Building Materials and Composites
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Lecture - 15
Ceramic Tiles and Vitrified Tiles

So, we are in the last lecture of this particular module on glass and ceramics. Here we will cover a slightly different topic from the earlier discussions on glass. We will talk about ceramic and vitrified tiles and have bunched the topic here at the end of this particular module. You must be able to recall our discussion on clay roofing tiles under the clay module.

These tiles have a coating that is glassy in nature, and therefore, we decided to bunch the topic under this particular module where you learn about glass. The main difference between the other materials which you have studied and this material is that tiles are a finishing material. It is not used for directly making walls, floors, or roofs but as a covering (or coating) on floors, roofs, and walls.

So, it is a layer that will bring in aesthetics and various other qualities, which one needs in a space.

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Let us now see the content in this particular lecture. First is the introduction, followed by the manufacturing process. Ceramic tiles are mostly placed on the floors and on

walls. Vitrified tiles are tougher and are gradually replacing stones. We had already elaborated on stones in Module 1.

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The basic materials used to manufacture ceramic and vitrified tiles are majorly clay and sand. Thus, composition-wise, they are not much different from bricks or even glass. These tiles also contain sand (silica). Ceramic tiles are entirely made of clay and sand. Vitrified tiles are made from clay, feldspar, and quartz.

Hence, this brings in a lot of difference between the two materials. Ceramic and vitrified tiles are finished materials. Here are some familiar pictures. As you see, this (see image) is where wall tiles are used. The dado of the washroom (in the urinal zone) is made of wall tile. Whereas here, you see a floor tile (fixed to the floor).

You can also see a lot of patterns on these tiles- they can also be made. Here you can see a large-sized tile, whereas, in the other picture, the tiles are small. but it is very difficult to identify the edge-line (joint) between the tiles. These are made of vitrified tiles. These are smaller in size, and here (see image), they are almost invisible and are larger in size.

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If we glance into history, we will see that this kind of tiles have been used for hundreds of years, and they are not a new product. During the Renaissance period, Italian buildings had seen a lot of applications of these tiles. The tiles you see on these walls (see image) were also called ‘Majolica’ tiles. Those were put on wall and floor surfaces for beautification. As evident from the images, all of these were hand-painted.

On top of it, a coating (or glazing) was applied, which is the reason behind studying this item under glass. You may recall that when we studied terracotta, either grounded-glass was mixed with clay or was put in the furnace. So, glass gets fused onto the surface- the fumes from the furnace gets coated on top of terracotta, imparting an impervious coating on it.

Recall the term ‘impervious’, implying that water absorption is minimal. This assures a long life for the product. A lot of historical examples can be found for these tiles. In those days, either lead glazing or tin glazing was used. Tin glazing gave an opaque look, while lead glazing provided a transparent look. The city of Delft in the Netherlands is famous for its tin-glazed earthenware, popularly called ‘Delftware’.

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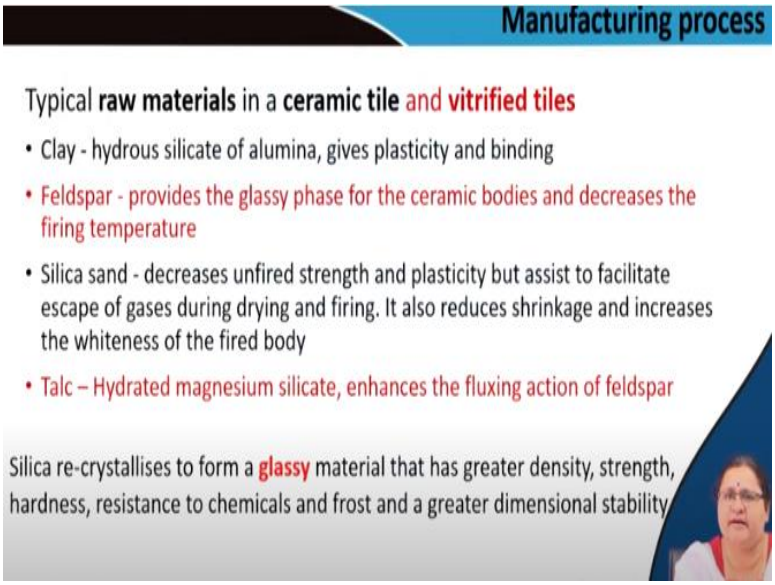

