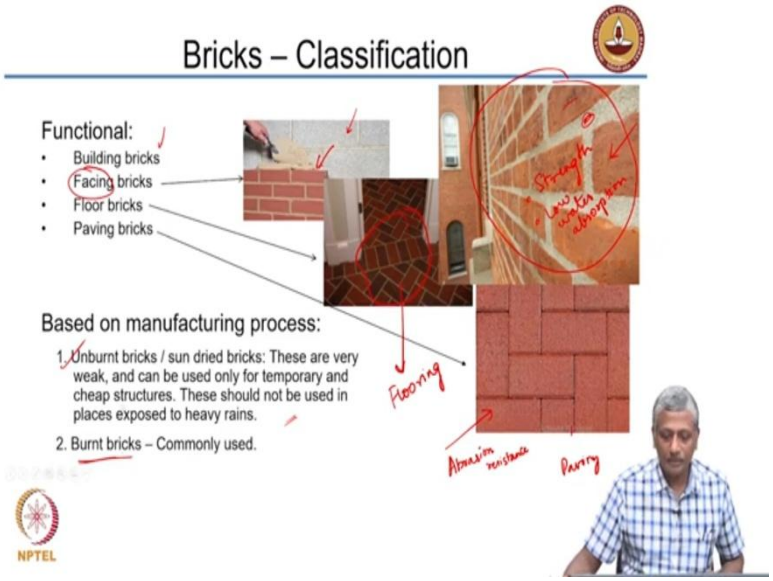
Basic Construction Materials
Prof. Manu Santhanam
Department of Civil Engineering
Indian Institute Technology – Madras

Lecture - 19
Stone, Brick and Mortar - Part 2

(Refer Slide Time: 00:14)



We all often think of bricks as only the ones which are used to make the houses, to make the walls in a house. But then bricks have other uses also. You can actually make bricks for very specific uses. For instance, we know that mostly the bricks are used for building walls, those are called building bricks like what is shown here. This is a typical scene from a house where you see a wall which is bricks, jointed together with mortar.

This is a typical scene from a wall. But bricks can also be used for other functional purposes, for instance, facing purposes. Supposing you have a wall of concrete or wall of any other material and you want to give it a nice aesthetic brick like appearance in the front. So you have these special bricks called facing bricks. So here you can see the background is actually a concrete block wall. And you are putting, sticking these nice panels of facing bricks on top of the concrete wall. So structurally, these facing bricks are not taking up any load. They are simply providing the aesthetic brick like appearance on the surface. So that's called a facing brick.

Sometimes you may see that bricks are lined up on the floor. Instead of tiles you sometimes have brick flooring; especially it's quite common to find in verandas in houses. You often

find brick flooring in verandas. Brick flooring requires the use of a special type of brick called flooring brick. Sometimes even in parking areas, in academic institutions, especially when you have cycle parking for instance, you often see the use of flooring bricks.

What is the difference between a flooring brick and a building brick? In a building brick, typically it has to ensure that you have a good environment inside the house and protects you from the weather essentially. So a building brick should not absorb too much moisture and should protect you from effects of the weather. I will touch upon that a little bit later, but what about a flooring brick? People walk on it, there are small light vehicles that are going on its top. As a result of this, there will be a lot of abrasion from the surface of the brick. So in the case of flooring brick, you need to design the brick for abrasion resistance.

So we need to design these flooring bricks for abrasion resistance. And that's where they differ from your building bricks. The building bricks are not typically designed for abrasion resistance; they are designed for strength, to carry the load basically in the axial direction. And then they are also designed for low water absorption. So, typical building bricks would be designed for strength but floating bricks will be designed for abrasion resistance.

There are 2 types of flooring bricks that I have shown here. These are for paving. They are used in outdoor conditions for paving. And these are flooring, which are used in indoor conditions. Flooring and paving bricks are both basically bricks that are laid out on the floor. When it is interior, we call them flooring bricks and when it is exterior, we call them paving bricks. So these are designed primarily for abrasion resistance and they should be strong enough to be scratch proof. Especially in the house, when we start moving furniture, you don't want the floor to be scratched by it. So, these bricks should be designed adequately enough such that they are scratch proof.

