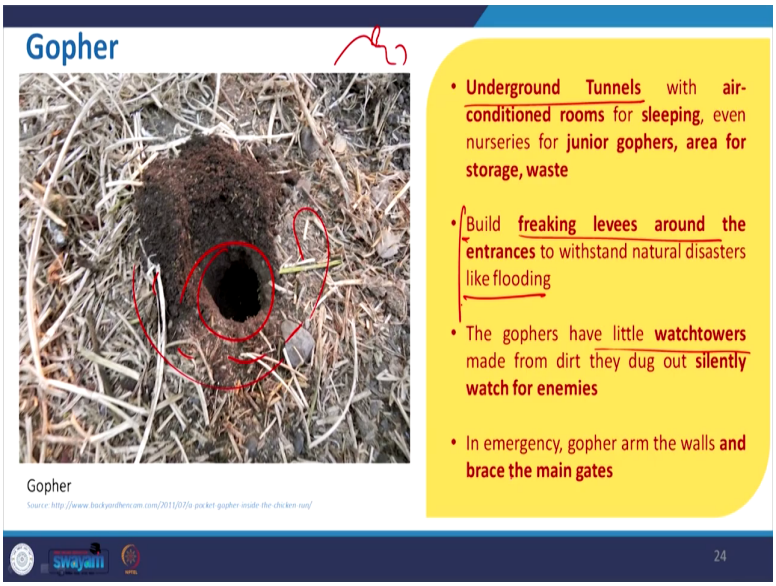

Now, this is another example where it is really like a disturbing element go for like the people who cultivate, because this is really they are really getting frustrated with this so, but they create such good opening and they built almost the underground town ship so, with all the

facilities so, care basically the underground tunnel with air conditioned rooms for their sleeping, for like their kids and also for the storage and also they maintained the hygiene so, in the next slide we will see that how they create the area, where the uses for the west for that.

Now, again another interesting thing is that; they create some freaking leaves around the entrance, which will basically protect the inside structure from the rain to penetrate or go inside and then another important thing in this they create some watch tower, how they create it to create the tunnel the residuals will be pile off here and there and they can watch silently the what are the things happening, is there any enemies or something to be disturbed they just blow the whistle and they have some escape route.

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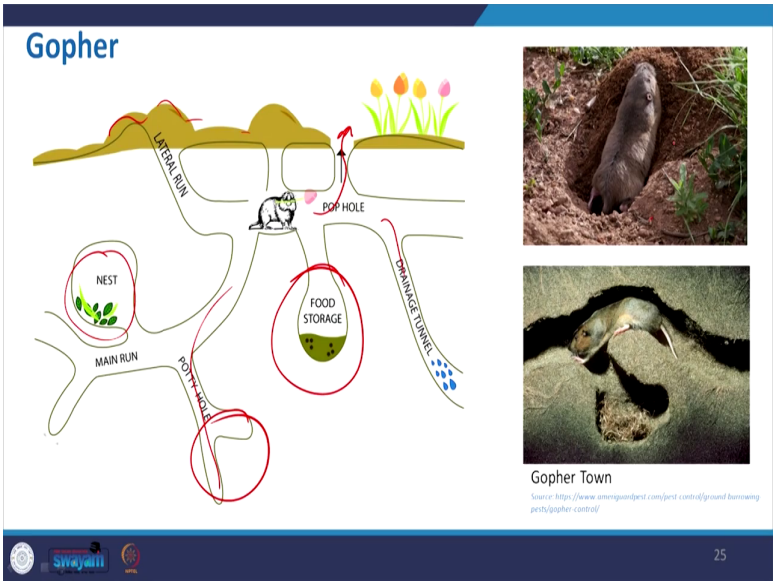

So, without delay let us see the system. So, here it is the schematic system that I have taken from a source. So, where they have like the nest where they like; really grow for the kids and

they also have the food storage so, whatever they collect they story it for the future use then they have a drainage tunnel, which is also connected

so, they have like a potty holes so, where they can use it as a latrine or something and you can see that there are some multiple you know this powerful hole is for the emergency exit and you can see that, how these are piled up. So, the overall town ship this particular features, how they made it with proper planning and all this is really a great thing.

So, this is the image and here they are creating this particular hole, they pile up the mud and all so, again this is giving sense of the panning and creating the overall structural arrangement like; how they put all these facilities and this food storage away from the waste area or the drainage so, these are something like how they distribute the whole space and then create this.

So, again this is one good example of underground structure and again with this they are ventilated so, they also use this particular structure for their need.

