Structure, Form, and Architecture: The Synergy

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Lecture - 34
Cost Effective Structure and Architecture

Hi everyone. Welcome back again to the online NPTEL course on Structure, Form and Architecture, The Synergy. Today, we are at lecture number 34 and we will be discussing on Cost Effective Structure and Architecture.

In my previous lectures, when we discussed about earth like structure for earthquake prone area or structure for wind prone area or even for the flood prone area we discuss different techniques, and mostly they are not basically the low cost technique. But sometimes in architecture or even to make structure for the people who are having poor affordability, we have to add op some you know low cost technology.

But low cost technology does not mean that it will compromise the quality of structure or it will compromise the strength and it will compromise the safety of the users. So, how we can really make it cost effective for the building in terms of various component of your structure, maybe the material, that will be the discussion overall discussion in this lecture. So, without wasting time let get start this session.

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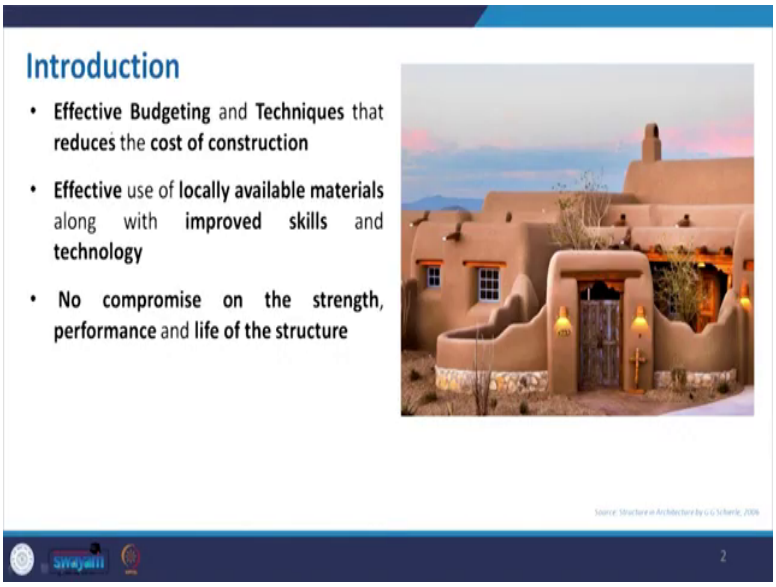

Now, what is effective, cost effectiveness? So, this effectiveness as we can see in this slide, it is effective budgeting and the techniques which will reduce the cost of construction. So, that it is not to select something you know very cheap or very you know having very low cost, but we can make it effective, more effective with proper budgeting which is very much essential before you know starting any construction work.

So, how the process start? I guess all of you know. Like the moment we need something to build, we desire something to build, then we approach to the planar, to the architect, to the designer and then we just say our requirements. And then based on the requirements what an architect or designer will do? They try to optimize the spaces whatever the available you will have a site, then you have some kind of fund to available with you and within that one will the architect who are the specialist in that job we will just try to optimize.

So, that it will fulfill your requirement, it will be also done in your budget and at the same time it will make a tradeoff between you know like what can be done within that. But during that budgeting even the selection of material the finishes of a building that will depend like whether I will go with the Kota stone, marble or plain cement finish of the floor. So, that will really affect the total cost of construction.

So, there will be a tradeoff between the you know quality of material, the you know different aspect of material, like if you want to use some onyx marble very costly stone as a finish and definitely one has to pay more. But at the same time when you just deteriorate the quality of material in terms of like a deteriorate the cost of a material, but we should also look like we should not compromise with the strength of the material for which that is being used. Even there in the budgeting we can make it effective, not only the design build form, but also the operation cost of the building.

Now, how it is going to happen? If you have a site where you can get a good amount of daylight from sun, and on an average you do not have any other buildings or any surrounded structures which will make shadow to your building and then you cannot get any such open space in that case definitely your the orientation of your building could really save some energy cost to a building, ok. Then means, a proper design will guide these through you know maximize the daylight penetration to your building. So, by that way also the design will help you to reduce the energy operational energy costs to that and then other aspect as well.

So, the budgeting part and the design part really plays a crucial role. Along with the techniques that we use. Now, if we use some technique which is very complex in nature that involves machinery\ that involves skilled labor, then definitely the cost. Maybe the material cost is not that significant, but the other costs of the machinery and the equipment will add some additional cost to your budget. So, that is also crucial to choose a good technique for that.

Now, coming back to this slide again in this effective use of locally available materials along with improved skill and technology can make a construction cost effective. Why? If a material

is available locally, locally it does not mean that next to your side, but within a minimum reach, so that the transportation cost of a building material will be reduced. At the same time like the damage to the material will also get some kind of reduction in the total figure, and at the same time if it is locally available if that is already being you know matches with the nature, so that can add some more you know beauty into that.

So, sometimes also in this we have a different subject called vernacular architecture and some of you already gone through that subject, so where how we can use the locally available material. But we have to remember one thing we cannot compromise anything on the strength of the building, performance of the building and the life of the structure. So, we just use something and then tomorrow I have to replace it and tomorrow it will not sustain after a heavy wind or so, that will not really help.

Even in the last discussion when we were talking about the flood resistant structure, I have told you that if you increase your plinth level above your like base flood elevation level, so definitely the initial cost to the building is high. But definitely the consequence of that, like it will be really helpful where there is a flood situation then your building will be in safe position. So, whether you will invest initially to secure it to you know increase the durability and then longibility of your building that is definitely a call that one has to take.

So, in this case you can use the locally available material, you can improve that material and also improve the construction technology, you adopt some emerging technologies that we will discuss in this also then probably that can give you a desired solution. So, here you can see this structure is being made with the mud, compressed mud where like normally we cannot simply take this mud because you know in a area where there is any rainfall and then this all washed out, but at the same time like if we just improve the material with you know some admixture of the cement as fine like as a binder then definitely that can improve the situation and that can use as a building material.