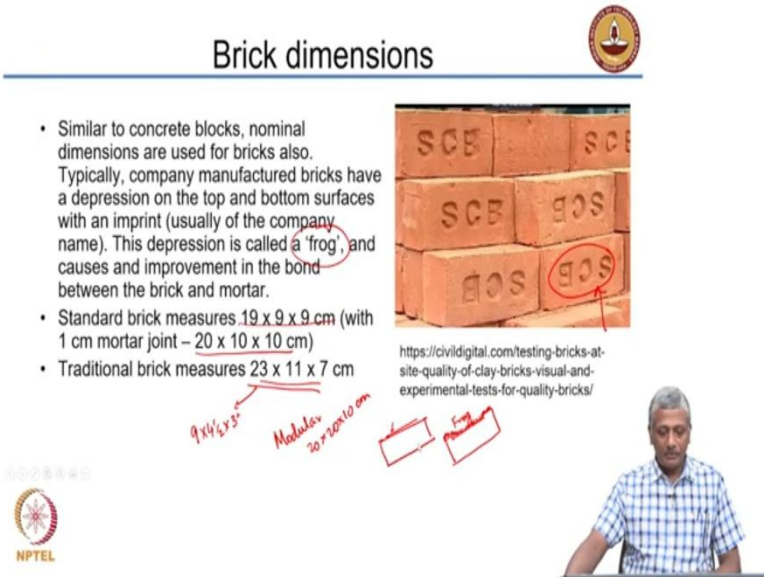
You can see that with the use of different colors in the flooring brick, a very nice pattern has emerged. It's still looking quite beautiful. You don't really need to have good looking tiles to make a very good looking floor. You can actually have bricks also. So that is basically the functional performance of the bricks or functional need of the bricks either in a wall or on a floor on a pavement. Based on which you are defining the characteristics or classifying the brick.

There is another way of classification of the brick based upon the manufacturing procedure. Some bricks, especially when you go to rural areas where you don't have very good burning facilities, those may be unburnt bricks, simply the brick is molded, textured and simply dried. Now obviously, this sort of a brick will have a problem with respect to low strength, it will be quite weak.

Secondly, such bricks will not be highly resistant to moisture, they may start degrading when there is torrential rain, for instance. Because again, it's just moulded clay and when it starts absorbing moisture, it will start expanding and failing. So you don't want that to happen. We don't want to use them in areas that are exposed to heavy rains. But if it is a dry area, you don't really have a problem.

So, these bricks are not for load bearing wall construction but more for purposes like compound walls, for instance. Because if a compound wall falls down, nobody really worries too much about it. The masonry wall inside the house construction should be solid and have sufficient strength. For that we have to use good quality burnt bricks, that is good quality burnt bricks need to be used for residential construction.

(Refer Slide Time: 05:24)



We have now looked at different types of bricks. Now let's talk a little bit about brick dimensions. As I said earlier, the modular dimension is typically written as 20 x 10 x 10 cm. So this modular dimension of 20 x 10 x 10 cm, assumes that you have a 1 cm thick layer of mortar around the brick. So the actual size of the modular brick is 1 cm less than that, which is 19 x 9 x 9. So it assumes that you have a 1 layer or 1 cm thick layer of mortar on top of it.

