Building Materials and Composites
Prof. Sumana Gupta
Department of Architecture and Regional Planning
Indian Institute of Technology-Kharagpur

Lecture - 03
Clay Products 2

Welcome back. Let us start today's lecture, lecture 3 of module 1, which is the continuation of clay products.

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So, what will be covered in this is- basically bricks made with alternative materials. So, it is a shift from clay to alternative materials; what are the alternative materials that help in making bricks, and then we will go back again to the clay items of terracotta, porcelain, stoneware, and clay roofing tiles.

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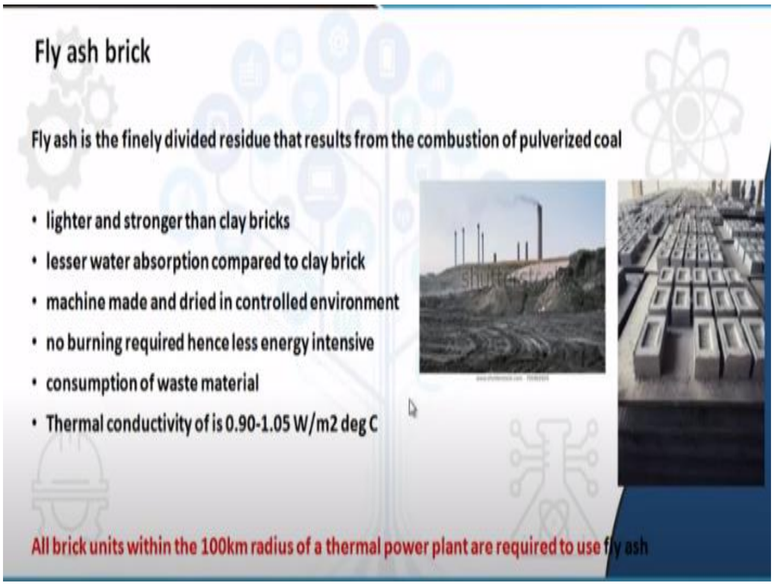

So, brick, as we have all understood, was the basic building material, which most developing countries like ours are using, but, it causes a lot of depletion of our natural resources. At the same time, we need to look into the wastes, how we can take care of them, and whether we can utilize them up in the form of this tablet or brick. Fly-ash is one such waste product, which is coming out after the combustion of pulverized coal.

It is very fine, even finer than sand. It moves around in the atmosphere in and around a thermal power plant (generation area). It pollutes the atmosphere too. But it is collected in ash ponds wherefrom it can be carried to a brick-making area following similar principles; it was tried or evolved as an alternate building material replacing clay brick. So, it is a little lighter than clay brick. It absorbs less water.

It is machine-made and dried in a controlled environment. And, no burning is required. Hence it is less energy-intensive. At the same time, it consumes a lot of waste material. The thermal conductivity of fly-ash is 1.05 W/m² °C recall that for clay brick, it was 1.25). So, it resists heat (thermal energy) from coming inside the building.

Thus, it is better than clay brick in thermal resistivity. Now, why will people select it for construction? The Central government in India has declared in the codes (building standards) (as mentioned in my initial lecture) that all bricks used for building construction within a 100 km radius of a thermal power plant must be fly-ash bricks.

So, what are the advantages? It is energy-wise less energy-intensive. It uses the waste (as its raw material). It does not take so much time for manufacturing. It has to be dried in a controlled environment first, and then you can sun-dry it. These are moulded from machines, as you can see in this picture taken from Gava fly-ash brick factory in Kharagpur. The fly-ash which is lying here (see image) has been converted to this brick.

So, a lot of construction is being done by these fly-ash bricks. It has become popular and gradually at par in price with clay bricks. Earlier it was much cheaper. People believed that the low price was due to being of inferior quality, and hence many did not buy them. In reality, fly-ash is of sufficiently good quality.