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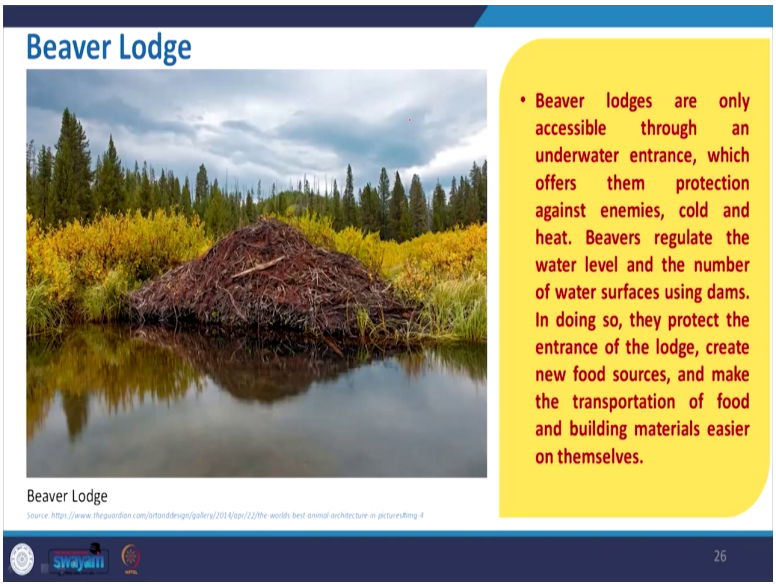

Now, we are coming to the end of this discussion so, in this case it is the beaver lodge so, normally in the area where you have some lagoons or some water body; so, there they create this kind of structure. So, in this case they also can regulate the water level and then create the dam.

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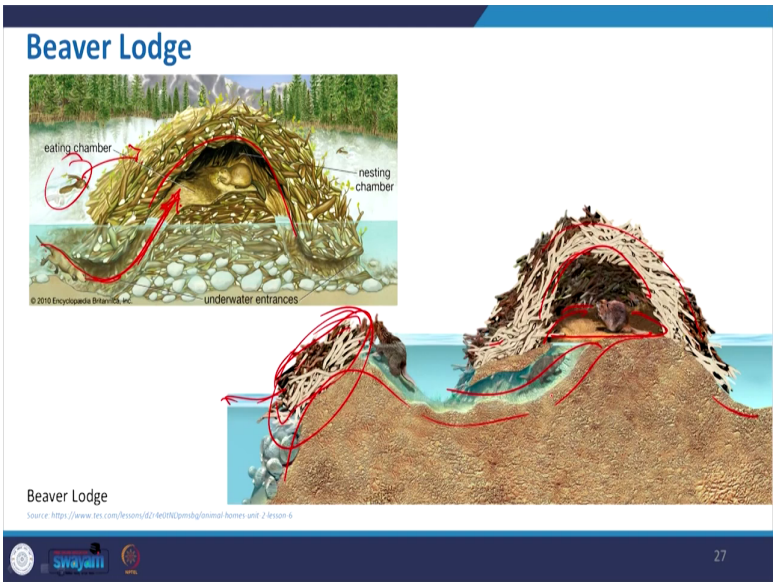

So, what exactly it is let me take this you know slide to explain you so, this is the water body so, this is the settlement of that so, they create a dam in this portion so, that the reduce, they reduce the you know speed of the water the flow of the water and then they create this particular nest to piling up the tree branches and other things.

So, like the previous image we have seen the overall, this is looking a heap of some you know garbage, but actually it is well designed and well executed by them and the interesting thing, if you see in both the picture they can swim, they can bring these and here you can see that they are making this structure and then from below the water they have entrance to this and once they reach in this flat this is basically the dry land so, where they can survive they can eat they can also you know you know reproduce.

So, this is the structure they built and again this is some structure or tent they built of some of the tree branches and other material to protect them from the external environment and also from the other creatures and this is really interesting to have the entrance below this so, this is something the way they maintain it and creating this dam to you know slower down the flow of like; high flow of the water body or something which will actually protect their main nest.

So, this is really some great work by them and like all these examples we have seen, these are some limited information, but there are many like we can take the example of butterfly or maybe; we can take example of different kind of nest so, every time we get the sense that, how accurately and whatever the available materials to them they have they select it and built it.

So, starting from the beaver to the beaver lodge so, you have seen various you know deviations sometimes they have taken material from the nature, sometimes they create it at their own with the saliva or the you know spider silk they create at their own, but ultimately the outcome they create that is for the survival, the storage for the food or may be just the most important reason to get shelter to protect their life's from you know from external environments and also from the predators.

Now, this light is basically the manmade creation, but inspired through those.

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So, here if you can see this kind of membrane structure which is also a representation of the spider web. So, different trades and some rope like material being used to create it, this is the similar kind of approach there and this is the nest so, as we have seen in this particular nest of beaver. So, this is inspired by them and they create it, to get nights environment of creating the form of this architecture.

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And, it is continuing here like the honey comb structural approach, being taken in the elevation this is already we have seen in the last slide was it was a 3D printed house, but here again it is the formation of your what we call the wasp kind of structure; where you can see the surface.

So, layer by layer so, they print it. So, its very nicely done and this is the example from the Beijing Olympic stadium, which is also inspired by the bird nest. So, all these structural member, they put together so, give overall ambience to that. So, this lecture I am hopeful that it will really give us some insight, how we can get inspired from the animal architecture and I would like you to really search more on that, and enhance this vocabulary of collecting the information like different kind of you know material being used, different kind of structure being formed by those animals, the birds, ants and other.