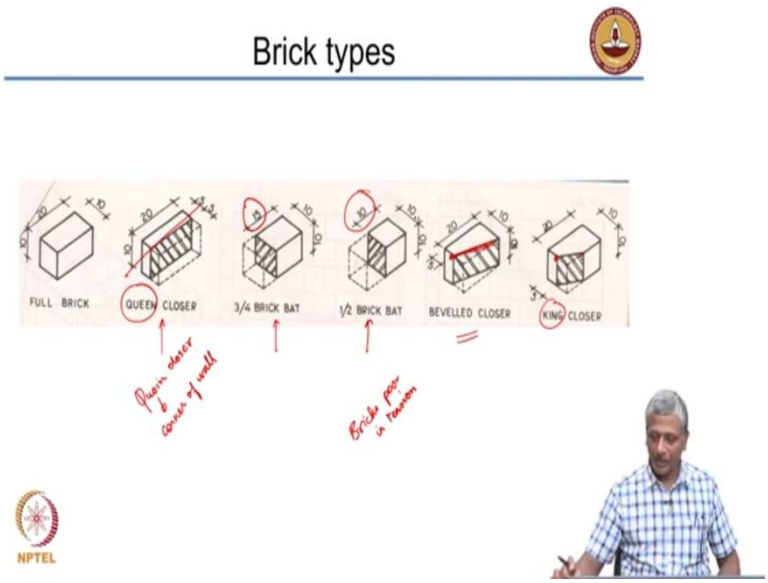
If you really go to a construction site and you pick up a brick, it is not going to be 20 x 10 x 10. This is a modular brick which is essentially for design purposes and for drawing purposes, we don't really encounter these bricks in practice. In practice what we will see are cuboidal bricks and these cuboidal bricks are typically 23 x 11 x 7 cm. This kind of a weird number is derived from 9 x 4.5 x 3 inches, that's essentially 23 x 11 x 7 cm.

In the past when English were here, we were using the old English units, which were in foot, pound, inches and so on. As a result of which, we still have the same sort of regulation for our typical bricks, which are cuboidal. We have a rectangular cross section, not a square cross section like the modular brick.

This is a typical type of a brick and you can see the imprint of the name of the company that has manufactured this brick. And that imprint is typically a depression into the top surface and that is called a frog. This depression on the top surface is called a frog. In some of the bricks, you may see that the top surface itself is not perfectly flat, on the other hand it is somewhat like that. You have depression like this on the top surface and that depression is called the frog and it has an interesting need to be there also.

What happens is, now because of this frog, the available surface area on the top for bonding with the mortar is more than the surface area in this case. The surface area for a flat case is lesser than the surface area for a case where you have a top depression. So you have a greater amount of area for bonding with the mortar. That's why in most cases, you will find the bricks having the frog, not just to the point of view of bonding, but also from the point of view of advertising the name of the company that is manufacturing the brick.

(Refer Slide Time: 08:11)



Bricks often are devised into different shapes on the site. And this can be done quite uniformly by the person who is laying the bricks. The mason who is working with the bricks often has sufficient capability to break the bricks into different shapes. Now why do we need different shaped bricks? We will come across the rules of bricklaying later and then try to understand what are the typical arrangements of bricks which make bonding possible. There you will see that there are needs for special type of bricks to be used to get the kind of shapes that we actually want.

Now in many cases, you can mould these bricks into these shapes also. But then how many of these moulds can you actually have on site? So oftentimes we need to have expert masons who have the capability of actually using their trowel to simply slice these bricks into different sizes.

What are these different sized bricks? When they are done in a proper manner, these different size bricks exactly measure like this. For instance the queen closer is a brick that is split longitudinally, you take the trowel and split the brick longitudinally, so that you have a brick of dimension 20 x 10 x 5 cm, instead of 20 x 10 x 10 cm.

A brick bat is when you cut the brick in the other direction, transverse direction, to make bricks of different length. So instead of 20, now we have a length of 15 for a 3/4 brick bat or you have a length of 10 for a 1/2 brick bat. So you can cut bricks in different fashions to get different types of special bricks out of it. And these special bricks have very particular needs to fulfill when you actually construct the entire wall.

You can sometimes go for very different shaped bricks also like a bevelled closer, where you are cutting along an incline from the center of one face to the edge of the other face.

