Building Materials – II

Lecture 4

Welcome to the UGC lecture series. Todays lecture we will be looking at **unit 2 clay products** from the subject **building materials 2.**

In this lecture we will be looking at the **different types of clay products** available in the market like **burnt clay bricks, paving bricks, hollow bricks, terracotta, porcelain, stone ware. How are they `manufactured, what type of glazing is available on them, glazed ceramic tiles, and ceramic sanitary appliances, stoneware pipes and fittings, and also roofing materials like Mangalore tiles pot tiles and pan tiles.**

All these are manufactured from the raw material clay. **So what is clay**?

Clay

Clay is a stiff sticky fine grained earth that can be moulded when wet and dried and baked to make bricks, pottery ceramics and such. Clay is a type of soil. So amongst the soil , clay has the least particle size that is lesser than 0.002mm. S o that , the image you see on the top right is the texture of clayey soil. It is very fine. **Clay is a fine grained natural rock or soil material that combines one or more clay minerals with traces of metal oxides and also organic matter is also mixed with the clayey soil.**

Now lets see the **history of clay**:- Around 26,000 BC, early man discovered that clayey soil can be moulded when wet it can be moulded. And when it is dried in the sun it forms a brittle heat resistant material. Thus started the form of making pottery and such.

And around 6,000 BC, the Greeks discovered that if you instead of drying the clay under the sun, if you fired it , it has more resistance to weathering.

Around 4,000 BC in Egypt , they discovered that the silicone mixed in the clayey soil under the, when it was burnt in the kiln it fused together and came out as a glaze or as a glassy layer on top of the clayey product. So around the , then the Egypts tried to refine further the process of removing the glass from the , separating it from the clayey soil. And around 50 BC to 50 AD they discovered how to do that and then optical glasses , window glasses in such were discovered. Around 600 BC, china and areas around china they discovered porcelain clay which is more whiter in colour and the first ceramic composite was created by the Chinese. This porcelain clay is more durable and is made by firing clay along with feldspar and quartz. These are types of rocks. Then late 20^{th} century people discovered that refractory materials that is materials that are able to withstand extremely high temperature. They found out that if you coat clay products with aluminium oxide and such they have heavy resistance to heating and heat and fire and they can be used for the insides of the walls lining a kiln or a furnace and this helped greatly during the industrial revolution.

Then further developments in clay and ceramic led to ceramics being used in other fields such as in construction of resistivity or conducting materials like Edison tested a protora of ceramics for resistivity for using his newly discovered carbon microphone.

In 1889 the American Ceramic society was formed by Elmer G. Corton and the primary goal of the society was to continue doing research in ceramics and how other metal and ceramics can be used were else. And further during the course of many other scientific discoveries, now-a-days many ceramics which are made from clay are basically used in a lot of hi-tech instruments in phones, in rockets, parts of rocket, even they are made, they are used in cars, rockets, computer parts, or even you know like, machines, huge machinery and such.

Now **what happens to clay under fire**:- So basically clay when you mix clay with water it becomes mouldable, so you can see the molecular level the bond is something like this. You have clay an OH1 and OH 1 and clay. Then this is quite a weak bond when you fire it , this weak hydrogen bonds are replaced by a strong oxygen bridge and the water is removed. So you see a difference in volume. So that is why when clay is dried or after the clay is fired the clay shrinks during the firing process.

Now **types of clay products**:- there are various different types of clay products we categorized it very generally into **utilitarian and decorative items**. So **utilitarian** you have **clay blocks or clay masonry, paver blocks , tiles, , roof tiles, floor tiles, wall cladding tiles, terracotta tiles** and certain ceramics under **ceramics we have stoneware, porcelain** and such. They are also used in certain utilitarian and technical aspects.

And the next is **decorative items**, ceramics are widely used in terracotta ceramics are widely used in **pottery and other decorative items porcelain ware, table ware, stone ware.**

Now among the clay products the masonry, the clay masonry, that is the bricks,or the blocks are majorly used products amongst the different clay products. Now we will see **clay masonry, paver blocks wall cladding and roof tiles.**

Starting with **clay masonry or bricks**;- there are a variety, wide variety of clay bricks and masonry blocks available. The most commonly used in India is the 230mm × 150mm × 150mm clay block, clay brick. We saw the different types of clay bricks and the manufacture of clay bricks in our previous unit. In this image itself you can see the difference. In the hollow bricks itself there are so many different types within that you have different colours by adding different pigments you get different colours and just now the rectangular or cubioid form which is also found in other forms like you can see in the top left corner of the screen, so for corner bricks which are not exactly at 90 degree angle but an obtuse angle you have different types of bricks, so all these are bricks are made to order , they have separate moulds or separate machines to creating such bricks.