Now, moving forward we have to understand this 6 aims of any construction, and each of them are contributing to the cost. Now, where we are talking about in this lecture on cost

effectiveness, so we can contribute to each of these aims and then we can reduce some costs in certain part of time. So, let us look into this what are the 6 aim.

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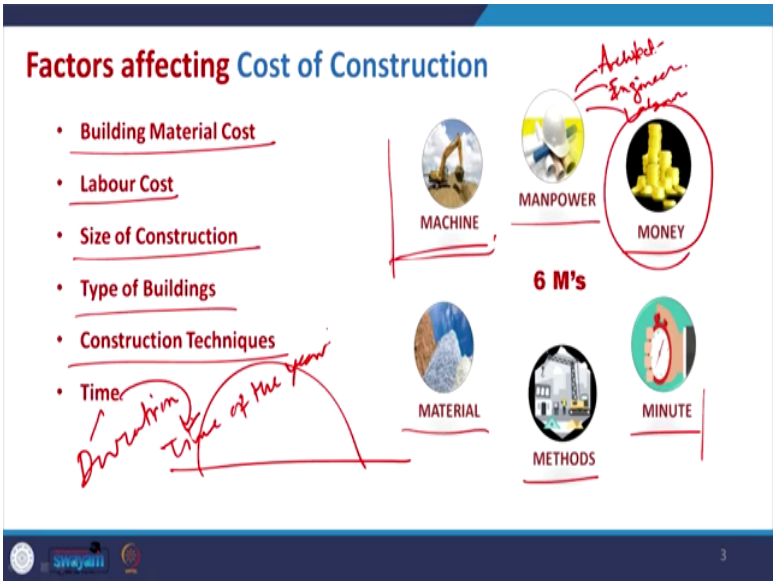

So, it relates with the manpower. Since manpower includes the fees that you pay for the architect. Like tomorrow we are pursuing architecture and then one to become architect, so definitely you will do that work in terms of some professional fees. And then as a client if you go to an architect, so cost involved. During the construction you have to pay to the contractor or to the labor and then various resource persons, the plumbing person, the electrical person, so one has to pay either you pay directly to a contractor and then he will take care of the distribution and how the appointment or else you have to pay, so that is very important. That includes like your architect, then engineer, then you have a labor skill labor, then semi skill labor this is very important. And then this is also very important for us. We cannot deny it. If

we do not have the wealth, we do not have the money then probably, we cannot fulfill some of the desired at that extent.

Then the time is another important if one can manage the time of construction then definitively that can also manage the budget. If a project is getting delayed by some kind of a situation where it was not preplanned or the project is not properly managed then that will increase the cost of the equipment higher that you higher or the cost of the labor, you cannot simply say that the work is getting delayed I will cut the salary something will be very complicated.

Then the methods, whether you will go with a very manual method, whether you want fast construction and then you use some kind of a you know automation to that that can also contribute to the cost. The material the material can be conventional material, but at the same time, now in this particular time we are already you know getting some things of the you know future shortage like for the conventional materials. So, like water will be a problem, then getting their course aggregate and then sand as fine aggregate. So, these will be very much problematic. So, if we can think of some alternative materials that would help us to make our things cost effective and without compromising the strength, means whatever the strength we can get from a concrete and if you use the alternative material to concrete we should achieve that particular strength.

Then whether you use the smart system whether you use some advanced machine for your construction especially and it depends on the scale of the project. If we want to make a small one a story building and then I am I am planning to make a high raised like Shanghai Tower or Burj Khalifa then definitely the machinery that required the skill will differ a lot. So, definitely for them the constraints the criteria are different. But whereas, like when you think of the buildings maybe something a low cost housing or maybe cost effective housing then selection of the mission can also defer the cost of construction.

So, here that is the reason like building material, labor cost, building material cost, size of construction, that this is basically the scale. If you just have just think of precast or prefabricated element like construction material, that means, it will not be casted in the side or cast in (Refer Time: 13:34). It is basically fabricated somewhere else and it will be just you

know plug and play kind of arrangement. Then, in that case like for a small construction, it will not be cost effective because you have to have a area where these prefabrication can go, you need some kind of machinery.

So, for a large scale construction definitely one can set up these prefab you know set up or lab and then can be tested and then you know can bring into side, and then that can be easily used. And which will save time, which will also maintain the quality, and like reduce the errors.

The type of buildings definitely this is another factor that is influencing the cost of construction, whether we go with a very simplistic, very simple form of a structure. Like I will make just you know housing a very rectangular shape the building typology something else. But if we just plan to do something of a auditorium or a big convention hall with a dome then definitely that will change, the considerations will also change, the construction technique as already have discussed.

Then the time. This time is the duration in one sense and also that you know time of the year. So, if you pick up a good time for like construction, not a heavy construction that will take a year after year, but for any construction that can be managed with 2 or 3 months. Then when you will do it? Like any RCC construction we will require some curing, then whether you will plan it before rainy season or after rainy seasons. So, these are the things that will really affect the cost of construction.

Now, achieving cost effectiveness. So, there are many techniques, but this cost effective architecture and structure that could be a full fledge it course, but here my point is to just give a very brief idea focusing on some of the selective material. But definitely what you need to do like I have to extend the list. After this discussion definitely you get certain idea and then based on the links I have in this slide or you search more on different you know maybe materials, different techniques by which we can achieve this.

