Course Name: Architectural Approaches to Decarbonization of Buildings

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Lecture 02

Renewable building materials based Case studies

Hello dear students. So we have been seeing what are renewable materials, what are their characteristics, what are those materials and how A combination of renewable materials along with appropriate technologies can yield low carbon buildings and low embodied energy buildings. Today we will just have a look at case study of renewable building materials which have been used in buildings. For this class and the forthcoming class we will take a look at couple of case studies. The first one is the Meti handmade school in Bangladesh which is made completely using bamboo and is a handcrafted school. Now this Meti handmade school in Bangladesh is located in Dinajpur, Bangladesh.

It has a warm and humid climate and as we had studied in the previous few classes for warm humid climate, the building needs to be very porous to allow a lot of breeze and wind movement. The total area of the school is 325 square meters and is designed by Anna Heringer and I.K. Roswag, was completed in the year 2007.

This project seeks to prevent the ongoing population migration to the city due to facilities in the city by raising the standard of living in rural areas. The main factors that could spur building development in rural areas are high labor costs and readily available local resources like bamboo and earth. The development and refinement of historic building techniques along with the transfer of knowledge to local craftsmen change the perception of these methods. So, Bangladesh is one of the most densely populated countries in the world. It has lush alluvial plain in the Gulf of Bengal.

Almost 80% of the population live in rural areas with an average of almost 1000 person living in every square kilometre. Earth, soil and bamboo are the commonly used vernacular materials in these buildings in these areas. Although construction methods are prone to many errors and many buildings are constructed without foundations or damp proof cores. These structures are typically only 10 years old and require frequent maintenance and are frequently vulnerable to damage because of wrong information or being ill informed about the appropriate construction method. With the free and open

learning environment, METI school seeks to support each student's unique skills and interests while accounting for their varying learning speeds, various learning pace.

It provides a different approach to teaching than the conventional frontal method. This idea is reflected in the architecture of the new school which offers a variety of places and purposes to complement this method of construction and teaching instruction. Now this is the plan of the Meti school. On the ground floor it has thick You can see the earth walls are extremely thick on the ground floor. And three classrooms are located each with their own access opening.

and it opens into an organically shaped system of caves in the rear. So, it opens into a system of caves in the rear of the. So, you can see in the rear it opens into small system of caves and in the section you can see that this is the classroom and this is a small alcove called as the cave as can be seen here see it's a cave. Which is only and then you have classrooms only in the ground floor. Separate classrooms only in ground floor.

The upper floor is by contrast very light and open. If you see bamboos here very transparent and transparent in the sense very light. So, it is very light and open. The openings in the bamboo walls offer sweeping views across the surroundings. It has large interiors providing space for movement.

So, this is a large interior space here providing movement to people and because of this views as well as breeze. It's very porous. And shadows from bamboo strips play across the earth floor and contrast with the colorful materials on the sarees in the ceiling. The ceiling has a number of sarees draped. I could show you in some other picture that Now the ceiling has sarees and the light from this and through this casts a beautiful shadow on the floor.

This is the classroom area. And this is the cave area. So students can seamlessly move from classrooms to the cave area. That's by far its design. So you can see the thick walls.

The walls are extremely thick. mud walls and there are classrooms and then this is the access to the cave from the classrooms. So, you can see on the ground floor this is made up of clay it's with its alcove and this is alcove or caves or whatever they call and these are made up of bamboo. This is also made up of bamboo and only in one place you have double height and you have these spaces are large and permeable allowing breeze to move in and also light to penetrate inside. These are the saris on the ceiling through which light enters and casts a colourful shadow on the ground and you have seamless wind movement across the classrooms.

You can see the infill is made up of bamboo mat and everywhere there is use of bamboo on the first floor. Now the upper storey is a frame construction of four layer bamboo beams. and vertical and diagonal members arranged at right angles to the building. The end of the frames at the short ends of the building and the stair also serves to stiffen the building. These are connected through additional structural members with the upper and lower sides of the main beams and equipped with additional wind bracing on the upper surface of the frame.

Beneath, it provides support for the corrugated iron roof construction and is covered with timber panelling and adjusted in height to provide sufficient runoff. The ceiling of the ground floor is a triple layer of bamboo canes as can be seen here. So, you have bamboo canes, you have the cave area and this is the classroom area whereas this is the cave area. The ceiling here has three layers of bamboo canes with the central layer which is arranged perpendicular to the layers above and beneath. So it is arranged, the second layer is arranged perpendicular to the in section.

This is how it looks. So first layer, second layer which is perpendicular and third layer which is on top of it. and beneath to provide lateral stabilization and a connection between the supporting beams. A layer of planking made of split bamboo canes is laid in the central layer and filled with earthen mixture analog to the technique often used in ceilings of European timber frame construction. And then there is a infill of mud here.

The structure is supported by brick masonry foundation that has 50 centimeter depth and has a face cement plaster finish. The most popular item produced by Bangladesh building material sector is bricks. The other most important and significant addition to native earthing building abilities is the damp proof course. Two layers of PE (Polyethylene) film that is readily available locally make up for damp proof course. The ground floor is realized as load bearing walls by means of a cob walling like technology.