ADVANTAGES:- So clay masonry, we have to understand why clay masonry is so popular and so the most widely used building material. It is because clay masonry it has certain advantages which are it aways **Designs for the future, its simply sustainable, it is as safe as houses, it encourages comfort and clean air, it is quite energy efficient and affordable.**

So when we see **design for the future**;- why is it good for the design of the future. It is because it is endlessly innovative. Like You can see in the images here how they have used bricks in a different way. Here they have used In the 2nd two images you see they have used bricks to just form a screen wall and how they have used it forming the screen wall so successfully. It is very versatile and it is quite adaptable to the modern innovations in construction. This makes clay this makes bricks masonry very easy or very adaptable to the future design.

It is **very sustainable** meaning the carbon footprint required to make bricks or masonry is comparably very low to the carbon footprint required to make steel and concrete and such. And bricks have a very long life span. If you see the old structures in India they had bricks, they were made out of clay bricks. Its just made out of naturally and locally available materials also. It reduces the cost of transport as well. Production cost of bricks is quite highly efficient and the possibility of reuse and recycling is more in bricks. For example over burnt, or lesser burnt bricks also you can use in some part of the building .

And its **as safe as houses** meaning, it has high mechanical strength. Its as safe as house meaning it has high mechanical strength bricks have very good fire resistant or earthquake safe. They are very stable under different moisture conditions and are robust against extreme weather. If you see the kilns of furnaces usually they are lined with bricks because they have very good fire resistance. They promote comfort and clean air. They are very good for indoor air quality they are 100% VOC free. They don't require for making bricks you don't use any toxic chemicals during the process and they have excellency against moisture. They have a good thermo conductor. They make the space warm during winters and cool during summers. Electro smoke shield brick walls are also shields occupants from modern day equipments like antenna and such. They have very good acoustical insulation as well . Bricks are very energy efficient . They insulate the building and envelope it completely. And are very energy saving also.

AFFORDABILTIY:- This is one of the most important and critical points for bricks. Bricks are very affordable very economical over the whole lifecycle. They require minimum maintenance, have a long life span and a low energy bill. So because of these reasons brick masonry is highly in demand, is used very comparatively high , more than the other construction building blocks that are available in the market.

Now we will see the **different types of paver blocks** ;- in the image itself you can see so many different types of paver blocks are available in the market. Not just you have the original clay colour. Also you can coat it with other colours also. it will increase the aesthetical value. The same paver block at the bottom left corner you can see bricks used as paver blocks and different

shapes and different configurations. These different shapes are attained by using different types of moulds, or different types of forming processes.

Then we have **clay wall cladding tiles** . in this you see bricks itself are sometimes used for wall cladding. In this image you see the original wall at the back that is in the white colour and then yopu have a clay brick wall cladding which is supported by a steel frame. In the right you see an image where this white substance is called spaces that leave the required spaces between each wall cladding brick. On the bottom left you see not just in 2 D, you have bricks available such that you can even have 3D wall cladding also. And there are processes to manufacture such bricks or such tiles as well.

Then we have **terracotta wall cladding:-** Terracotta wall cladding which is coming into trend now very much in the Indian scenario. You see textured terracotta tiles here and then more aesthetical terracotta tiles. Terracotta tiles is not just is not used only for wall cladding, it can even be used to make murals like this. And here you see on the left there is a long wall , half of the wall is completely cladded with terracotta wall murals. Terracotta wall murals also have a very modernistic, it can be used for modern building as well . you can see this image the wall cladding you see here is completely terracotta wall tiles.

Clay Manufacture

Now we will see how these **clay products are manufactured**. They follow more or less the same procedure as we saw in the manufacturing of bricks. you have the clay extraction, then you prepare the clay. In this stage they add lime, sand, in additives or pigments in case you want a coloured clay product. Then goes through mostly, most of the clay products goes through a process of extrusion where the hole at the end of the machine is given a shape where the shape desired, for example if you want a round clay tile, at the end of the extrusion machine the hole is in round shape, so you get a completely rounded cylinder coming out. And then you cut it to the desired sizes. And after extrusion, you can also have a process called forming,in case the clay has to be formed in to some profile. Then finally the extruded or formed into the desired shape this clay is then taken for drying where it leaves off, where the water naturally evaporates. In case if there is some coating given to the clay product then it is done after the drawing stage where the coating is given after the drawing stage then the whole batch is taken for firing. After firing usually they take few samples are taken from the batch to check for quality. If it is conforming to the quality standards, then it is sent for packing and it is sent to the site where it is to be used. Now-a –days with different advancement in technology automatic clay block making machines are coming out like the one you see in this image .This machine can make the blocks that you see at the bottom. This many different types of blocks which consists of, paver blocks , consists of bricks, hollow bricks , and corner bricks, and coping bricks And such and copingblocks. All these types of blocks this machine can make.