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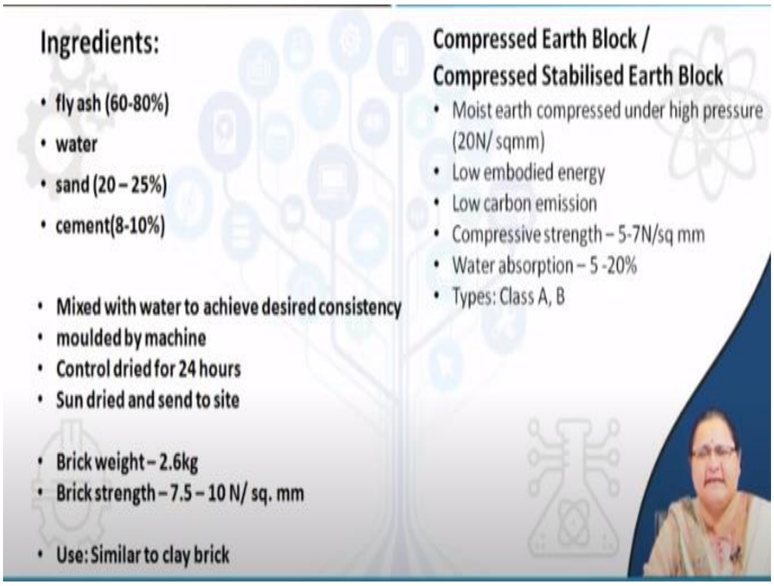

The ingredients of fly-ash bricks are around 60 to 80% fly-ash, the rest is sand (20-25%), and cement of which is about 8 to 10%. It may also be replaced by lime because cement or lime is the stabilizer which helps the items to become whole. These are mixed with an adequate amount of water to get the desired consistency, moulded, control-dried for 24 hours within a factory shed, and later on put under sun, and finally becomes ready for the site.

Its strength is as good as a second class brick. Weight is almost like that of a first-class brick—however, clay bricks maybe a little heavier. Fly-ash brick maintains this 2.6 kg weight, and its use is similar to that of clay brick. You may or may not plaster it. The water absorption is up to 15%.

Now, I will introduce another item here, which has been experimented with by the Auroville Earth Center in Tamil Nadu since 2005. These are "Compressed Stabilized Earth Block", that comes in the form of bricks or in different shapes as required. This is nothing but moist earth (or clay), and under high pressure (around 20 N/m^2), they become building blocks.

They have much lower embodied energy as compared to even fly-ash brick and also clay bricks. It has low carbon emissions. As fly-ash brick flies around and creates a lot of pollution, similarly clay-fired bricks also utilize a lot of fuel-burning, which leads to carbon emission. But since these compressed stabilized earth blocks only use pressure to make a stable earth (clay) item, the pollution component is much less.

The compressive strength is between 5 to 7 N/mm^2, which is also quite good. Water absorption varies between 5 to 20% depending on the type- there is class A and class B. The Auroville Earth Center has constructed a lot of experimental items or buildings within its premises, which demonstrates that compressed stabilized earth block is a building block that can replace fly-ash bricks or even clay bricks.

So, with this information, I think we have covered all types of bricks and related items, which are the basic building blocks.

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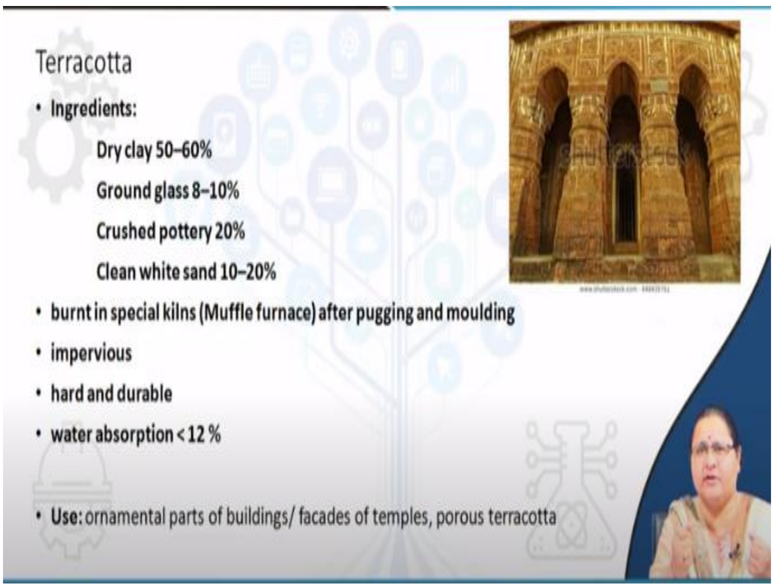

Let us move on to terracotta. Maybe some of you are familiar with this kind of image which has been displayed here. This is the facade of an entry of a temple, and you can see a lot of ornamental works being displayed. These structures have been facing inclement weather for hundreds of years, and yet nothing has been damaged. Why so? The ingredient is not just clay.