We will now discuss the manufacturing process and how it is different from brick manufacture. Here, the raw materials are very fine and have to be consolidated (or compacted) to a great extent, such that porosity (which was widely prevalent in the bricks, causing 15 to 20% water absorption) does not impact the final product.

The coating would impart more density, strength, hardness to the product, with additional benefits. The basic material is clay for both vitrified and ceramic tiles. The process of manufacture of both tiles are the same- only the ingredients are different. Clay, as you already know, is the hydrous silicate of alumina, which provides plasticity and bonding to the product.

Silica sand decreases the unfired strength and plasticity but facilitates the escape of gases (fumes), which are generated due to the reactions during the manufacturing process inside the furnace. It reduces shrinkage and increases the whiteness of the fired body.

Feldspar provides the glassy phase of the ceramic bodies and decreases the firing temperature. Talc (hydrated magnesium silicate) enhances the fluxing action of feldspar. These two items are added to vitrified tiles. It makes the tiles more rigid and strong. They also attain a characteristic white color, unlike clay ceramic tiles, which are red in color.

I will show you the pictures later. The mix is heated at high temperatures, when the silica recrystallizes to form the glassy material, which imparts additional qualities to the tile. It makes it frost-resistant and chemical resistant. The dimensions of the tiles do not change (warpage is negligible), unlike what was seen for clay.

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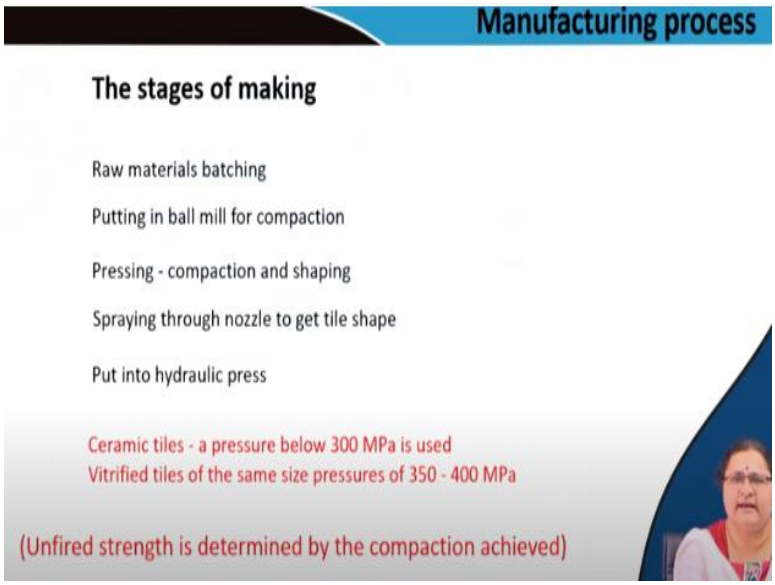

Coming to the stages of manufacture, the first point is raw material batching. Here, the word batching imply to assimilate the proportions of the items which are to be mixed together. So, a measured amount of items are to be brought in batches (in required amounts), after which they are mixed together.

This is an essential part because it provides the entire quality of the material. In the next stage, the batched items are inserted into the ball mill for thorough mixing, before it goes for compaction. The final mixture becomes uniform (homogeneous).

Once that is done, it is put into the mould where it is pressed with the help of a hydraulic press, leading to the compaction of the material. These tiles are compacted to the maximum extent possible. For ceramic tiles, the compaction requires a pressure of around 300 MPa, while vitrified tiles require a higher pressure (350 to 400 MPa) for compaction.