Now lets see **clay roof tiles**:- .So you have different types of clay roof tiles, you have normal type of clay roof tiles, or terracotta tiles. You must have heard of the famous madras terrace roof which use aachickal or kandikal that is hand made clay blocks or clay tiles. Then you have terracotta tiles that give a good aesthetic asset like the one you see here. So it is usually the one on the right side is how it is applied. You have a timber frame on which it is kept. And from the bottom if you see the terracotta tiles like this. And mostly like this on top it will be a Mangalore tile roofing or pot tile roofing like the one you see here.

A variety of clay roof tiles are available. Some of the varieties are given here. Pan tile, roman tile, Chinese or Mangalore tiles, you have plain tiles or slate type tiles. In this image you see how a clay pot tile is installed on a roof. In this sketch you see there is usually wooden strip or some metal strip that is placed on top of the sloping roof ,and then the clay pot tiles are kept on top of it and you have nail holes here through this nail holes it is nailed to strips at the bottom. Clay pot tiles are among the first type of clay roofing that was used by the human.

Now we see **Pan tiles**. Pan tiles are usually s- shaped tiles the ones you see the image you see here individual tiles like this s and then you have a projection here which locks the other tiles so we have the projection it goes like that. And then you have Mangalore tiles, Mangalore tiles are this is the profile of the Mangalore tile. So the locking system of pan tiles work like this ,so if you have a roof like that which slopes towards this end, you have one tile coming like that, and you have the other tile coming like that, so it is on the same level of the slope. While the Mangalore tile what happens is, if this is the slope of the roof then if one tile goes like that and the other tiles goes like that ,so that how the locking system happens, so this is the difference. And Mangalore tiles are more widely used because they are more durable and they cover a longer span longer area so you need lesser support at the bottom. In this image also shows this image also shows how the Mangalore tiles are locked, and apart from just the normal roofing tiles other various different types of tiles are used , clay tiles are used in a different level like depending on were the tile is used, at the ridge level or at the valley level. See the different types of clay tiles like accessory or auxiliary used tiles also. .

Lets see how **clay roof tiles are manufactured**. The two processes either they are moulded by hand or there is equipment that moulds the tile. And the apart from that they follow the same processes of moulding, drying and firing in the kiln. After firing there is some coating given it is done before the firing. So these sketches show how this is done.

Advantages of clay roof tiles. Clay roof tiles have given a **very traditional looking style**. They are available in a **variety of colours and patterns, exceptional weather resistance are shown by this clay roof tiles. They have superior durability and long life, and very low maintenance.** They **are easy to replace** when they are broken, if one roof tile is broken they can just replace that one roof tile alone. They are **fire proof** with class A rating. They have **excellent insulating properties for energy savings**, and the smooth surface is **non-porous**. So **they don't**

absorb water and its also self cleaning because it is resistant to moss growth and resistant to sun's UV rays.

Now **other clay products** in roofs are you can even use bricks to form roofs like this you can use bricks to form arch roofing. And now-a-days you are this clay roof tiles are coming integrated with solar panels like you see. Now-a-days clay roof tiles or terracotta roof tiles are coming integrated with solar panels like this when you see each tile has its solar panel which connects to a wire a common electrical board. And then you have clay products which are also used for fill–a-slab. You might have heard of fill-a-slab. It fill the spaces were the concrete is not needed. The images you see here where clay pot images you see here where clay pot is used for fill-a-slab even Mangalore tiles are also vital use for fill-a-slab.

Ceramics

Ceramics a materials which is inorganic non-metallic solid prepared by the action of heat and subsequent cooling. What products come under ceramics usually a wide variety of products come under ceramics, which include your stone ware, porcelain and even terracotta. But for our easy understanding we keep terracotta separate from ceramics. So we have clay products, terracotta products and ceramics. Ceramics which include your stone ware and porcelain ware. Ceramics also now a days include domestic, industrial and building products in a wide range of ceramic art .

