Basic Construction Materials
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Lecture - 22
Stone, Brick and Mortar – Part 5

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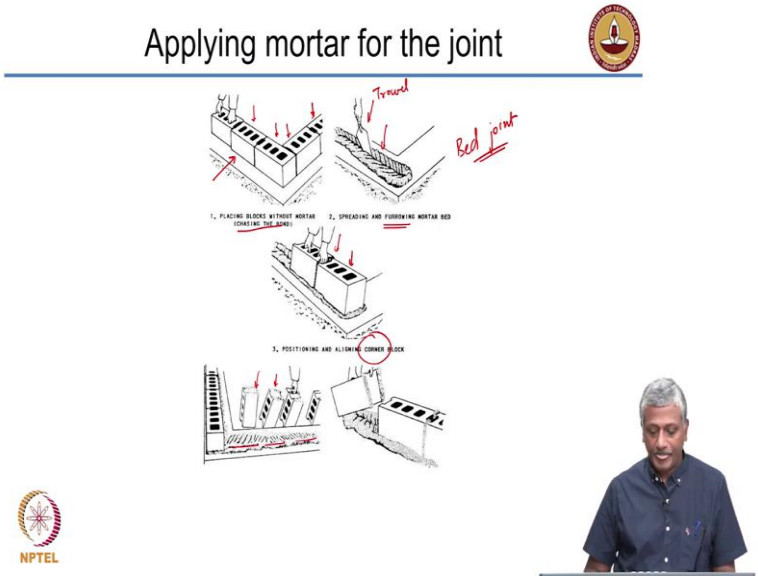

Let us now take a look at how mortar is typically applied for a joint. So let us take this scenario for a wall that has been constructed from the ground level up, that means from a foundation that is in the base of the ground and then from there we are constructing the wall up. So first what is done is that the blocks are placed without the mortar on the foundation. So here, it is a strip foundation.

Many of you may have learned a little bit about foundations previously. But essentially, a strip foundation is a continuous concrete foundation that comes under the running length of the wall. So in this case, on top of the strip foundation, which is typically made of concrete, these blocks are first simply placed in position in the pattern that they are expected to be laid for the masonry wall.

So that means, we are just placing it and seeing that the things are okay. So that process is called chasing the bond. Now, the next process is to remove these masonry blocks and place the mortar on this bed, the mortar is placed on the bed. So this is a bed joint, because it is exactly the first layer of mortar. First layer of masonry is going to come above this mortar layer, which is on the bed joint.

So this mortar is first placed on the foundation and then you can see that this person is actually using a trowel to furrow the mortar. So that is furrowing, so spreading the mortar and furrowing it. So essentially, it is almost like furrowing a field, you might have seen people before ploughing. Before sowing the seeds in a field, we will be using some sort of agricultural instrument to furrow the field, essentially to ensure that it is properly mixed up and then once you are done with that, you place the blocks in the arrangement that you originally planned.

And generally, you will start placing from the corner block and then build towards the center and most masonry you start from the corner and then build towards the center. So, you see here, these concrete blocks which are hollow are getting placed one after the other on the mortar bed that is laid.

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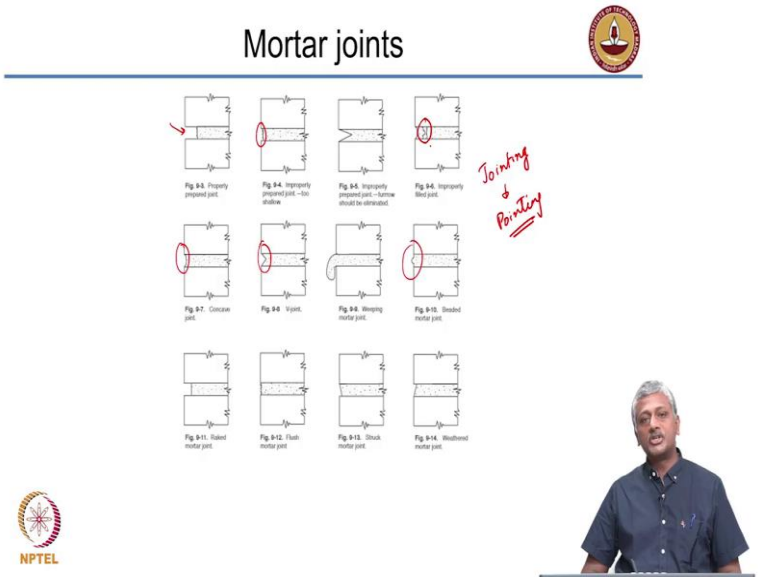

So, moving on, there are different types of mortar joints, which you can actually see in construction. Very often, you may have seen during the process of application of these mortar joints for construction of brick walls or for stone masonry walls. However, very often at the end of the day's work, you will see that the mason will tend to finish the mortar joint and give it some sort of an appearance.