Clay has been supported with ground glass, crushed pottery (that is, broken pottery items that have been grounded), and clean white sand. So, along with clay, which has the maximum percentage, it also requires adding ground glass, crushed pottery, and white sand- again mixed thoroughly, multiple times in the pugmill, and then moulded with this ornamentation on it.

After this ornamentation, the entire product is put into the muffle furnace and is burnt. Because of adding glass, it provides an impervious layer (or coating) on top of it, preventing water absorption. The final product has a very low water absorption (even less than 12%) property. It is very hard and durable and can stand for years together. This is a very rich ornamental part.

Terracotta ornamentation has to be made uniquely for every building. So, obviously, the price is higher. Various decorative items (such as terracotta plates) may be manufactured in a similar way. You may install these terracotta works in building entrances to emphasize the design (or make it grand). Thus, it can give you a heritage value to it because these were used in our temples. But the mass-scale production of terracotta is no more practiced.

In modern times, you can use templates, you can procure (order) it as per your desire from manufacturers, and only then it can be used. Terracotta finds its use in ornamental parts of a building, temple facades, and the like. Sometimes it is entrenched with air to make it porous, making porous terracotta. You can add an extra amount of glass to produce glazed terracotta.

And you can make use of this terracotta in the way you want and place the order as per your desired façade design.

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Now let us move to the other two items, the porcelain, and the stoneware. You can see the pictures on your left-hand side. The washbasins, the cisterns, the commodes, the water closets, the sinks- all the sanitary fixtures have a glass-like coating on top of it, and it appears seamless and smooth. This is used due to its anti-microbial properties.

It cannot be stained and not affected by acids or alkalis. It has a permanent coating on top of it, which is the glaze. This is made of China clay, feldspar, kaolin, silica, and clay baked together at a high temperature to achieve vitreousness. Similar to brick manufacture, the kiln temperature may rise to 1100°C or similar. These items are baked further at higher temperatures to acquire the property of vitrification.

The mixture must be baked at temperatures of around 1400-1500°C to get vitrified. Once vitrified, it does not absorb water, and this glaze on top of it becomes transparent and gives an impervious look or characteristic to the item. Another alternative item is stoneware (refractory clay), which is made from silica and alumina.

In the case of stoneware, you add stone dust and crushed pottery (as we had used in terracotta) and bake it to a high temperature again to achieve vitreousness and low porosity. It will be hard, compact, strong, and durable. It finds its applications in places like culvert pipes (see image), where resistance to weather is necessary.

Where there are chances of stain or chemical action, you can put stoneware; they are not much affected. They are not so porous but not impervious like porcelain. And these are mainly used for underground water services because you cannot replace them as and when required. It would not even come to your notice if anything has happened there.

So, these are hard and compact, durable items that are put underground. In underground sewer lines, you can use stoneware; it can withstand any pressure on top (vertical load), so it would not break, and it is quite durable. Some sanitary wares are also made with stoneware.

Another related item (which I have not put into the slide) is earthenware. Those are not so stable like stoneware and are not much used in the building industry. They may find some applications in pipes and plumbing.