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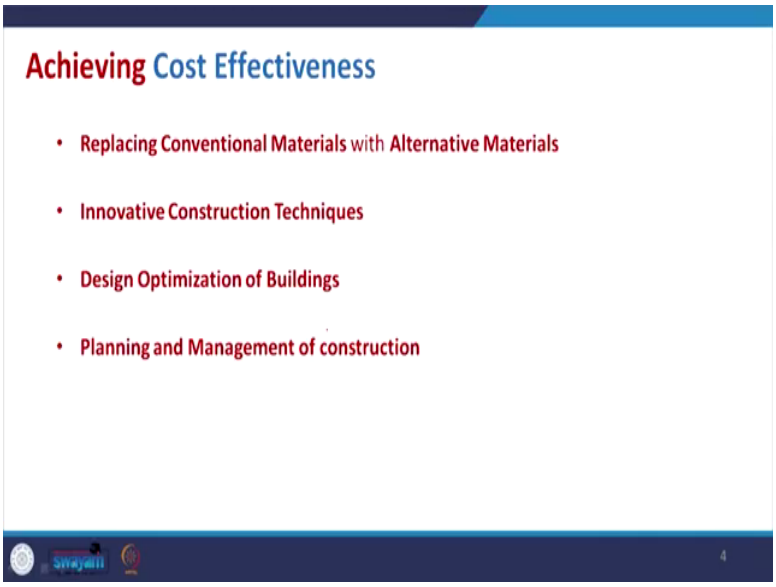

So, 4 points that I would like to say here the replacing conventional material with the alternative materials that is very important, as because like not only like a new thing to be tasted and some innovation can be applied, it is not exactly the case, but the conventional materials now it is something it is depleting. So, this depletion will be very rapid because of like the high demand. Each day mini houses are being built across the globe and the construction should be very much accurate and also timely you know it will has to be timely delivered. So, with this stipulated time like definitely conventional material will take time to get the curing and to get the adequate strength.

So, alternative materials like pre prefabricated you know concrete material or else something different technology that can help those materials to plug in very quickly. So, that can be used.

Now, in this case alternative material to the conventional material does not mean that the alternative will be cheaper, but the main point is some way or rather it will affect the cost of the building. Now, maybe in case one alternative material is costlier than the conventional material, but the time it will take to complete the project and that the during that time all the labor who are working for the project and there if we considered the salary to that, and then the rent for those equipments definitively overall cost can be lower where you use those kind of alternative materials.

Now, innovative construction technique that we need to adopt like whether it is you know traditional pose dome, structure then step by step that we go or else this is just you know a plug and play concept with the prefabricated panels, the walls, doors is already a like what you have to bring to the side and then assemble. So, this kind of technology can be used even some of my presentations I have shown about, I have talked about the 3D painting. So, with the help of 3D painter we can make houses. So, these are the things that are already you know coming to the market and in future maybe will be going for a very super fast construction technique, and then we can get a good quality you know building in a week time.

Now, again if you take the third point then it is design optimization of the building which is also essential. Even you select the right material even you select the right technique, but the arrangement of your building the design that is the prime job of an architect, then that case like how to optimize the space, how to really make each line the drawing you make that will be something like a wall or door window.

So, how you can optimize it? Say for example, if you make such in certain length and then to in order to feel that particular length with some brick, so you have to cut always some brick and you have to make the joints or else you make some certain angle where like or the curve where it is very difficult and there will be more wastage of brick to get this particular curvature. So, how you can tackle it in a better way, so that design should tell about that. So, wastage should be minimize in terms of the you know available space, also the material.

Now, the planning and management of construction: even you have very good drawing with you, very well designed, very well optimize architectural design, you have good technology you have good materials, but in the management when you are going to implement it on site and there is some mismanagement. So, there is not a good flow, like when the materials to be procured and when it to be you know cure. So, the proper management also influence on the cost effectiveness of any construction project and that too for the building as well.

Now, coming to the cost effectiveness over very simple building and these lecture as I already mentioned that this topic is very interesting and that can be delivered through a number of lectures and that could be a same sufficient subject for the student of architecture or you know pursuing civil engineering or anyone having the light area or interest. But in this presentation I will try to focus on a small scale building not skyscraper or so; so, where basically in the construction technique if you see in this slide?

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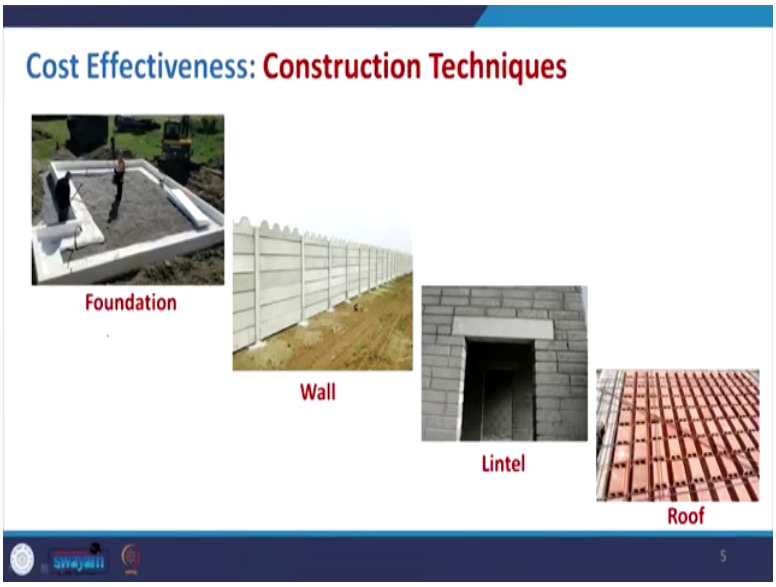

So, basically we can divide or structure in 4 component foundation, wall, lintel, roof and also you can consider the plinth and other components, but these are the major components by which if we explore the building. So, these are the cases which is very essential to you know get all kind of like precision.

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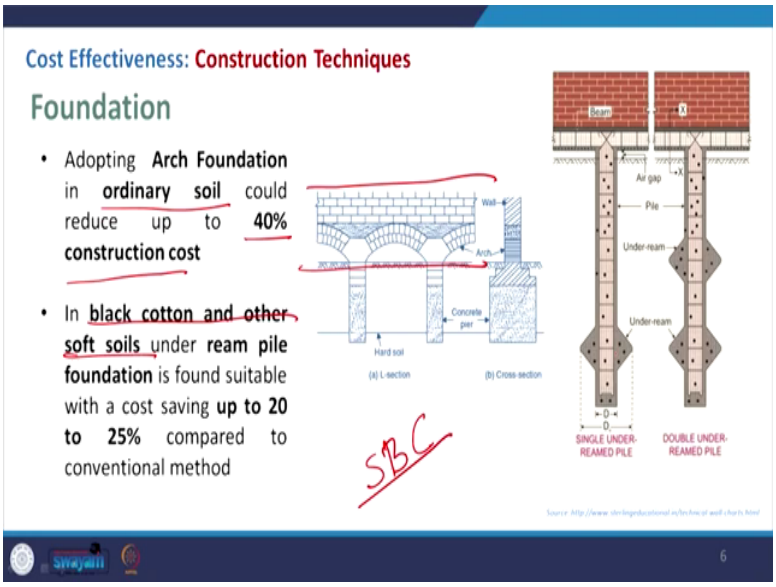

Now, coming to the foundation, so for wants to reduce to the building, earlier there are examples where people they used the arch foundation or the inherited arch foundation. It is considered to be you know cost effective, almost it can save up to 40 percent construction cost of the foundation because the foundation itself is getting a huge construction when you go for the super structure which is above the ground then compared to the cost which is your foundation and footing is higher and this arch foundation for original resource.