So these appearances are captured in this picture here. So you can see that there are joints that are sometimes into the masonry, which gives a nice appearance because you see the masonry actually projecting outwards, sometimes they are flush. But in such cases, it is a little bit difficult to a certain whether this is properly applied or not, if you really want it to be

properly applied with a mortar appearing on the front, you may want to actually have a concave sort of a joint or a grooved or a v joint.

Sometimes we may actually have some sort of a beaded joint which shows the mortar and a slightly different texture on the front of the masonry wall. All these are basically, ways to finish the joint. So they essentially, these techniques which relate to jointing are also called pointing. Essentially, you are finishing up the mortar at the end of the day's work in between the joints. Sometimes you have issues like this, there is air void that is existing between the mortar joint under the brick, which you cannot see from the surface but it is existing inside.

It is not a good thing to have. Because it is weakening your joint. Just these are just some examples, next time that you are on a site where you see some bricklaying or stone masonry laying going on, make sure that you notice how they are actually finishing the joints or finishing the mortar in the joints or how they are pointing the masonry wall.

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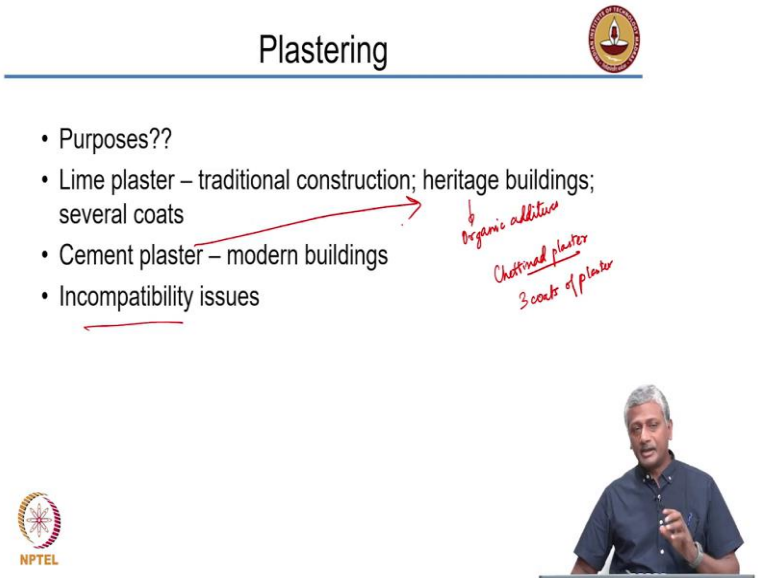

Now, of course, plastering is something that is a common activity you see in various buildings, you see that the plaster is essentially, as we talked about previously, this plaster is nothing but a mixture of cementitious materials and aggregate which you apply on the surface of a structure. Now, what do you think are the purposes of a plaster? Very often, we do not leave our surfaces as such we want to paint our surfaces to give an external rendering to the building.

In such cases, when we have red brick walls or stone walls, they may present a slightly awkward appearance if you have mortar joints in between. So what we do is we lay a layer of plaster on top of the brick and stone masonry and provide an even surface on which we can do the further painting and so on or for the texturing for instance. So plastering is done primarily for the purposes of providing an even surface for painting.

But more importantly, plastering is good for the perspective of protecting the masonry, especially bricks, against effloresence. So if you have external water, for instance, that may be absorbed by the brick, the plaster acts as a layer to prevent this water from directly getting to the brick. So we can reduce the efflorescence to some extent by using a plaster. Of course, plastering can sometimes be also used to hide improper use of bricks or bricks that actually do not aesthetically look pleasing.

Many of you may have seen very good quality bricks in a brick wall, which is being left exposed, that means without plastering and that is because these bricks are of very high quality with respect to their low water absorption and also their appearance which is perfectly flat and smooth without any major defects on the surface. When there are defects, many people would tend to close them up with the help of plaster. In India, of course, a lot of concrete also gets plastered.