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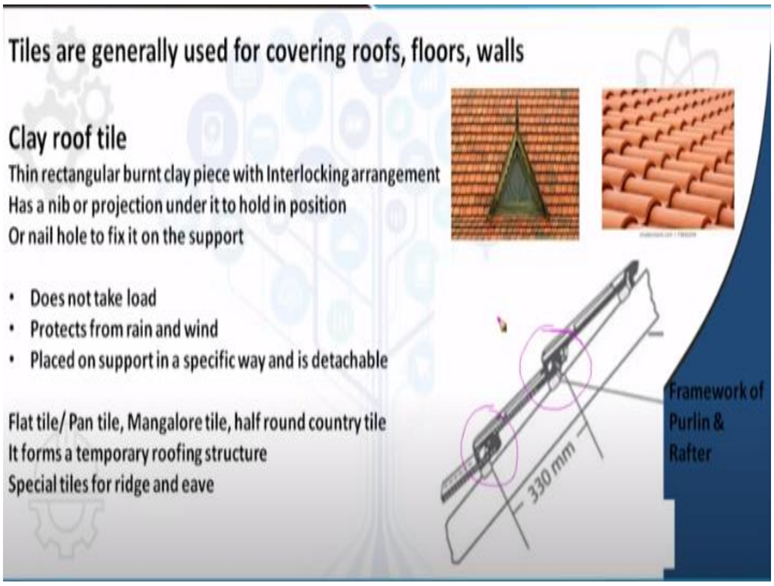

Now, after we have finished with all the items, we come to the last topic under clay, which is clay tile (particularly clay roofing tile). We have flooring tiles, we have wall tiles which are also made of clay, but we will cover them when we discuss glass and ceramics. So, what you see here - this clay roof tile is used as a unit to cover the roof. These are very popular in the countryside.

It is usually sloping (as you see in this section), and the most important point is they are much thinner than brick, and they cannot withstand heavy loads. Up to one or two human weight may be supported by the tiles(for example, the weight of two or three people) who may climb on top of the roof for some repair or replacement work. But in general, clay tiles cannot withstand load. Thus you cannot have an independent floor constructed on top of it. Its primary use is only to protect the structure from rain and wind.

So, tiles are used as covering or roofing. What you had already seen is that bricks were created for walls. But in this case, it is made for the roof. It is usually installed in an inclined position and are interlocked unit-by-unit. In the case of brick, you had to affix them in place with mortar. Here, clay tiles are not added or fixed; they are kept interlocked and are replaceable when needed. If one of the tiles gets damaged, you can replace it with a new one. So, now how are they fixed?

The picture provides some details. The appearance of tiles may vary across the country. It may be available in different shapes, but the principle remains the same.

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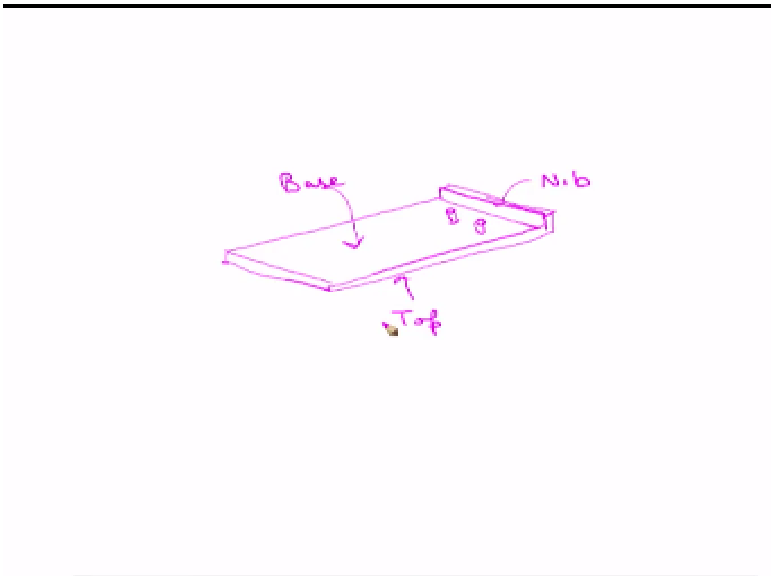

It has a supporting member or a nib that will help it to hold (or cling), which is called the 'nib'. It keeps the tile in place to cling to the purlin or the framing system. Here is a better picture- there are two holes, which are called the "nail holes", that run through the tile thickness, which is used to screw it with the support on to which it is clinging. This nib may be continuous; this nib may be in pieces.

This is the base of the tile (see image) and that is the top part (which you see in the below image). It is actually like a claw that is holding the horizontal member (the frame) and sitting there. So, what I drew is a very flat tile or a pan-tile. Across the country, we will see Mangalore tiles, half-round tiles, etc.-having various names and forms, but you have to remember there is an interlocking arrangement.

I had drawn the flat tile. We will discuss the interlocking mechanism in the next slide.