Types of ceremaic at **the molecular structure** there is two types, which is **crystalline and non-crystalline.** And crystalline is basically opague ceremaic and non-crystalline is basically a glassy type of ceramic. And based **on application** we have **white wares and technical ceramic**. White ware is your stone ware, porecelain ware and your vitreous tiles and such. Technical is where ceramics are used in engineering , advanced or special ceramics like the ones used for space shuttle, missile nose, cones , ceramics disk brakes used in your cars and such.

Now **ceramics products:-** So you have porcelain, you have stone ware and you have terracotta. Terracotta is also known as earthenware though terracotta is more widely used term.

What is the **difference between porcelain, stoneware, and terracotta**? The difference is the **clay used**, **terracotta normal clay** that we get is used. While **Porcelain ware the clay is more white** in colour usually found in areas around China. And **stone ware the clay has some mineral compounds** which when you use after firing the products the stone ware products is more impervious to water and it has a certain glaze also around it. While terracotta does not have glaze but you can provide the glaze if you want. And **firing method** is different. **Terracotta usually is low fired**, while **porecelain and stoneware is heavy fired** they require more firing or more temperature. **And properties** Because of the clay used and because of the firing process the properties they show is also different. **Terracotta is porous can absorb water**, while **porecelain and stoneware canot absorb water, more brittle and more hard**,.

General properties of ceramics are they are very **hard and brittle, strong in compression, weak in shearing and tension. They withstand chemical erosion due to acidic or caustic environments**. A major reason why ceremaics products are used in chemical labs, sinks and all will be made of ceremaics and **they withstand high temperature**. Another reason why ceremics is used as a lining material in your furnace or in kilns.

So lets see **terracotta**;- terracotta is a type of earthen ware, a clay based unglazed or glazed ceramic where the fired body is porous. Lets see terracotta. Terracotta is a type of earthen ware which is clay based , it can be glazed or unglazed where the final body is porous.

Uses of terracotta are it is used for **sculpture, murals wall cladding**. Unglazed units of terracotta are used for structural purposes as well and glazed units are used for building exteriors. Usually characteristics are it is **low fired, and it is quite it has a good fire resistant and it is strong** also. And terracotta has a **very long life so it is very dependable and durable material**.

Now **types of terracotta**;- various different types of terracotta are available in the market. few of the majorly used are glazed architectural terracotta, brownstone terracotta, ceramic veneer terracotta which is majorly used for exterior work cladding and fire proof terracotta.

Now lets see what is **porcelain?;-** porcelain is also known as china or fine china, is a ceramic material made by heating materials generally including clay in the form of kaolin. In a kiln between temperatures 1200 and 1400 C. majorly porcelain as you **know is used in porcelain ware, even bathroom fittings, tiles and other decorative items. It is also used as porcelain tiles and building construction. It has very low permeability, it does not absorb water, has good elasticity, and compared to terracotta it has more strength, is very white and translucent. And porcelain has high resistance to chemical attack and thermal attack.**

Now **stoneware:-** stoneware is a vitreous or semi- vitreous ceramic made primarily from stone ware clay or non-refractory fire clay. Stoneware like porcelain is **fired at high temperature**. Stoneware is also used for **decorative items** like stone ware pottery and stone ware products, used for table ware and art war. Stone ware is very resistant to chemical attack , is used **for acid storage, and electrical is very good insulator for electricity. And stone ware in building industry is used for pipes and pipe fittings**.

Now lets **see ceramic tiles**:- ceramic tiles. Tile is a manufactured piece of hardwearing material from ceramic. Now tiles are generally used for covering roofs, floors, walls, showers or bathrooms or other objects such as table tops or counter tops Of kitchen and such.

Lets see how **clay tiles or ceramic tiles are manufactured**. Ceramic tiles are made of clay. The first step is to prepare the clay. So now depending on the type of tile we want for example anti-bacterial type ceramic tile you have certain additives to make it anti-bacterial or if you want more resistance or more wear and tear add certain additives and prepare the clay, then they are formed into sheets and cut into desired sizes. Then these clay tiles are sent for drying. Now if it

is an unglazed tile these dried tiles are fired. If it is a glazed tile then there are two processes of firing. First is where they are glazed with a coating and then fired. That is called as single fired glazed tiles. The second process is where the wet tiles after drying are fired and then a coating of glaze is applied and then fired again. So two times they are fired and these tiles are called doubled fired glazed tiles. Double fired glazed tiles are more stronger and have a heavier wear and tear resistance but compared to single fired glazed tiles They are more expensive.