This is something we will talk about, probably touch upon in the subject on concrete also. But that is a really futile exercise. And it is just going to waste your money if you start plastering, concrete. Now, I will come to that later that if you do not use proper formwork for concrete you often have the need for plastering, but as far as possible, avoid plastering concrete. Brick walls and stone walls are very often plastered. Stone not that often, but brick walls are most often plastered, especially for residential construction.

Now, if you go to older structures, heritage buildings, a lot of these buildings have lime plaster. So, in other words, the binding material is not cement like in modern buildings. It is actually lime that was used in the past. Several of these heritage buildings will have to use a lime plaster, lime mortar first of all for binding the units and the lime plaster for covering the surface and you will see that the practices of lime plaster are very interesting.

They use several different types of organic additives which are typically used with the lime plaster. I talked about this previously, organic additives are used to give some textures or some sort of smoothness and some sort of applicability, better consistency for the lime plaster for applications. Just to give you an example, there is a plaster called Chettinad plaster which is quite popular in the Madurai region of Tamilnadu. Here they have 3 coats of plaster.

The first coat is having a fairly rough texture because they use a slightly larger grains of sand. That is probably the thickest coat because that provides the stability and the water resistant characteristics and so on. On top of that, you have a thinner layer just to provide a much smoother surface. And finally, you have a plaster which probably will not contain much fine aggregate or sand. They may have very small size sand or fillers or quartz fillers for instance, mixed with organic additives like egg white, for instance.

You might have seen, I do not know if you have seen this practice but if you do a search for Chettinad plaster, you will actually get to see this practice. It is very interesting, the final layer they use pigments, coloration basically with the lime and then they also use egg white and this gives a very nice shiny finish to the top surface. Now cement plaster, of course something which is used in most modern buildings.

As I said, plastering involves the use of cement and sand mixed with water and then you make this mortar to plaster the surface. Very often, you encounter problems of incompatibilities when you use cement plaster for heritage buildings that have used lime in the past. As I talked about before, lime plaster or lime itself, forms a material that is quite porous.

As a result, if there is any moisture behind the lime plaster layer, it can dry and come out to the surface. Cement plaster on the other hand is quite dense and it would not allow any moisture to come out easily. Because of this you get compatibility problems. So, in general, in a structure if lime plaster has been used, it makes sense to continue using lime plaster for treatment. For any repairs, you should not be using cement plaster for repairs.

This is something of a common sight when you actually visit some of our temples where they have done repair of existing heritage monuments with cement based mortars or cement based plasters, it could be quite disastrous in some conditions.

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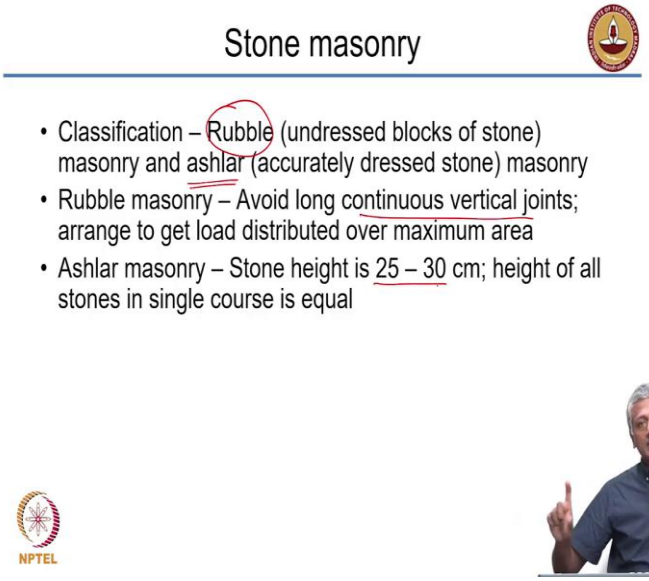

Now, having looked at the masonry mortars, let us now look at the arrangements that typically are associated with the use of masonry. So let us first talk about stone masonry. Stone itself, as it is obtained from a quarry does not have a definite shape. I mean of course, some types of stones are deposited in well-defined beds with very clear cut cleavages and the plains of fracture, so that when you actually break them into pieces, they still come out with some sort of a squarish arrangement.

But many of these stones need to be dressed to give a certain type of an arrangement or appearance for the block itself, which is used for construction. So when you do not have any appearance, it is called rubble. Rubble basically is exactly what you get and break it into smaller pieces and you do not really dress them properly. But when you dress them properly and accurately give a proper dimension to the stone block, we call it ashlar masonry.