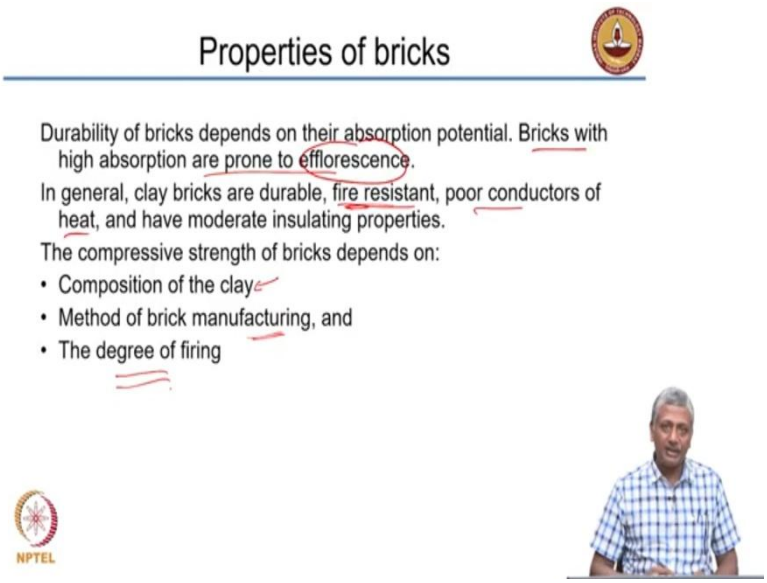
You have also the king closer, where you are cutting from the centre of one face to the center of the adjacent face. So again, it depends on the kind of requirement that your wall has. Sometimes to end the corners, you may actually need special bricks. In fact, the queen closer is also known as the quoin closer. A quoin is basically a corner of the wall. So for a wall to end and then move in the other direction, you need to be able to close it. What do you mean by closing it? You need to provide these bricks in an arrangement that makes it possible for the shape of the wall or rather the direction of the wall to turn the other way. So that's called a quoin closer or colloquially it's also called queen closer.

Now these are special bricks, as I said, you can have them moulded or you can have them shaped by the mason. So mason has the ability to actually use a trowel to shape it on site. Of course like most construction materials, bricks are also poor in tension. Bricks are poor when it comes to taking tension. Most construction materials, brick, stone, concrete, everything all these materials are very strong in compression but poor in tension. Steel of course, is as strong in compression as it is in tension.

One material that is opposite is wood, which is a lot more stronger in tension, especially when you are going along the grains of the fibers that are there in the wood, as opposed to compression. So wood is stronger in tension than in compression. So different materials have different types of attributes, you need to use them correctly.

As far as bricks are concerned like stone or concrete, they are also very poor in tension. So when you are trying to have a trowel to slice the brick, it slices easily. Because the edge of the trowel puts the brick into tension, so it is able to fracture quite easily.

(Refer Slide Time: 12:22)



What are the properties of bricks? We want to design the bricks to take the load of the wall. And of course, the brick does not work on its own, it works in a composite system along with the mortar. But how important is the mortar? We will talk about that in due course. So what are the properties of bricks? As I said, typical building bricks are designed for their strength and for their resistance to water absorption.

A lot of the issues of durability of the bricks deal with the absorption of moisture by the brick. And that is a very important aspect to remember. If you can protect your brick from moisture absorption, you have greater durability that you can get from bricks. Bricks with high absorption are prone to what we call as efflorescence. What is efflorescence? The name itself implies that something is flowering. But in the case of buildings, efflorescence is not necessarily a good thing.

The flowering part that we are talking about, are salts that are present either in the brick or in the water that come out of the surface and give the wall a very poor aesthetic quality. Now, we typically associate flowering with nice quality flowers, this is not the case in building. Efflorescence actually means that we are having some salts that are present either in the brick or the water that come up to the surface and then start crystallizing, leading to a very poor aesthetic surface, or very poor aesthetic quality of the surface.

In general clay bricks are highly durable, but then the water absorption potential determines a lot of their problems. Bricks are also fire resistant. That's why they are excellent, when you have to line certain structures and protect them against fire. For example, in furnaces and

kilns itself, you can line the interior by bricks. These bricks will ensure that your material which is making the kiln on the outside, maybe it's metallic for instance, it will be protected from the heat because bricks are very poor conductors of heat.

That's why bricks are very good for your walls also, especially in tropical areas like in most parts of India, because the heat from outside getting into the house can be quite terrible. And because of that if you have a brick wall, it seems to protect significantly against the conduction of this heat into the house. Now oppose this with a concrete wall, concrete is not as good an insulator when it comes to heat. So when you replace a brick wall with a concrete wall, you will find that the interior gets a lot more hotter.