The stage of compaction is necessary in order to make the tile more dense and consolidated, such that it gains strength. So, nothing is fired till now. These tiles are actually quite thin (within 5 to 6 mm thickness). After pressing and shaping, the tiles

are sprayed through these nozzles, which gives the final coating to the tile surface. It is again put back into the hydraulic press.

Again, as earlier, ceramic tiles are compacted with a pressure of around 300 MPa, whereas the vitrified tiles get a pressure of 350 to 400 MPa. Then the product goes for firing. The 'unfired strength' , as mentioned here, is determined by the compaction. This compaction step is essential since it aids in making the tiles less water-absorbent.

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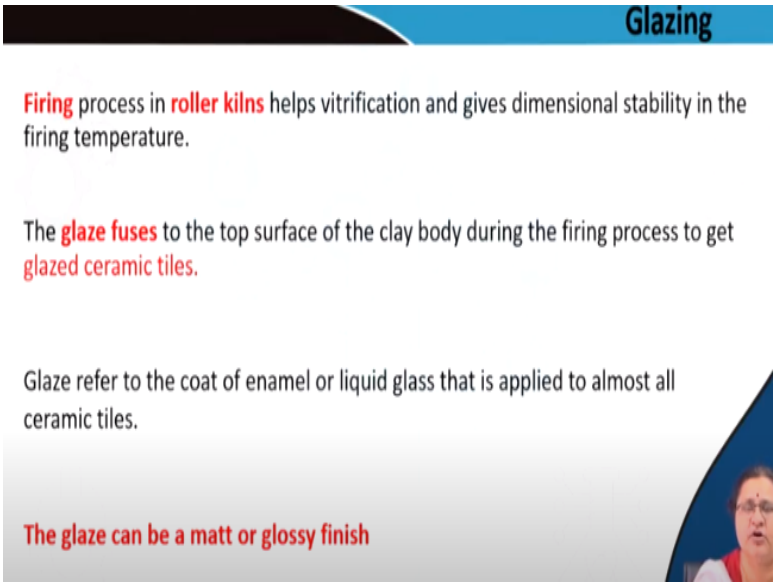

In the firing process, the unfired tiles are put into the roller kiln, where vitrification takes place, and this imparts dimensional stability and vitreousness to the tile. The glaze (top layer) fuses on the surface of the clay body during the firing, and thus, these tiles are called glazed ceramic tiles.

If the glaze is not sprayed on top of the tile during the spraying stage, it will remain unglazed. Hence, ceramic tiles are of two types: unglazed type and glazed type. Here, the term 'glaze' refers to the coat of enamel or liquid glass that is applied to almost all the ceramic tiles. Again, the glaze can be of different types- matte or glossy in finish.

So, those are further details of the manufacturing process, but we are more interested in the various types of tiles and their corresponding applications (usage).

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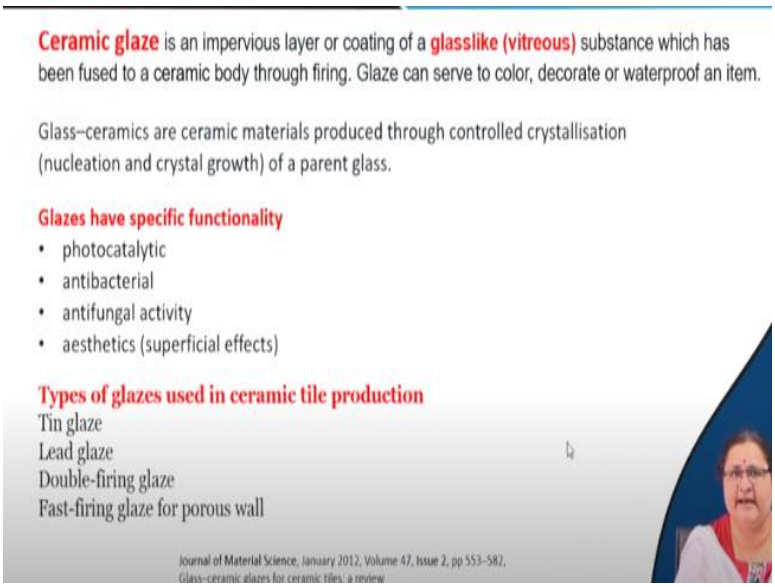