So rubble is something that is as collected and broken into pieces and ashlar is what is accurately dressed that means you give them a definite size and shape. So in rubble masonry, when you arrange them to make a wall, what you need to do is avoid continuous vertical joints. I will come to this when I actually describe you the type of rubble masonry. What is the idea? Vertical joints if you are aligning, that means you have a layer of mortar starting from the top of the wall to the bottom.

Now, this wall becomes quite easy to fail, because the failure will go right through the mortar joints. We talked about this earlier that the mortar is weaker than the masonry unit. So if

failure has to happen, it will happen right to the mortar joint. So if you have overlapping vertical joints, then obviously you will have a very clear cut plane of failure or plane of weakness and again, because the size and shape are not fixed, you need to arrange these different blocks in such a way that you get load distributed over the largest area possible.

In ashlar masonry, it is more or less like a brick masonry because your size of the stone is quite well defined. So we have specific arrangements in which you can place these stones. The stone height generally is 25 to 30 centimeters, almost double that of a brick. That means the length of the brick is typically about 20 centimeters, the stone length is typically about 40 centimeters.

The height of each layer is typically around 25 centimeters. Height of all stones in a single course is equal. So when you use ashlar blocks in a single course. So as I said a course is nothing but a horizontal layer, a single layer of masonry units, so all the bricks or all the ashlar blocks of stone will be of the same height.

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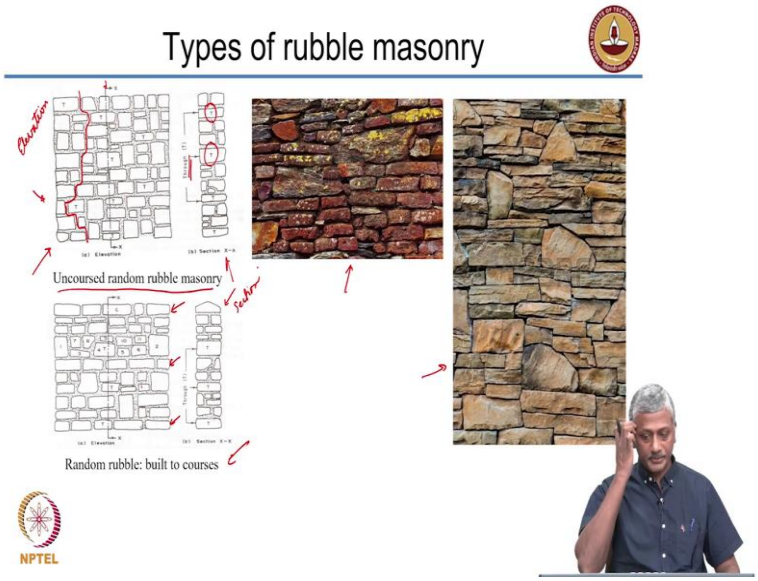

So the different types of masonry are shown here. So the first one on the left here is the un-coursed random rubble masonry. Now, when I say coursed, that means that I have some sort of uniformity in the horizontal direction, at least in one of the courses. If I have uniformity in all the layers in the horizontal direction, that means it is a proper ashlar or brick masonry, but for random rubble masonry, I cannot do that.

So here what is called uncoursed random rubble masonry is consisting of these blocks of stone arranged quite nicely, you can see that the blocks are still arranged quite nicely, but they do not have the same size or shape. They are arranged quite nicely to ensure that you avoid any vertical joints which are overlapping. So you see here, this vertical joint is coming like this, then like this, here, here, here, here, here, like that.

So there is a distinct displacement of the vertical joint, you do not have a continuous vertical joint. When you take a cross section through this wall, through this rubble masonry wall, you see that these blocks are arranged in such a way that you can use some stones which are marked as T here or through stones, which are running through the thickness of the wall. So they ensure that the entire wall functions as a single unit.

You can see examples provided here of your rubble masonry, random rubble masonry. And to some extent, you can call this also as a random rubble masonry because the stones each have a different shape and size. Now, you can bring in some sort of order in random rubble masonry, we are building it to courses. So what does it mean? Every once in a while, you have these regular courses appearing, that means you have a uniformly thick layer appearing or repeating after every certain number of layers.