There are a lot of issues that you need to think about as a civil engineer. It is not just a simple question of which material provides more strength, but you need to use the material that provides all the given characteristics that you need. Just as I said, for a building, brick strength and water absorption are important and for a flooring brick, abrasion resistance is quite important because you have weights getting carried on the surface. So again, all these aspects need to be thought about before designing the material.

The issue is, with bricks you have very little choice in terms of engineering the material quality to a large extent, because it all depends on the quality of the soil that you have in a particular location. Now to make bricks, you obviously cannot truck large quantities of soil from a different location just because it's good. You have to start looking at additives to improve the quality of the soil that you already have in place, otherwise it becomes too expensive to carry good quality soil from a different location.

So very often, as I said, one could look for alternatives to replace the soil like fly ash, which can improve the quality of the bricks significantly. And what is improvement in the quality? Essentially it is improvement in the strength and lowering of the water absorption. I will come across this, I will describe to you the properties of these bricks in just a few minutes.

Of course, as I said bricks are good insulators or poor conductors of heat. And they are also very good against fire. So in most brick masonry structures, fire is not that big of a problem. Fire becomes a problem when you have reinforcement. In reinforced concrete structures fire could be a problem because reinforcement cannot withstand very high temperatures of fire.

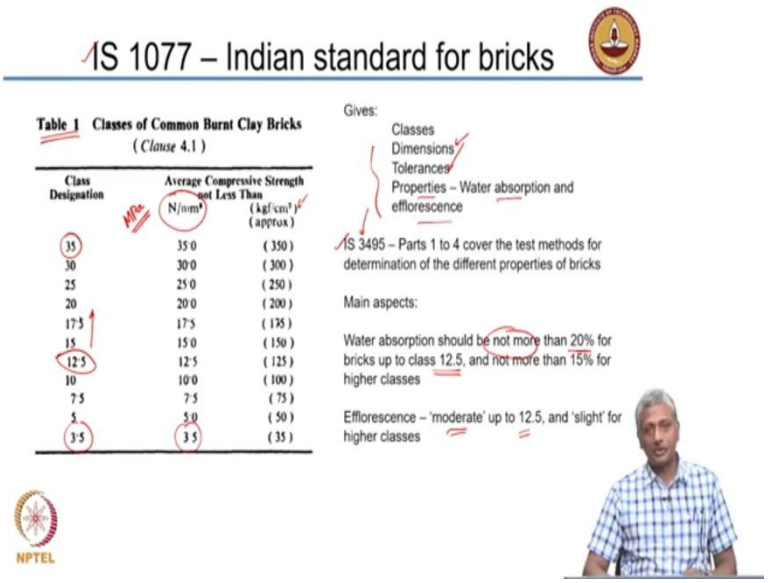
Steel reinforcement tends to lose its stiffness and starts deflecting significantly, causing the large amount of damage to be there in the structure.

Now, what is the compressive strength of the brick depend on? It depends on what clay you have, do you have the right quantity of silica and alumina in the clay, what are the impurities which are affecting the strength and so on. So those are some issues that you need to worry about.

The method of brick manufacturing, as I said, you can either use an unburnt brick, which is simply dried. Obviously that is going to be of low strength. Or you have the fired bricks or burnt bricks, which are going to have a high strength. Within these burnt bricks, the degree of firing is also important. At what temperature does you kiln operate, can you control the temperature, can you control the time that the burning is actually done? And that is also very important, because not often do you find the kilns in rural areas having any kind of control on the temperature and the duration of the process. So if you can engineer this, if you can actually design furnaces, where you can control the rate of temperature increase, decrease, the time of maintaining the temperature and so on, you can come out with very high quality bricks.

So, if you are going to an industrial manufacturer of bricks, they will have all these facilities where they can control the temperature, the time to which the brick is fired and so on. In such cases the quality of brick will be always consistent. But when your bricks are coming from lower quality manufacturing processes, you will end up getting high degrees of variability in the properties of bricks. So one load of bricks you get will be very good, the next load that you get may be substandard. So in such cases, you need to be careful about selecting the right sources.