So, we have to remember this that the soil condition we cannot always make foundations similar to all of soil conditions, sometimes you may have a very good save bearing capacity of soil. So, SBC of soil will determine the type of foundation that we can take. So, it may be over isolated foundation, combined foundation, then we can go for the pile foundation and the mat foundation, so it depends on that.

So, we are now going to discuss that in detail in this presentation. But for ordinary soil where the bearing capacity is good enough, so arch foundation can really help it to you know get the structure. But where the soil is a black cotton type and then this is a serious issue, then probably we lot get enough a strength at the lower depth, then probably in that case we have to go for under ream pile or foundation. So, in this case that pile being used and then the under ream has been created to make the grip, so that will also help to reduce the soil pressure and that particular movement.

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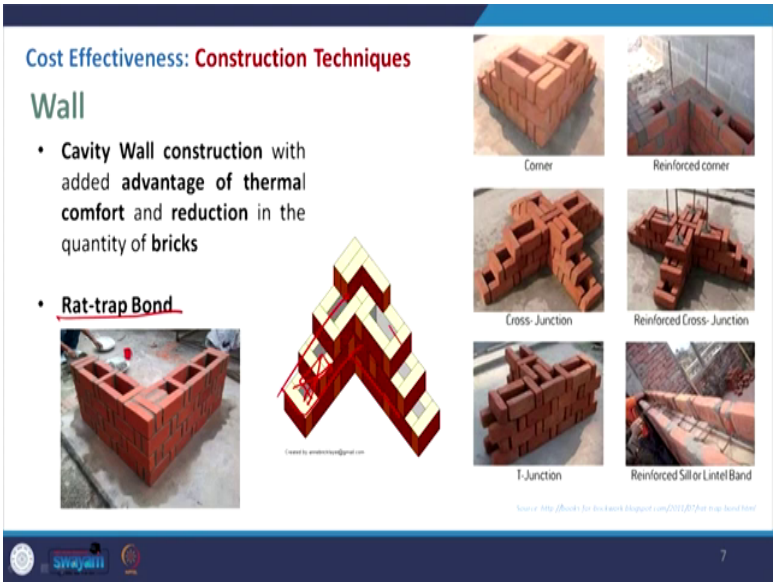

Coming to the wall: so, wall construction again like you must have studied different kind of brick bonds where we consider the brick wall. And here we just discuss on the wall with the brick and definitely that wall can be made of something else. We can use timber, we can use the RCC wall as a shear wall or else we just use the steel frame and then the glass panel to that, but in this case like when you discuss about the brick wall, so we have you know use the

English bond or the Flemish bond, but the problem with them is not with a strength or something they are really good. But at the same time in order to make it cost effective we can think of reducing the material and that can be achieved with a cavity wall.

So, cavity wall construction will help to reduce the number of material for a given area or parameter or given volume of work at the same time that cavity will also act as the insulator. So, that is a dual added advantage to that and one of such cavity wall construction that is there in this slide that is called Rat-trap bond and here you can see these jeep image have picked up from internet. So, here you can see how it is been laid. So, a brick size like it is basically being made like this where the cavity is being maintained. So, that you can get your you know adequate width of the wall at the same time you get some ADF or insulation, and definitely as because the same area is being covered, so with a void then definitely that is saving the you know the volume of the brick.

But that does same time there is a another important parameters that is your the use of the brick. So, we never we use the English bond or Flemish bond then we have to cut the brick we have to use the queen closer or sometimes you have to come and get the hub bed, but in this case mostly we will be using the full size brick, so that wastage also to be managed.

But the constraint it when you designed. So, we have to design with the units. So, all the doors windows opening should be designed accordingly, so that there will be no such cut and then there will be some brick. In order to giving strength to this wall because this is useful for one storey, two storey, even there are examples of three storey building we can use some kind of reinforcement to give the strength.

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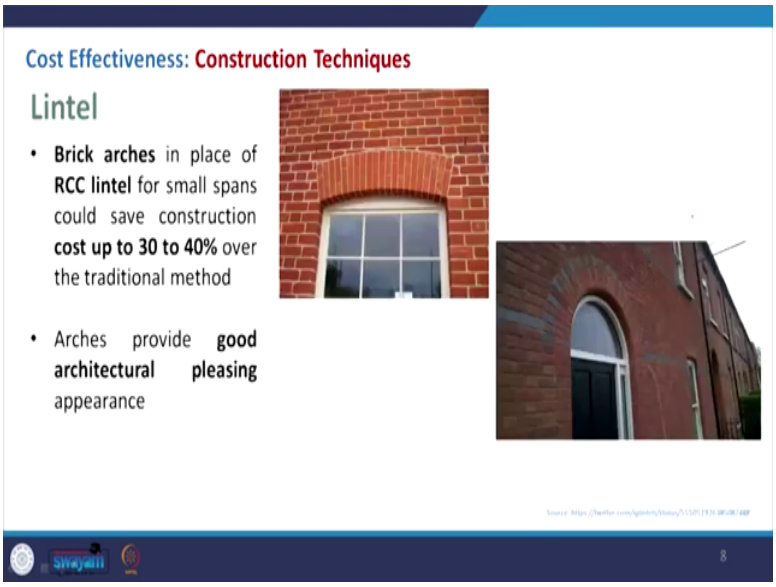

Coming to the lintel, in place of a RCC lintel we can go for the brick arch which will help and reduce up to 30 to 40 percent of the cost. But again the case is where this can be applied where there is no such problem with the earthquake because in the earthquake we have discussed that if there is this is a building is situated or it has to be planned in earthquake prone area, so we have to give a band. So, then probably this piece lintel will not help. But yes, definitely arch can be one of the option and many buildings you know in earlier days even in some part of the country even across the country people they still use the arch to you know even give a nice safe, this curvature giving a nice aesthetic whether it is a segmental arch or semicircular arch.