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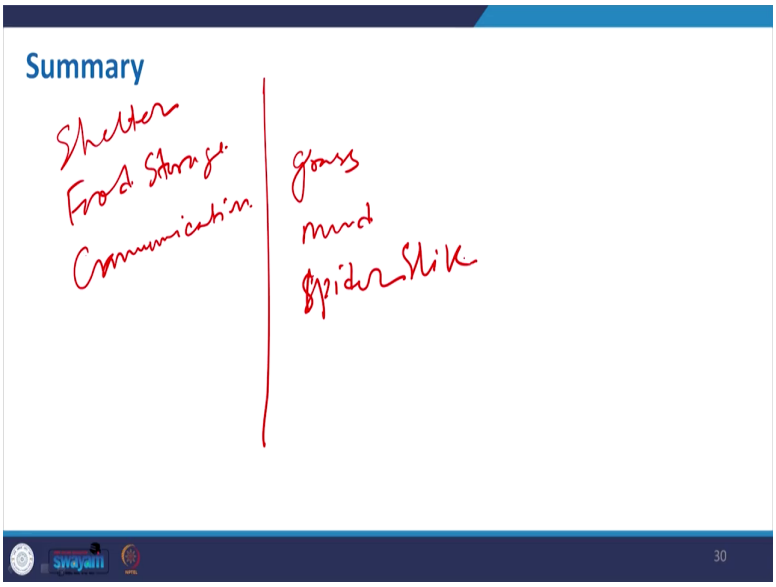

So, that is why that will help and with that if we summarize here basically; like starting from like the main purpose is shelter and then food storaging you know we have seen in the gopher case, that we have this and then communication so, the nicely built structure will also make it very attractive to the soul mate.

So, this was there and then again the material selection, we have seen from you know grass to the mud and then it may be the spider cell so, it will actually, you know we can make the long list how they make it so, I want you to do that so, we will have more example in due course of time.

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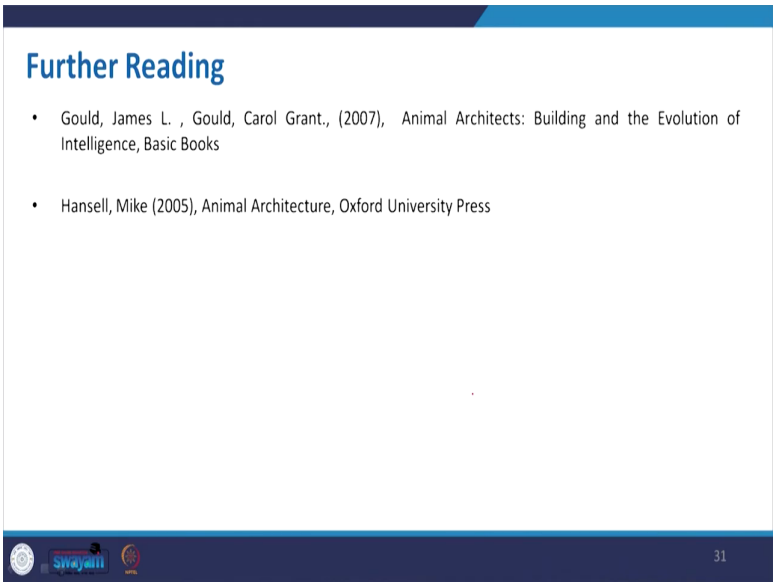

So, with that I also put some two books regarding that so, this is one from the animal architects; building and the Evaluation of Intelligence the other ones is the Animal Architecture. So, you can go through this two books to get more idea about their, you know philosophy and other thing which will help us.

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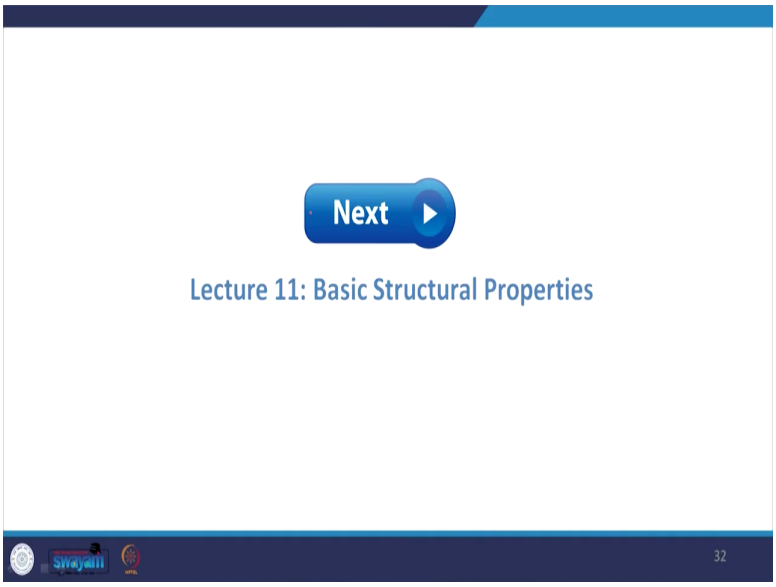

So, with that I conclude it; and then we will start with the structural you know properties and all we will slowly moving to different structural system and again I thank you for taking part in this course and till next lecture it is bye, bye from my side.

Thank you.