With the help of cows and water buffalo, a long straw earth combination is created, which is then piled to a height of 65 centimeters per layer on top of the foundation walls, creating a mud construction. After a few days, any excess material that reaches beyond the breadth of the wall is cut with sharp edges or spades. After a drying period of about a week, the next layer of cob is applied in the third and fourth layers the door and window lintels and jams are integrated as well. The ring beam made up of thick bamboo canes as a wall plate to the ceiling is also integrated so these are all cob walls made up of mud There is a damp proof course. So here you can see foundation.

And then you have classrooms here. These are the caves. And then you have the upper floor. And this is the double storey height. And then you have the roof layer.

All the materials that are used are renewable because so far mud is used on the ground floor in the form of cob walls, roof is made up of bamboo and the walls of upper floor is made up of bamboo. The exterior surface of the earth walls is visible and the window jams are rendered with a lime plaster. The framework construction of the facade to the rear is made up of bamboo canes placed in footings and made of old well pipe and with split horizontal timbers as lattice work. So, there is intense lattice work here. And all these are split bamboos, bamboos posted there.

This is made up of clay. Now, the interior surfaces are plastered with clay plaster and painted with lime based paints. The caves, so-called caves, are made of straw earth daub applied to a supporting structure of bamboo canes and plastered with red earth plaster. The upper storey facades are clad with window frames covered with bamboo strips and coupling elements hung onto the columns of the frame construction. A fifth layer of cobwalling provides a carpet, a parapet around the upper story forming a bench running around the perimeter of the building and anchoring the upper story frame construction and roof against wind from beneath. A textile ceiling is hung beneath the roof and is lit from behind in the evening.

The cavity behind the textile ventilates the roof space. So, a beautiful and perfect example of use of renewable materials and since it is a school building, the on-site labour And training of workforce takes place only with the rural people. The masonry foundation was constructed by a company from the regional capital Dinajpur. The earth building works and bamboo construction was undertaken completely by the local labourers. The building techniques were implemented and developed on the job together with the architects from Germany and Austria.

25 local tradesmen from the vicinity were trained during the building works creating new jobs and providing professional help for self-help. So a complete picture of how low embodied and low carbon buildings can be built with renewable building materials using technology from say tradition as well as contemporary period to build the school and getting labourers or help primarily from the local area and making it into a self-help labour intensive project. So, the METI school is an exemplary nature transferability follow on projects. The school handmade showcases the potential of good planning and design from the arrangement of the building on the site to the realization of aspects in detail. Further, it demonstrates the possibilities of building with earth and bamboo using simple methods as the continuation of the local rural building tradition and can serve as an example for future building developments in that area.

So, this building Meti school becomes a good example to showcase as it is built using

local people. The next example we see is called as the Tecla house which is a 3D printed house from locally sourced clay. Now, this is a 3D based, 3D printed based house which is low carbon home prototype. It's the first eco-sustainable housing prototype with 3D printing with the ink being raw earth. And Tecla is a combination of technology and clay.

And it refers to the fact that the house was built with clay that was taken from a local river bed. The house is constructed from two linked domes. So there are two domes like this which are 3D printed. The goal is to provide low cost emergency shelter for climate refugees without sacrificing the inherent thermal insulation that clay offers. So, the extreme form flexibility is the most significant benefit of this house as a combination of renewable material which is mud plus 3d printing which is technology and it offers a lot of freedom to the designer because no house needs to be same. There can be variations And this variation or optimization which is arrived at, now this is the infill.

Now the house can take any degree of sinusoidalness. Three factors are taken into consideration when you optimize the infill. this system the thermal mass which rises with increasing thicknesses of the earthen material to the infill the ventilation aspect and the thermal insulation aspect based on that the 3d printing mud is filled in any of these and this is an example of how optimization is Optimization of the three aspects thermal performance, thermal mass and ventilation. How these three are arrived at? Based on that this is the house structure and this is the 3D printing where the 3D printer this is a 3D printer and the ink fills into this form. So, this is the section wherein you can see how ventilation is provided and how it can be, infilled.

This varies based on the optimization. And the last small example we take is of Padmanabharpuram Palace which is a vernacular architecture. It is located in Kerala and it is a 16th century palace of the Maharaja of Travancore in Kerala. It is made completely out of intricate wood carvings and murals and is an exceptional example of indigenous building techniques and craftsmanship in wood which is still withstanding the testimony of time as it was started in 1601 AD. And this is the plan and the section of the Padmanabhapuram Palace. Which is completely or very popular because it is made up of timber or wood.

So we stop our class with this. As we have seen examples of buildings built with renewable materials. The first is a hand crafted building called Meti school. The second is Tecla housing for the refugee which is a combination of renewable material plus technology. And the third example is a vernacular architecture of Padmanabhapuram palace made completely out of timber and built in 1601 AD withstanding the test of time. With this we stop today's lecture and we meet again with yet another interesting topic. Thank you.