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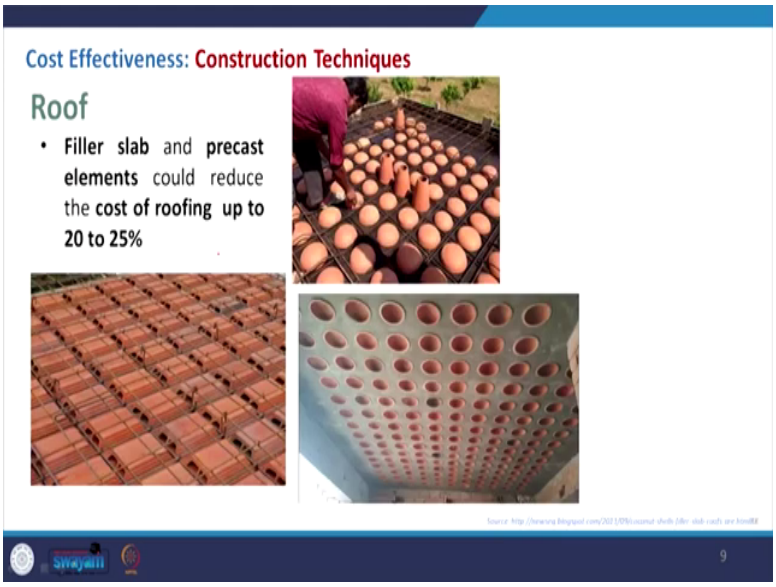

Coming to the roof, yes here we instate of a plain you know homogeneous and same thickness a slab, concrete slab. Now, this is another cost effective technique where use some kind of (Refer Time: 28:29) tiles or this kind of form and then the concreting has been done and then after removing the shattering from the bottom it will look like this. So, without compromising the strength this can be achieved to the filler slab and that can save up to 20 to 25 percent of the cost compared to the like your traditional concrete RCC slab. So, this is going to be very much helpful to reduce the cost of the building.

And at the same time this kind of arrangement even like someone may try something different, like to put the lights, suppose these are the hollow members, one can use some light fixture and all, so that will also enhance the aesthetic view.

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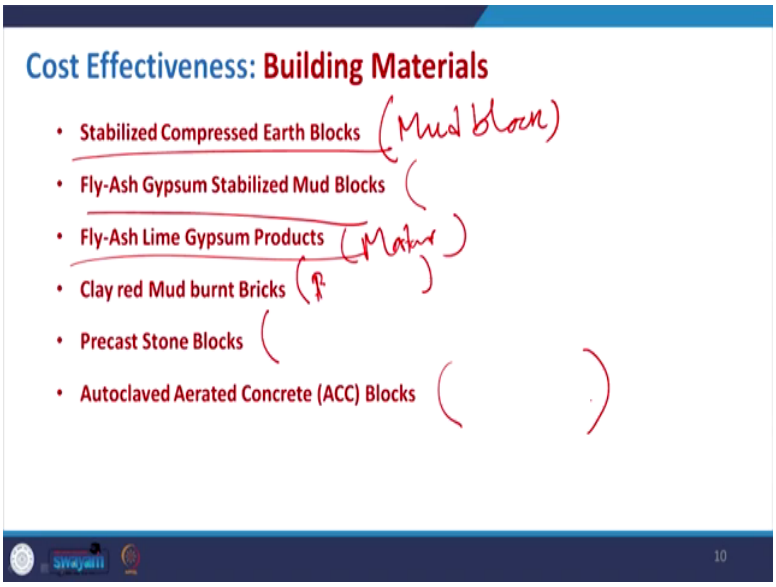

Now, coming to the building materials, there are like a good number of materials, you can list up on 100 or something like that materials that are now being tasted and in a process to apply in different context as the cost effective material. And now, it is the time where due to the scarcity of the raw materials people are using the waste material to create the building materials, there are different institutions, different you know research labs, they are developing this within India, even across India.

So, now there I have just selected few of them which are very much promising in the present day and already that be used in some of the building construction. So, first is your stabilized compressed earth block which is basically also the compressed mud block. Then fly-ash gypsum, the fly-ash brick that we know then fly-ash lime gypsum product that can be use as a alternative to the motor. Then clay red mud burnt brick, so that is basically aluminum waste or bauxite that can be use. Then the precast stone blocks or precast stone dust concrete block.

So, these are alternative available in brick size alternative to the brick and the construction will definitely give higher strength and that can be used.

Then the other alternative is basically the autoclaved aerated concrete which is light concrete material and also available in blocks. So, in case of you know using the mud, and the burnt mud be bricks, so alternative materials that are available to make the wall construction and this can be used for different purposes as well.