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So, if this is the framework, your tile is sitting like this.

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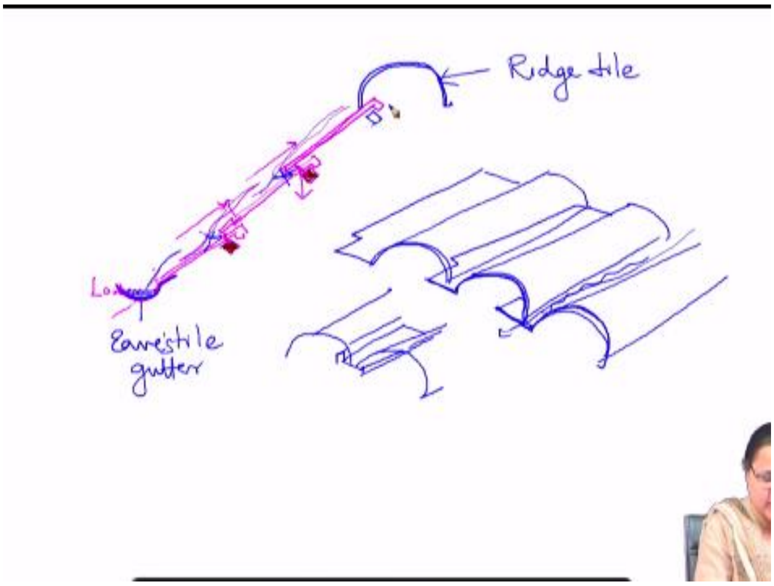

And your next tile is sitting like this (see image). You are starting your tiling process from the base (lower end), and you are moving to the higher (upper) direction because you cannot place upper tiles first without support. Thus you have placing your lower tile first and then you are topping with the upper tile, and below is the frame (maybe wooden) on which it is clinging.

So, how much distance will it overlap? The next tile will actually have to protect the nail hole. Here is the nail hole. So, the next tile should start from here (see image), so that no water can enter into the system into the room. So, you have to remember this upper tile should cover the nail hole and it must drain all the water to the next tile, and this follows downwards.

At the end, you must have a special gutter system which again will collect the water which is coming down and ultimately gets drained, such that no water can enter here and seep into the building. On the sides, you see only this circle shape with a very small gap which is allowing the water to flow.

But actually, the tile starts from here and goes till there (see image). Again, it starts from here and goes till the lower part (not visible). It may sometimes follow an undertile and overtile pattern. It may be something like this and then like this (see image). This is one tile and is supported with an overtile. There may be many types. On the side, there is again a interlocking method adapted so that water does not leak through the roof.

So, you have a tight claw-like interlocking arrangement. And the overtile (upper tile) is covering the nail hole so that no leakage happens. Thus, your roof becomes watertight. And any kind of replacement required is possible. Also, as already told, these are not capable of withstanding load. The tiles may break by the hitting (impact) of even a stone.

You may move or displace the tiles, uncover the nail holes, and replace the tile. At the ends, there is the eave tile, specially made for eaves gutter. We also have a special tile for the ridge (or the top). It is made such that no water can enter through any opening at the top. So, now this sits against the frame below. Let us revisit it.

So, this is the frame (see picture). Now how are these frames to be fixed? You have to know what is the locally available tiles' dimension. Based on that, these wooden supports (called 'purlins') are to be fixed, and these are the common rafters onto which they are to be fixed. And here comes the ridge, and the ridge tile. At the bottom you have comes the gutter tile, the eaves gutter, and in between these, you have to place your regular tiles.

Here you see further detail of the nail hole; the upper tiles are one on top of other. This is a very indigenous mechanism. This method is still followed across all our countrysides in rural India. They easily replace or repair the tiles when needed. Thus these tiles form a weather resistant or a proper roofing to their house.

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With all these, I conclude with the clay products and also the alternate materials used for replacing brick. The various other clay products that we studied are terracotta, porcelain, stoneware and clay tile. Under clay tile, we understood how it has to be fixed. Similarly, we knew that in case of brick- how bricks had to be arranged to get brick masonry.

Here, we understood how clay tiles are to be placed to get proper weather-resistant roofing. We conclude this lecture on clay, and thank you all.