So for example, here, this course is repeating after every about 4 to 5 layers of stone that are stacked up in between, so that is called random rubble built to courses. That means you are simply chosen your rubble pieces in such a way that you bring in some order in the arrangement when you see in the elevation. So all what are shown here is the elevation. These are all elevations, that means the front view and of course these are the sections. So these are elevations and sections that have been shown here.

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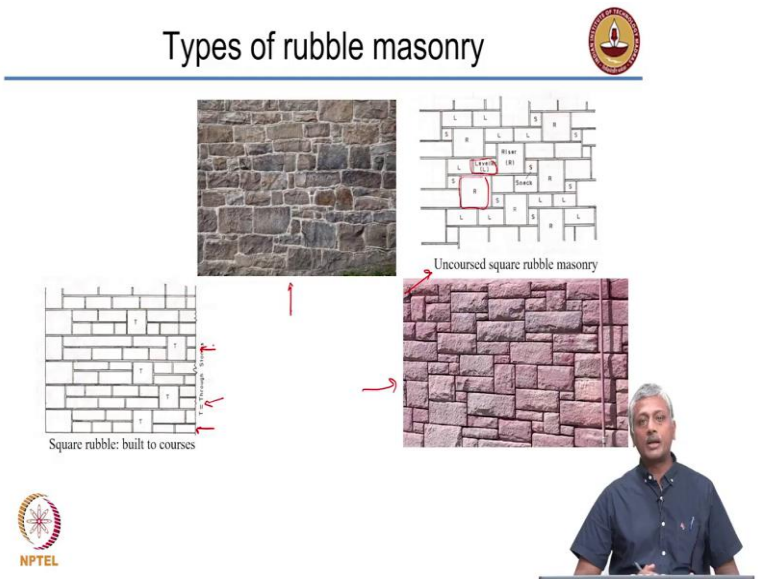

Now in some cases, the blocks that you get maybe from stones which are easily broken into squarish or cuboidal sections and that is called an uncoursed square rubble masonry. So you see here, there are pieces which are more cubical. There are pieces that are cuboidal and so on and so forth. So you can see, you can arrange them in this sort of fashion, or this sort of fashion to get a very nice appearance on the surface that is called uncoursed square rubble masonry.

Again, in this case also you can make an attempt to have some uniformity introduced, such as this, where you have horizontal courses, reappearing after a certain number of layers, so that is called square rubble built to courses.

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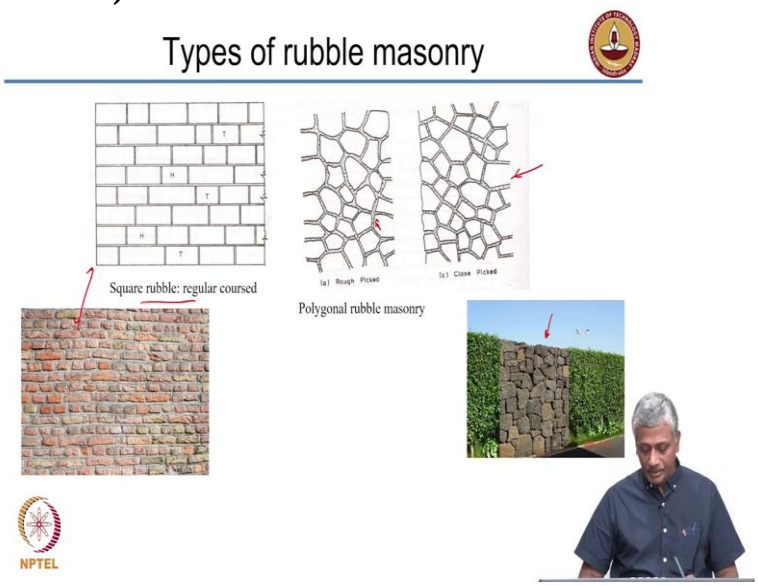

Now, this is something you would have probably seen in several locations, is called polygonal rubble masonry, where you have rubble of different shapes, which is arranged in a

polygonal format. Of course, you can see that there is a lot of mortar you used in this sort of an approach. But it gives a very nice appearance. Most of you who have gone to hill stations in the country, especially the ones in the south.

We would see that number of these hotels and resorts actually made up with these nice blocks of stone, which are irregularly shaped like a polygon. Now this is square rubble which is regular coursed, that means more or less each and every layer is the same height. Each and every layer is almost the same height. That is done by selecting pieces of stone that are having uniform appearance and you break them into pieces that are easy to arrange in this kind of fashion.