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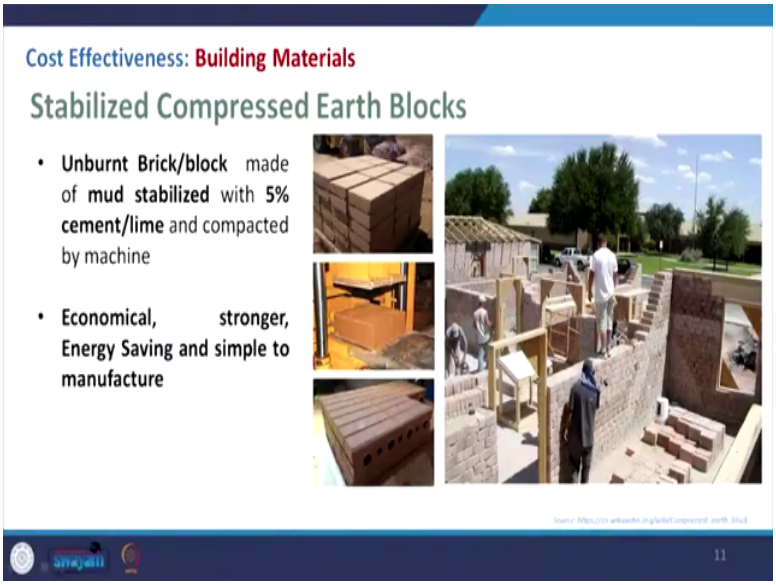

So, coming to the stabilized complex earth blocks, so this is basically the unburnt. So, there is no energy required to burn it. So, this is unburnt, this is the brick where the mud is used extensively and where the 5 percent and there is some variation 5 percent and then 5 to 10 percent variation with a cement or lime as some adhesive and that has been compressed with some machines.

So, that is giving enough strength and this is economical, stronger than the conventional, one and also the saving energy. Like, already for a traditional process the mud has to be burned, and then that needs some fuel and all, and then simple manufacturing and here you can see that this blog can be used that is giving enough strength.

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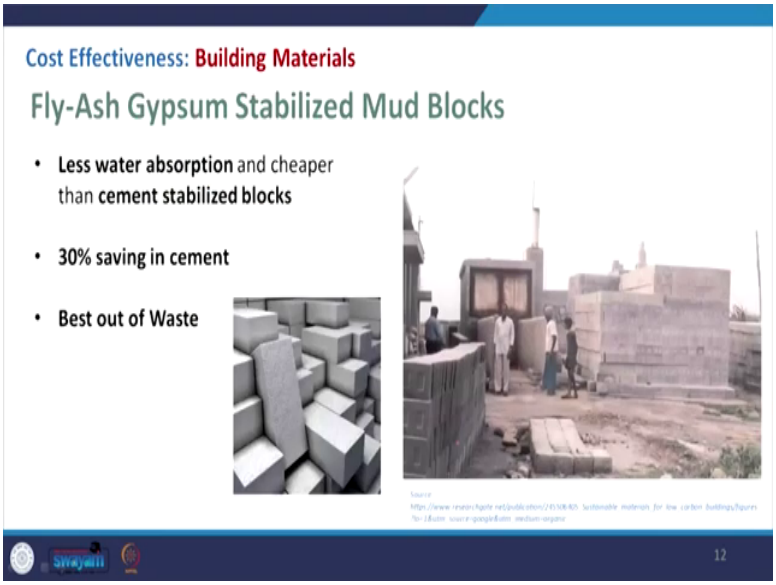

Coming to the fly-ash: now, fly-ash is basically the industry waste and now this is something where now many parts in many parts in India, so they are in practice to use the fly-ash. So, less water absorption can you know be one of the you know saving in the water industry, then it is also saving the 30 percent cement, then basically the best out of waste. So, whenever the fly-ash is basically the waste and then that can be used. It is this having a good strength that can be used at even if it is not absolute bearing, now in the case of the frame structure most of

the structure are the concrete frame structure, so this can be used as a partition wall or the external wall or sometime is even for the foundation or for the low cost construction.

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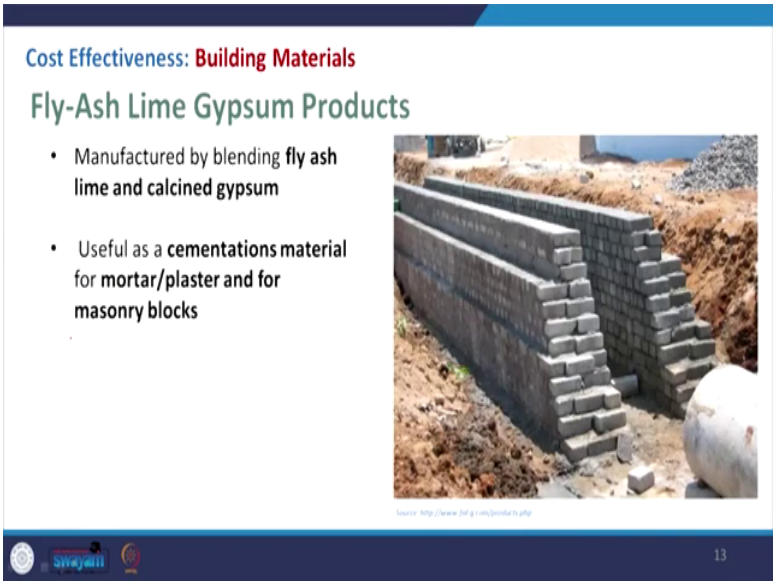

Similar, the fly-ash lime gypsum product can be used that is manufactured by blending fly-ash lime and calcined gypsum. So, it is a basically a cementation material like plaster which can be used to make the joints etcetera.

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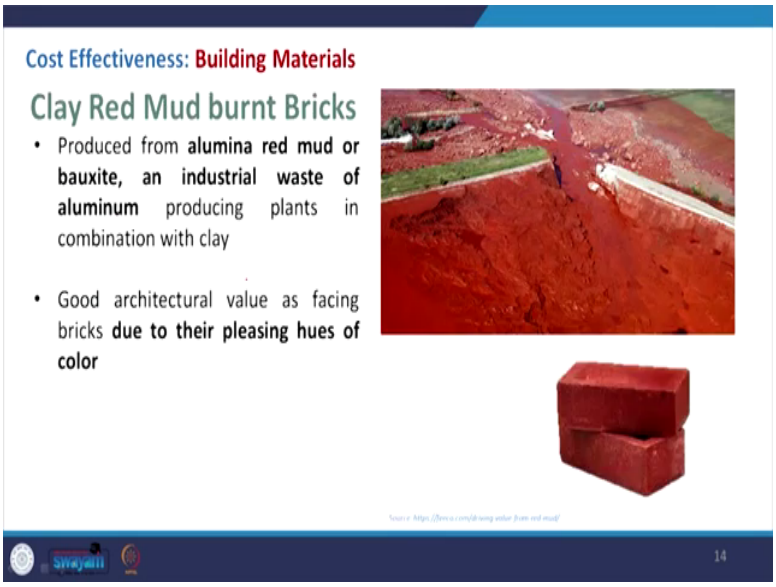

Coming to the clay red mud a brunt bricks: so, alumina red mud or the bauxite, this waste is being used to get this. Now, the advantage with this prominent red color if you really plan well for the external like exposed brick work construction for a building, so that can give a pleasing environment as you can see in this slide.