Let us come to the ceramic glaze, which is the glass-like layer or coating that imparts imperviousness to the tile. This layer is fused (not separable) to the tile. It has now mixed with the main body of the compacted clay tile. You may add colors to the tile, similar to the ones mentioned during glass manufacture. That will provide a single uniform coloration to the tile.

This also imparts waterproofing to the item. The glaze has different functions. As already mentioned, it is non-reactive to chemicals, particularly acids. It also possesses antibacterial and antifungal properties. After applying the glaze, the glazed tile will develop similar properties. They find applications in chemical, biological laboratories, operation theatres in hospitals, etc.

These tiles are applicable for interiors like pathological laboratories, surgical cabins, even in washrooms and toilets. For example, in a bathroom, if a wall surface was kept bare (just plaster and paint on a brick wall surface), it would have easily absorbed the bodily discharges from people, getting stained and stinky. Due to the presence of this glass-like finish on the tiles, the bodily discharge will neither react nor get absorbed into the wall and can be washed away with water.

You are now aware of these properties and can use the product appropriately to fit the specific purposes. These tiles may be tin-glazed, lead-glazed, double glazed, or fast-firing glazed, which constitute the various types of glazings. We will not cover those specific details.

Sometimes, you may have colorful art on tiles; they are actually fused behind the glass. There are methods using specific templates that generate such patterns. In early times, this was done by hand, and then the glass coating was applied on top. Those were handcrafted, but nowadays, the process may be easily mechanized.

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Other than these glazed tiles, we also have the unglazed ceramic tile, which looks a bit dull, and are mostly seen outdoors. They get their color from the minerals present in the clay, so the color is natural. You may add natural pigments to make it a bit different.

The unglazed ceramic tiles are pressed on their top surface and have only one thin layer of colo. They absorb liquids and therefore are very much vulnerable to stains. Though these floor tiles are thin, they are slip-resistant because they do not possess the glassy, non-slip, frictionless coating.

Since they are slip-resistant, they are suitable for outdoor areas where water can reach that, but it does not leave the surface slippery. These tiles may be polished if necessary, which is named as polished unglazed ceramic tiles. In the market, there will be a variety of options to choose from. But as an architect, you must have the insight to pick the appropriate product depending upon the use-case (where the product is intended to be used).

Therefore, if your area of application is a dry area, you do not need to consider the degree of water absorption when choosing your tiles. If it is a washroom, you have to think of water absorption. If a lot of people are expected to move on it, then a product with high strength and durability needs to be selected. As you had seen in the first picture, a set of urinals are attached to the wall. Since the tile is never going to be walked upon, we do not need to consider its strength.

Thus their compaction may not be up to the extent of floor tiles. But it can get stained, so the water absorption factor should be considered. Tiles are made in different ways keeping a specific application in mind. The architect has to choose the product accordingly.