Now **application of tiles** widely wide Aapplication of tiles. Ceramic tiles are widely used , clay tiles are widely used for roofing , flooring, pebble tiles ,ceiling tiles , wall tiles and other application like counter like you have kitchen counters, you have bathroom counters, backsplash. Backsplash is were if you are having in the kitchen certain portion of the wall is upto a certain height is tiled so that if you are washing or if you are near the sink or if you are washing the water from the sink does not go into the wall or make the wall weaker. And you have flooring tiles, and flooring you have floor wall access aesthetically used exterior you also have wide variety different types of clay tiles , ceramic tiles in the exteriors. In ceramic tiles you have glazed tiles and unglazed tiles like we saw.you have Vitrified tiles. In ceramic tiles you saw we have glazed and unglazed tiles if you see those tiles if you see the cross section of those tiles you have the clay portion here . then you have a glazing layer on top . and if it is double glazed tile it is more integrated into the playwrite. Now-a-days you have a different type of ceramic tiles which is called vitrified tiles. Vitrified tiles what happens if you cut a cross section through it, the whole tile is homogeneous. In normal glazed tile if the top row chips off you can see the clay or brownish or dark reddish clay at the bottom. But in vitrified tiles if it is chipped off, since it is completely homogeneous it will fall the same colour, same texture throughout. So in this type of tiles manufacture of vitrified tiles is different in a way instead of just putting a layer of glaze on top, the whole colour is added with the clay during the manufacturing process.

Unglazed tiles are also known as Quarry tiles. And lets see the different types of ceramic tiles that is quarry or unglazed tiles that is ceramic tiles. Now we have Porcelain tiles are different from ceramic tiles in the way that they are fired. They are fired at higher temperatures which makes it more dense and moisture resistant. Porcelain tiles are also less porous making them more stain resistant and for these reasons the porcelain tiles are suitable for both indoor and outdoor installation and they also make it more expensive.

Then you **have mosaic tiles**. Mosaic tiles are nothing but small pieces of ceramic tile. They are used for covering bathroom or kitchen backsplash or even small counter space areas . Most tiles are usually less than 6 square inches and made of porcelain or clay composition. They come in different shapes and you have squares, octagons circles or even you have mosaic tiles space in your mesh then you can use that mesh tile directly on to the where ever you want to add it .

Characteristics of a good tile; - a good tile **needs resistance to abrasion**, it **should not absorb water**,it should have a **good freeze resistance and fire resistance** also. Also a good ceramic tile should have **resistance to load.** Like you see on your image because of load part of a tile has

chipped off. Usually it is load or your home furniture or your equipments like fridge and washing machine and such that cause damage to the tiles. Ceramic tiles need to have **a resistance to corrosive or staining action** of substances like when we use it in bathrooms, kitchens or more places like chemical labs and all. Because of the chemicals present in water it will cause tiles to stain or to form mosses where in the groove and all. The common thing seen in ceramic tiles is with the use with the life span of the tile , the tile starts bleaching or losing its colour, it is not the sign of a good ceramic tile. Ceramic tile usually should have good safety characteristics like when we are using it in bathroom it should have a **good slip resistance.** People using the bathroom should not slip because of the ceramic tiles. So you have grooves or certain pattern embedded on ceramic tiles, To make it more slip resistant. Unglazed tiles mosaic tile have rough surface but glazed tiles usually have a very smooth surface so they need such grooves. The ceramic tiles has to be stained resistant. The more the poracity of the tile the less the stain resistance to. In glazed tiles there is more stained resistance when compared to unglazed tiles.

With this we have come to the end of this lecture. We learnt about **clay bricks, clay masonry, hollow bricks, terracotta tiles, porecelain, stoneware and their uses, and then we saw the different types of ceramic tiles –glazed ceramic, unglazed, fully vitrified ceramic tiles, we also saw the different roofing materials available in clay like mangalore tiles, pot tiles, and pan tiles and how they are manufactured.**

From your understanding in this lecture can you answer the following questions:-**What are the applications of terracotta in a building industry apart from decorative items what are the applications of terracotta in the building industry? ; and amongst bricks which is more preferred – solid bricks or hollow bricks and why? ; What is the difference between a glazed ceramic tile and a fully vitrified tile?; Can you identify the technical applications of stoneware and porcelain ware in building industry?**