(Refer Slide Time: 18:23)



Of course in most cases, construction materials are standardized by the Indian standards. As long as the bricks are meeting the requirements of the standards, they are good enough to be used in construction. So for bricks, there is the Indian Standard 1077, which defines the bricks into different classes based upon the strength of the brick. So here for instance, in table 1 of IS 1077, you have the class designations going all the way from 35 down to 3.5.

What are these numbers depicting? They are simply depicting the strength of the brick in Newton per square millimeters (N/mm^2) or in mega pascals (MPa). Newton per square millimeters is the same as mega pascals. So a class 35 brick has a strength of 35 mega pascals, a class 10 brick has a strength of 10 mega pascals. So again, the strength is also given in the old English system, that is kilogram force per square centimeter that basically is almost equal to 10 times the mega pascal strength, so 35 becomes 350, 20 becomes 200 and so on.

So based upon the strength of the brick, you define the category or class of the brick. To make very high strength bricks, you will need to select the clays that have very ideal properties to get there. And to make bricks of such low strength, which probably will not be useful for a regular load bearing masonry wall purpose, you may not need such a high quality clay. So again, it depends on the type of application for which you are designing the bricks, the requirement of the strength could be different.

Now of course, the standard covers a lot more than the strength, it also covers the dimensions and their tolerances. The bricks have to be of a certain dimension and it also tells you that,

what is an acceptable deviation from this dimension? What is the tolerance level that can be taken for accepting the bricks on site? Because ultimately, the engineer should be perfectly agreeable to the quality of bricks that have been supplied by the brick manufacturer. So, if the engineer is convinced that the bricks are of good quality, as long as they are meeting the standard, the engineer can use them for the construction.

The other properties that they talk about are water absorption and efflorescence. Now these are common tests that most of you who are studying civil engineering B.Tech would be undergoing in your laboratory classes. It is simple, you take a brick and you dry it in an oven until all the free water goes out. Then you immerse it underwater for let's say, 12 to 24 hours and then study the change in mass. That is basically our water absorption. For efflorescence, the bricks are made to stand upright in a tree of water. With time, the water basically rises by capillary action and pulls out the salts which are there in the brick alongside and you basically do a visual appearance rating of the surface of the brick.

Now in this course, you will come across many different standards. What we want you to do is, look up each and every standard and try and look at how these standards are devised, what kind of features are there, what kind of descriptions of the material are there, what engineering properties are described in the standards that need to be met in order for the material to be used in a jobsite.

The test methods specifically that talk about these water absorption and efflorescence are covered in a different standard, IS 3495. Please get yourself a copy of IS 1077 and IS 3495. Please refer these to ensure that you understand the stipulations that are there in our standard practices.

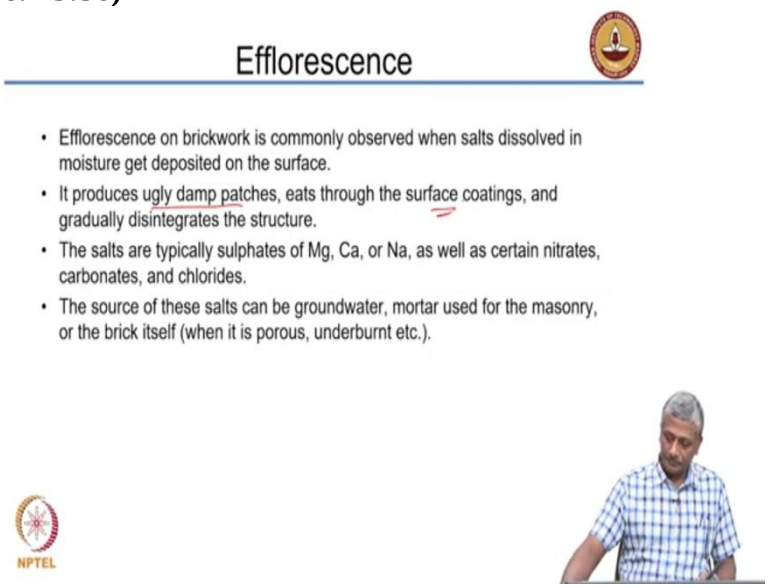
Now just to condense the main aspects of the standards, I should say that the water absorption in bricks is supposed to be less than 20% or they say not more than 20%, that means they should be less than or equal to 20% for bricks up to class 12.5 and above this strength class, the water absorption should not be more than 15%. You need to select your brick materials carefully, so not only does it satisfy the strength requirement but also has to satisfy the water absorption requirement.