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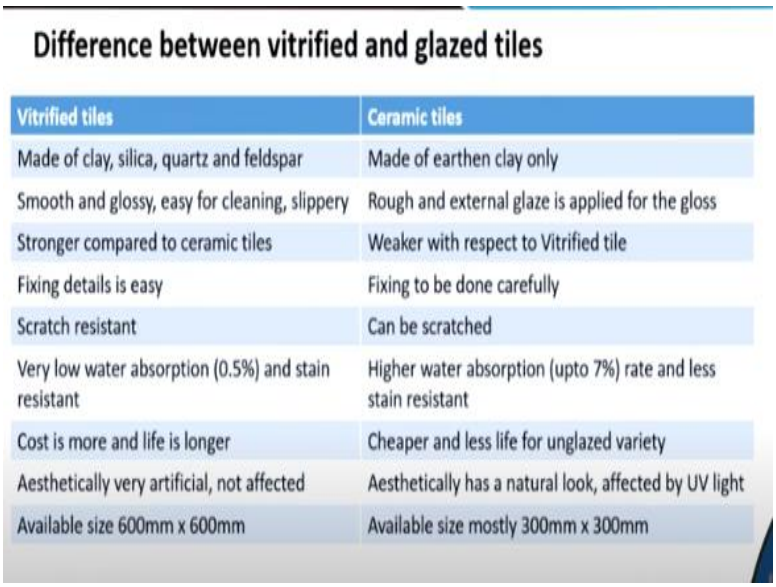

Difference between vitrified and glazed tiles

Vitrified tiles	Ceramic tiles
Made of clay, silica, quartz and feldspar	Made of earthen clay only
Smooth and glossy, easy for cleaning, slippery	Rough and external glaze is applied for the gloss
Stronger compared to ceramic tiles	Weaker with respect to Vitrified tile
Fixing details is easy	Fixing to be done carefully
Scratch resistant	Can be scratched
Very low water absorption (0.5%) and stain resistant	Higher water absorption (upto 7%) rate and less stain resistant
Cost is more and life is longer	Cheaper and less life for unglazed variety
Aesthetically very artificial, not affected	Aesthetically has a natural look, affected by UV light
Available size 600mm x 600mm	Available size mostly 300mm x 300mm

We will now study the differences between vitrified tile and ceramic tiles. The constituent materials are obviously the first point. Vitrified tiles are made of clay, silica, quartz, and feldspar, while ceramic tiles are made of earthen clay only. Next, the vitrified tiles are always glossy, easy to clean, but very slippery, whereas ceramic tiles have a rough surface (only top glazing may be given). The vitrified tiles are more durable because of their composition and also compactness (since the pressure applied during the compaction stage is higher for vitrified tiles), whereas the ceramic tiles maybe a little weaker.

Fixing is easier for vitrified tiles, while in ceramic tiles, it should be done much more cautiously (to avoid any accidental water absorption). We will discuss the fixing

details in a short while. Vitrified tiles are a bit more resistant to scratches than ceramic tiles. However, in some cases (for example, on using sharp tools), even vitrified tiles might get scratched.

Vitrified tiles are very low on water absorption (0.5%) and stain-resistant, while ceramic tiles have higher water absorption capacity (7%), and susceptible to stains. Vitrified tiles cost more and promise a longer life. Ceramic tiles are cheaper, and the unglazed variety has a shorter lifespan. Aesthetically, they both deliver a marble-like or granite-like finish. Such patterns are sometimes used on countertops nowadays- but the appearance becomes artificial- it is easy to distinguish it from stone tops. Using ceramic tiles can provide a more natural look.

The color of the ceramic tiles may fade away gradually due to ultraviolet light, but vitrified tiles do not face the same issue because the color gets embedded thoroughly with the tile owing to the vitrification process. In the case of ceramic tiles, the coating stays only on the top surface. Vitrified tiles are also available in larger sizes (600 mm ×600 mm) as compared to ceramic tiles (mostly 300 mm × 300 mm). A more detailed list of sizes is given later.