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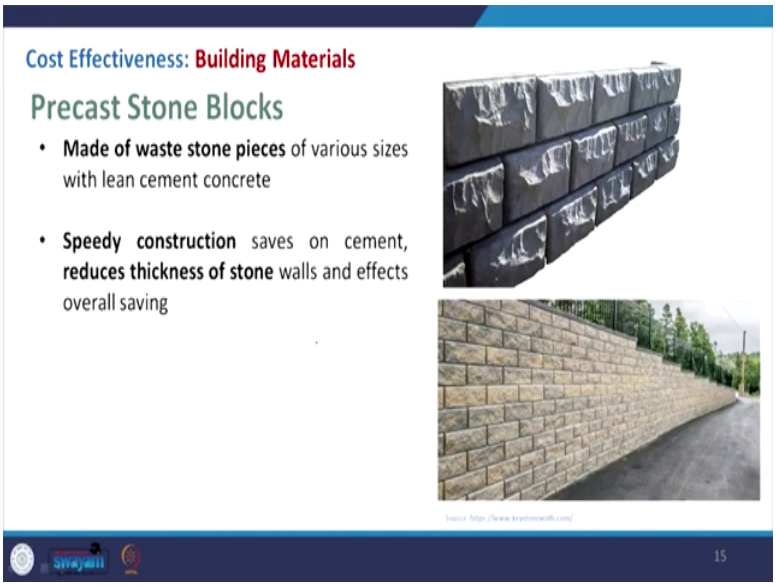

Coming to the precast stone blocks. So, it is again made of the waste stone pieces where there are the stone mean cut for some purposes, so that has been cut in a very nice manner that can be easily used. And sometimes even those are stone dust can be added as a in the cement concrete motor and that can give precast block and that is little bit bigger than the conventional brick size and that can give you nice you know aesthetic value as well as good strength to make this kind of construction. The construction is speedy and then in this case like it can save the use of cement and all.

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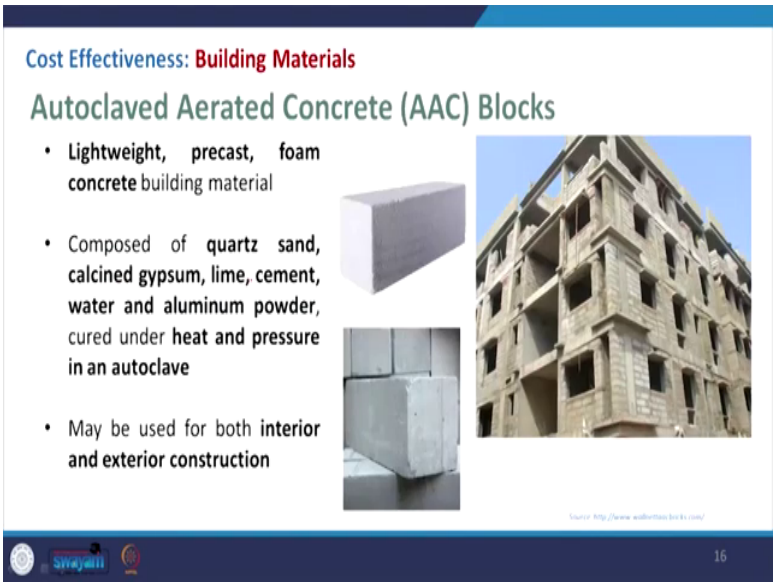

Coming to the autoclaved aerated concrete blocks. In this case as I mentioned earlier, this is lightweight, then precast and foam concrete. So, basically the compared to the you know concrete you know block of similar size this is having a lighter weight. So, compose of quartz and calcined gypsum lime cement water and aluminum powder and cured under heat and pressure in an autoclave. That is why the name also come into picture. So, that can be used as a external wall or it may be also used in the internal. And this is been useful as you can see that the within the RC fame that is this blogging use is as because it is light it is easy for the you know workman, workman for you know easily handle it and can be used with few layers that a full wall can be made.

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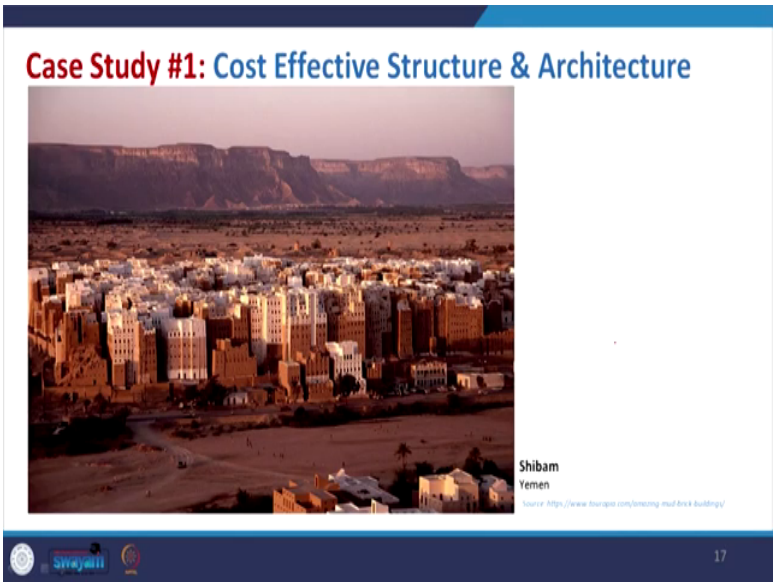

Now, coming to some case study where the cost effective material or technology being used. So, this is something an immense even. So, that is something of a mud a structure. So, it is considered to be high rise, and then compare to that this is something really beautiful in a Thiruvananthapuram.