But this is not ashlar masonry, this is square rubble masonry, because you have not dressed the stone, you have just collected the stone and broken it into smaller pieces, but it still gives a nice uniform layer thickness.

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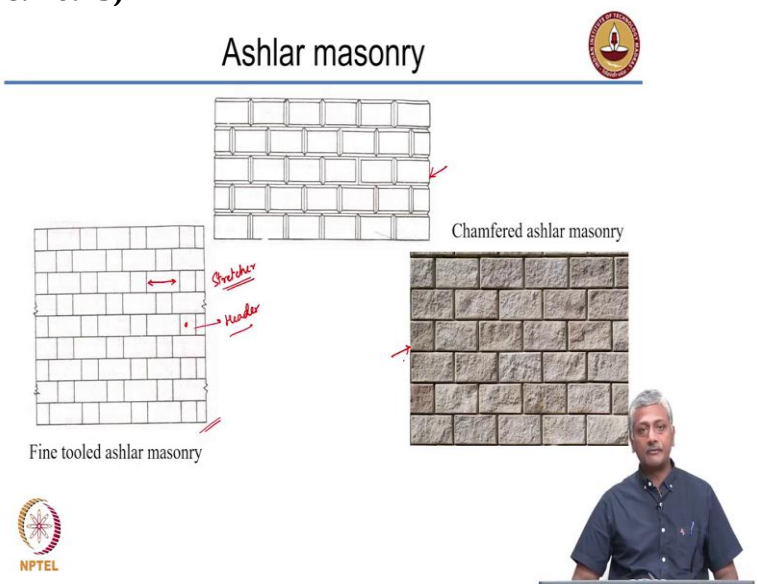

So of course, an ashlar masonry does not look much different compared to a brick masonry, it looks quite similar. So you see here fine tooled ashlar masonry. So again, just to go back to the definition, this sort of a block will be called a stretcher and this sort of a block, which is going into the plane of the board that is called header. It is arranged with the length perpendicular to the direction of the wall that is the header, the length of the brick or block is parallel to the direction of the wall, it is called a stretcher.

So that is called fine tooled ashlar masonry. So you have another example of a chamfered ashlar masonry. So here, each and every block is chamfered.at the ends. Many of you who have taken workshop courses in your college would know that chamfering means using a tool to sort of give a blunt edge to the corners and that chamfering gives a very nice appearance to the structure.

As you can see from this chamfered ashlar blocks that have been arranged in a very nice and neat fashion, gives a very pleasing appearance to the external surface of the wall.

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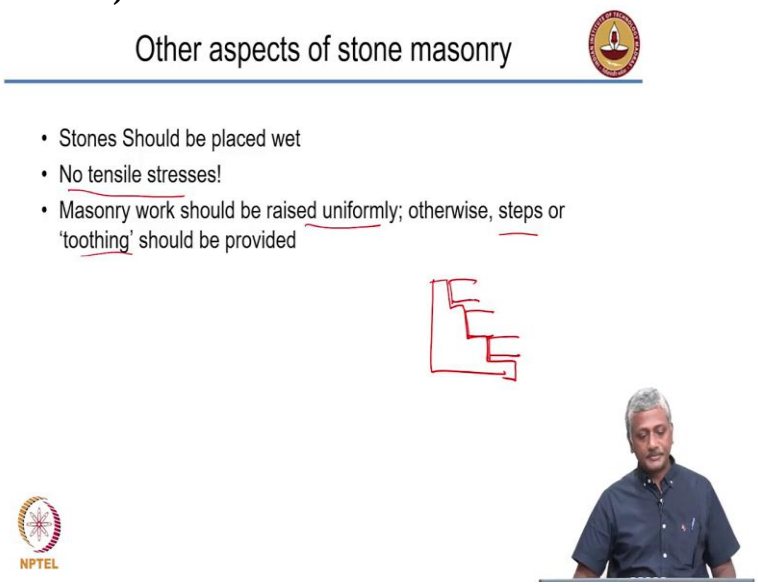

Now, generally stones should be placed wet. Of course when I comes to bricks, I will say the same thing. Any masonry unit, whether it be stone or brick or concrete block should be placed in the wet condition. Now think for a minute, why should this be so? When you place the stones dry, or when you place the bricks dry, what is going to happen? Because it is dry, it is going to start absorbing moisture from the mortar.