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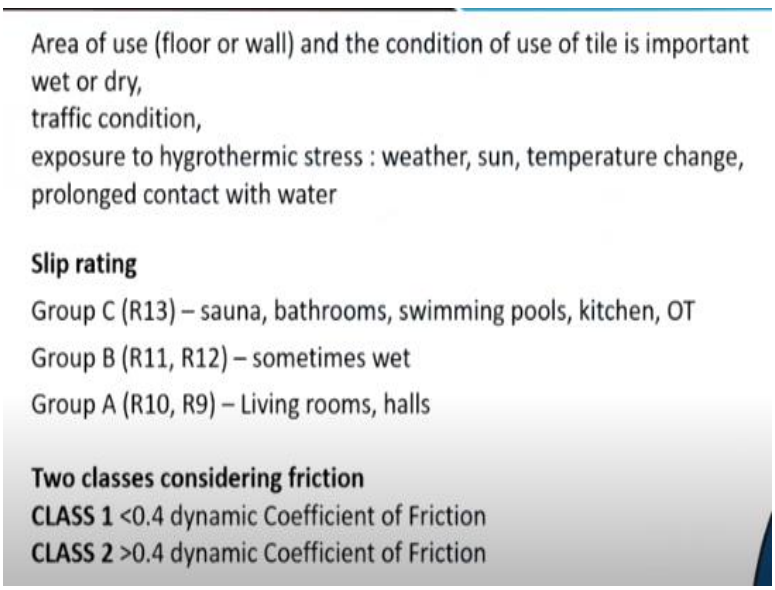

Now, we will focus on the area of use and the condition of use of the tile. The location of use- wet or dry, and the traffic condition (frequency of people walking over it) what is important to be considered. Think of a busy airport or a railway station. You cannot allow commuters to slip when walking on them. At the same time, a rich look

may be necessary (particularly in airports). Also, it has to be very sturdy, since the tile has to frequently bear the weight of people walking, along with heavy luggage being pulled across the floor. In short, it will face a lot of traffic.

So, we have to be careful in the selection of the tile. Consider office buildings, which regularly face exposure to several phenomena involving hydrothermal stresses, temperature change, rain (prolonged contact with water), etc. (depending upon location and climate)- so, these points must be kept in mind during product selection. The slip rating of tiles is mentioned on their packaging box. They are usually of three categories- Group C, Group B, Group A. (In European standards, the slip rating is measured by R-ratings, a higher number of rating implies better slip resistance).

Group C tiles are meant for wet areas, such as sauna, bathroom, swimming pools, kitchen, and operation theatres. These tiles do not get slippery even if water accumulates on them. Group B tiles are used for areas that get wet occasionally. Group A tiles are used for mostly dry places (such as living rooms). Considering friction, there is another class of tiles- class 1 and class 2, which depends on the dynamic coefficient of friction- a value of less than 0.4 is grouped under Class 1 tile, whereas values above 0.4 make it a Class 2 tile.

he dynamic coefficient of friction is measured when someone is walking, or something is moving on the tile. Thus, you can see that there are various classifications of these. As an architect, you have to understand the purpose and location of use, depending on which you may choose or recommend the product.

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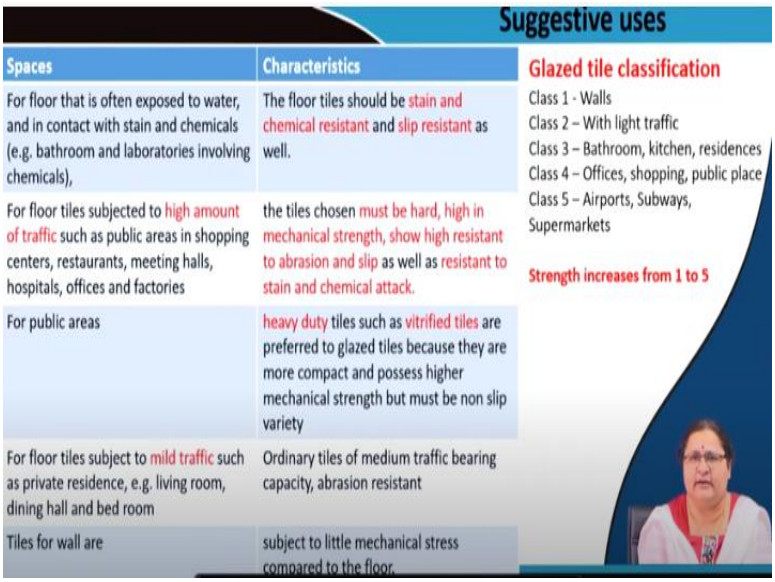