The other aspect that you need to think about is the efflorescence. And as I said, you get to give a visual rating of the surface of the material depending upon the salts that have crystallized outside. If a lot of the surface is covered, then you have a very high efflorescence and if some part of the surface is covered, you call it moderate efflorescence.

'Moderate' efflorescence is permissible up to the grade of 12.5, that is up to the 12.5 strength class of the bricks. But if you are going above this strength class, then the efflorescence has to be 'slight'. Please remember 'moderate' for classes less than 12.5 and 'slight' for classes more than 12.5. So this basically in a nutshell describes the properties of bricks that are typically used for masonry wall construction.

Now of course, you may have other standards or other documents that deal with specifications for bricks like facing bricks, flooring bricks and so on. As I said for flooring bricks or paving bricks, they will have to satisfy requirements of abrasion resistance also.

(Refer Slide Time: 23:56)



What is efflorescence? As I said again, this happens because there are salts present in the water or in the brick that come up to the surface of the brick, dry out and give an aesthetically poor quality to the surface. Efflorescence is commonly observed when salts which are dissolved in the moisture, either the water that was used to mould the brick or the water that is coming from outside carried by rains or by absorption through the ground and so on. That water may have salts in it. And these salts may come up to the surface.

Why are the salts getting into the brick in the first place? Because bricks are absorbing moisture from outside. Are salts present inside the brick? High possibility is there because the water that is used to mould the brick, because of the clay that was originally used to manufacture the brick, that may itself have some salts in it.

These salts essentially end up producing ugly damp patches on the surface. And if you have any surface coatings, they erode these surface coatings also and gradually it diminishes or disintegrates the structure on the surface. And that's really a problem because you don't want to have a nice strong brick wall which looks very poor on the outside, it is not a good thing to do. You need to have a wall that is strong, but also looks good on the surface.

What are these salts? These could be different types of salts which are present in water or in the brick. Mostly they are sulfates of magnesium, calcium or sodium and sometimes chlorides or nitrates also. Even sometimes, when you use mortar and there is a lot of lime in the mortar that can leach out to the surface, the lime which is calcium hydroxide will react with the atmospheric carbon dioxide to form calcium carbonate and that will end up giving a white color to the surface.

Essentially you see leaching as a white coloration of the surface. But of course, it depends on the type of salt that is present inside the material. And these salts can also be brought out by action of flowing water. For example, if water from the inside is trying to come out of the structure, it will push out these salts also. These salts will come out to the surface and start drying and that causes again these damp patches to form.

As I said, the source of the salts could be the groundwater, the mortar that is used for the masonry or the brick itself. Especially when the brick is porous or under burnt it can have a large amount of water absorption. And that basically can result in efflorescence. So you want the bricks to absorb less water, not just from the external surroundings but also from the motor that is useful binding the bricks together.

(Refer Slide Time: 26:36)

I will show you some pictures of efflorescence. It is quite commonly seen in many structures. You can see here the ugly white, damp patches that are forming on the surface. As they dry up, the salts crystallize and form these white patches. Now here, we can clearly see a telltale sign of water that is coming out from inside, because all the salts seem to have originated only from this particular line there. Then as the water drips down the building and dries out, the salts are basically getting deposited. So you see that this is a case of water leakage from inside the building, which is carrying the salts out. But this is also called efflorescence.

This is the best example that you can probably have of efflorescence. You can see how nice this building is otherwise, but totally that appearance is getting spoiled by the white colored patches that are on the surface.

This is a concrete block wall but you still see efflorescence here. It is not just a problem with brick. Any masonry structure can have a problem of efflorescence, as long as your material is absorptive. And if the salts present inside the water can easily come out to the surface. This is again a concrete block wall where efflorescence is being observed.

If you are a brick producer, you need to design your brick or choose your materials to make the brick carefully. If you are an engineer who is going to be using these bricks, you need to evaluate these characteristics before accepting the use of the bricks for the construction process.