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So, in this case this is center for development studies and many of the work of Laurie Baker you will find here. So, the use of brick different big burnts and not only the cost saving that whole architecture the beauties matching with the nature and also this is something really interesting.

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Similar to that like use of the corrugated sheet or some steel and then the compressed block, so we can get a very beautiful architecture. And definitely we have not talking about some high rise building where the mechanical system is required, but for a one storey, two storey building this kind of you know compressed mud block, fly-ash brick or the precast material can be used.

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This is another one where the brick exposed. Brick being used and also the filler slab that I have shown during that you know roof construction technique. So, this is giving very nice view from the inside. So, not only we are saving the money as well as also we improve the aesthetic value to it.

Now, it is all up to us like what we adopt or what we not because definitely when there is some reduction of the material or picking up a new technology or material. So, we rely on like whether it is tasted, whether it is giving it will give the similar result or not we are much scared, and this is basically the building construction like starting from planning to the execution and the final you will start leaving your house it, it is not very short term process because a building is planned and then it will take some time for the construction and then you start leaving.

So, during whole period it will take some time to adjust it and when you get some examples when we will see the taste results then only we can adopt that techniques or the materials. But now there are different you know developers, they are adopting this and its quite being successful in case of prefabrication there are some construction in China, Japan, even all over the world, even in India there are some projects which has been completed with very short time with the precast material.

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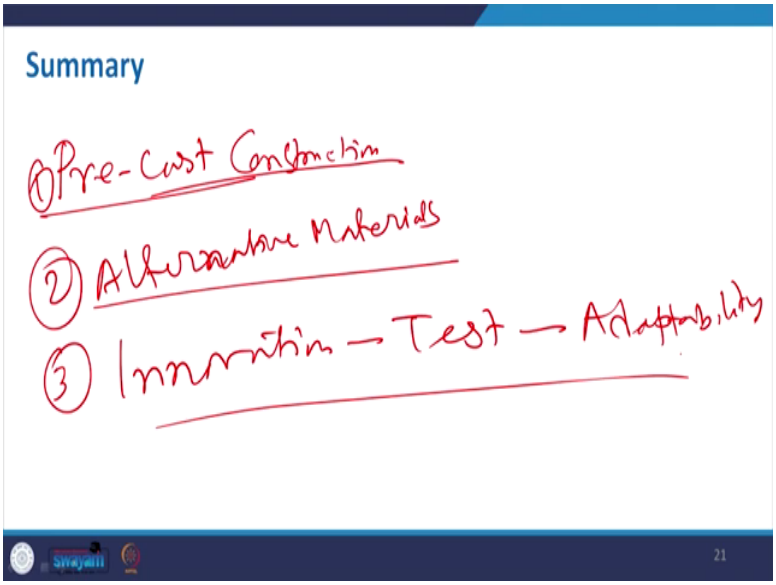

So, in these to come we really you know all of us as a majority we should go for this kind of you know precast construction, so which will save the time and at the same way like the alternative search of alternative material. So, these alternative materials we will save and then basically the last, but not the least what we need to, so that that is basically the innovation. So, we have to rely on the innovation, then you have to test it, and then adopt. So, this

adoptability of new techniques, new materials will take time, but in due course of time definitely one can go.

So, starting from your building designs, starting from selecting of the material, the right technique, the right orientation of the building different way of maximizing daylight. So, the whole together like from the planning to the execution and it is the total lifetime of the building if we can properly plan it, if we properly budget it, then definitely that could be a good cost effective structure and architecture as well and without compromising.

So, I am repeating this sentence again and again. We can pick up the cost effective things, but without compromising the quality related to the strength of the building, related to the aesthetics, related to the performance of the building in different you know load or maybe different externalities.

With this I conclude here. And this is one of the material already I have given a earlier slide.

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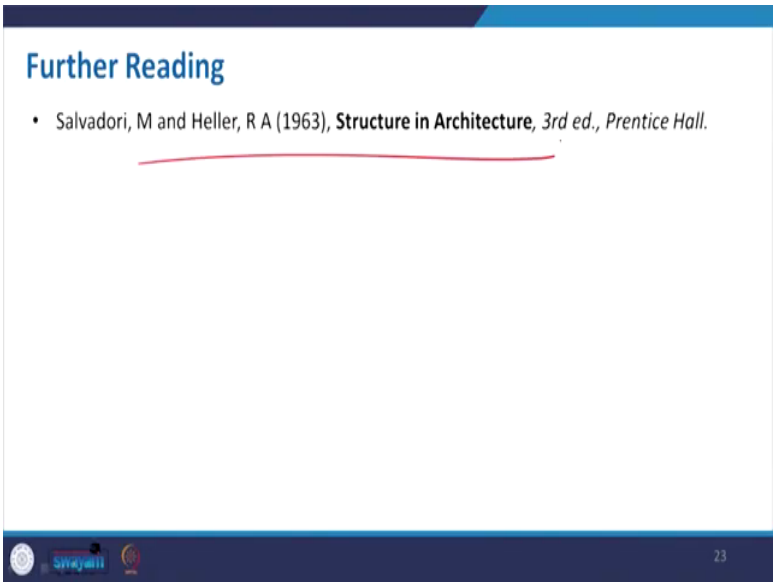

And I really want to thank you again to take part in this. And the next task for you to you know enhance the least I have picked up few materials, I have picked up few technologies, but there are n number of techniques available. So, you search and we will discuss over forum. And with that we will be waiting for the next discussion that is on the Structure and Light in Architecture, how the structure can help to improve the lighting of architecture and focus will be on the day lighting.

As I have just mentioned that not only all orientation building, so how you can optimize the light through your structural design or architectural form that can save some energy for artificial lighting and ventilation. So, we will be discussing on light and structure in the next lecture.

So, we will be meeting then.

Thank you.