Here are some spaces and corresponding characteristics (see table), so that it is easier to match the kind of environment you need and the corresponding properties of tile that is desired. Say, bathrooms or laboratories, where chemicals are involved - there you require stain-resistant and chemical-resistant, and obviously slip-resistant tiles. For high-traffic areas such as hospitals, shopping centers, restaurants, meeting halls, you will need durable, high mechanical strength tiles that offer resistance to abrasion and are slip-resistant.

So, that kind of flooring would be designed accordingly. For public (busy) areas, such as airports, railway stations, etc., you require heavy-duty vitrified tiles. There is another area- mild traffic zones, with a moderate amount of people visiting (such as a private residence). There, you may go for less-expensive flooring tiles which has medium strength and is abrasion resistant (such as class 2 tiles). On the right side of the table is another list, which matches the Tile class (Class 1 to 5, based on strength), with corresponding application areas.

Here, class 5 is meant for the airport, subway, supermarkets, which see a high amount of goods and human movement, whereas class 1 tiles are meant for walls subject to little mechanical stresses (compared to the floor), and therefore, their strength is quite low.

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After knowing all these, you also need to understand how to place the tile in position. The given pictures are illustrative. A serrated (grooved) base is made. Similar serrations are made on the walls too. This pattern is made using a specialized trowel. Thus, something is spread on the wall, on top of which this tile is fitted. These photographs are taken from the back of the tiles.

The second image at the bottom shows the backside of a vitrified tile, while the third one shows the back of a ceramic tile. They have checkered ribs that grip the slurry that has been spread, such that the tile does not come off easily after it is fixed to the floor. The tile remains in position. But in the case of a wall, it may fall off.

As far as falling off is concerned, adherence is more important in the case of wall tiles, but not so much for floor tiles. For floor tiles, cement and sand (1:4) mortar is used as the base (sometimes some cement slurry is also directly used). For walls, the quantity of cement is higher (4:1), and at times chemical adhesives are used to keep it in position to ensure adherence. If the tile falls off accidentally, it may hurt someone.

Another vital point to note is the color of the tiles. As you can see from the images, the ceramic tile is red in color (at the back and cross-section), basically because it should possess the same color as that of burnt clay, similar to a brick. The vitrified tile is white in color throughout.

So, you must have understood the significance of knowing about the fixing of tiles. Now, how to fill in the gaps? Eventually, there will be a large number of gaps between the tiles through which water can seep in and loosen the tile. You have to seal it with white cement. These tiles are spaced by means of 'spacers'- which helps maintain a fixed 2 to 3 mm space to allow any expansion; otherwise, it may lead to cracks. Like every other material, installing tiles also requires specific workmanship.

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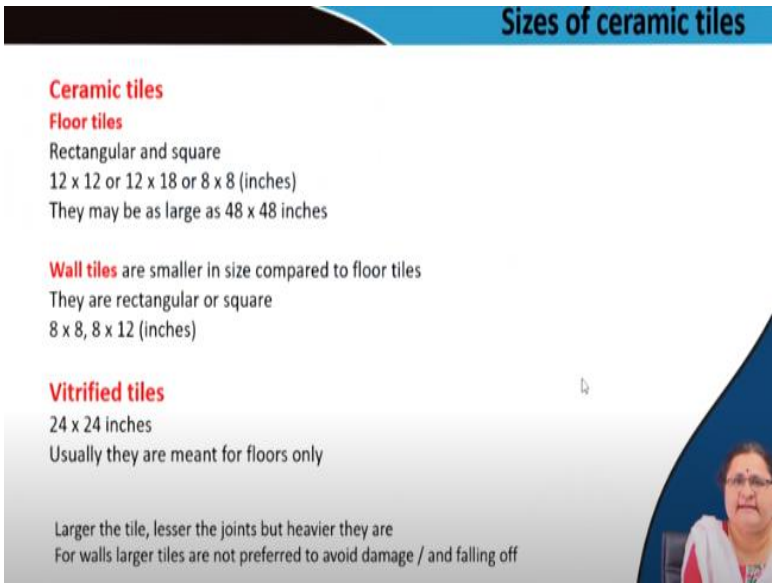

In the market, several sizes of tiles are available. Wall tiles are the smallest. Typical sizes include 4×8, 8×8, and 8×12 (all values in inches). Higher dimensions are not available because there is a chance of falling due to their own weight. Ceramic Floor tiles are usually found in 8×8, 12×12, 12×18, or 18×18 (all values in inches). They may sometimes be as large as 48 inches × 48 inches.

Vitrified tiles are bigger than ceramic tiles, and thus they make a lesser number of joints. They are a minimum 2 feet × 2 feet in size (that is, 24-inch × 24-inch or 600 mm × 600 mm). The larger the tile, the lesser the number of joints formed but are heavier. Thus, wall tiles are preferred to be smaller to avoid damage due to falling off.

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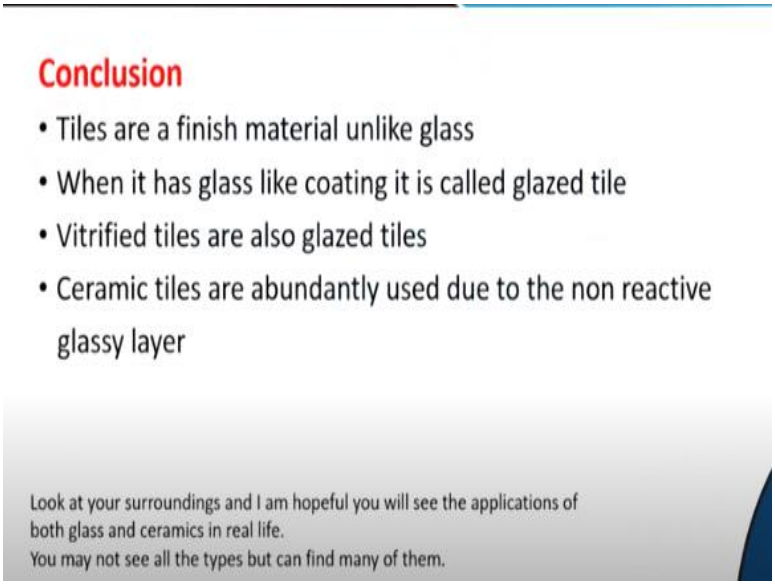

So, we can conclude this module with this short summary. Tiles are a finished material, unlike glass. When it has a glass-like coating, it is called a glazed tile. Vitrified tiles are all glazed tiles. Ceramic tiles are abundantly used due to their nonreactive glassy layer and are cheap. Vitrified tiles are often used as a substitute for stones and they impart an elegant look to the area. Also, we need to consider the slip-resistance and the ease of movement on the tiles.

Absorption of water, chemical actions, and the expected volume of traffic over the tiles- all have to be considered before tile selection. Before we finish this module, I would again request you to look at your surroundings and find out some areas where the discussed items are used. Many of the types may be easily found at your homes or at your institution.

You may visit a temple, a shopping mall, a restaurant, or any other public place and check out the type of glass used. Applications of tiles may be found in gymnasiums or swimming pool areas. Whenever you are visiting a place, train your eye to explore the different building materials used there. Analyze the space mentally and check whether the material is actually suitable for that space or not. This inquisitive behavior will make you a more successful person in this domain of architecture. Thank you.