Because the mortar is wet when you apply it. Mortar is wet when it is fresh, it slowly hardens, but in that time, it may lose some of its water to the dry masonry unit and this water that is present in the mortar may have some salts with it, which may then start efflorescence from the masonry unit. So efflorescence will be a problem when you place the blocks dry, so blocks should be placed wet.

The common strategy for all masonry is to ensure that there are no tensile stresses. You need to ensure that there are no tensile stresses in stone masonry and masonry work has to be

raised uniformly. So masonry work basically is raised uniformly, that means the height is built up uniformly. If you have to break the work and carry on the next day, you need to provide features such as steps or toothing.

I will show you a picture that will make this clearer. Essentially this means that you provide a structure like this - Steps to ensure that when you start the next day's work, you start fitting from this point onwards, like that. So that means we maintain a good joint between different day's works.

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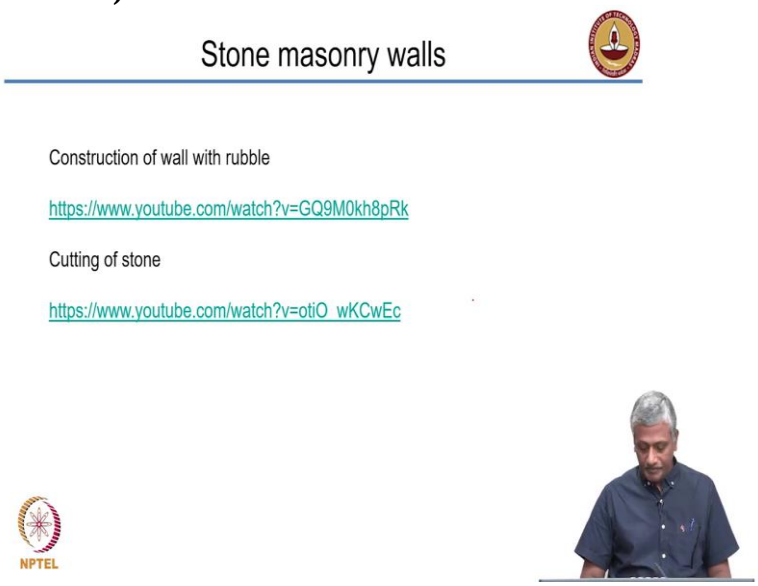

There are some interesting videos that you can actually watch on YouTube. There are many more than this, I have just listed a couple of them. One is the construction of a wall with rubble and the other is dealing with cutting of the stone. So you can see how much effort is actually involved to actually cut the stone and the desired shape and size. So these videos are very interesting for you to watch. Again, you can do a search and find several tons of videos, which will actually help you look at the field practice because these days a lot of interesting information is available directly for download from the web.

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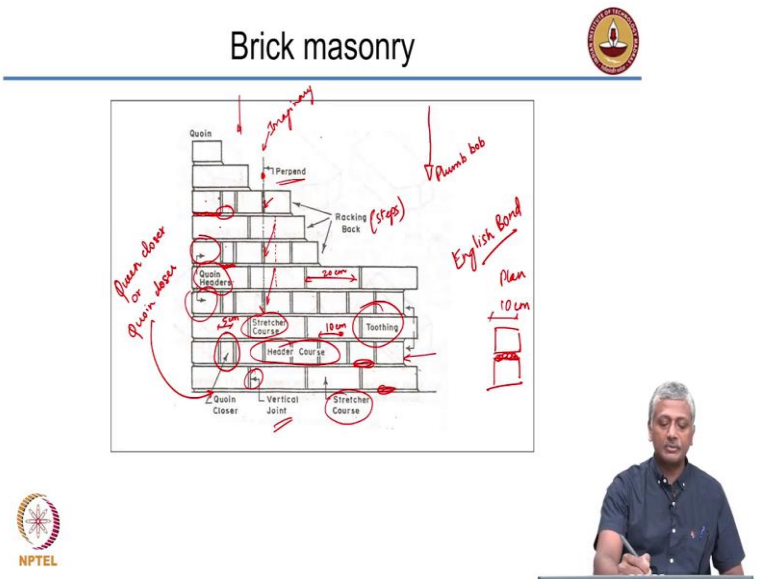

Now, again, just to bring to light the use of toothing, or steps, this is exactly the picture that I was talking about. So when you provide steps like this, after the end of the day's work, you can continue the next day's work by arranging bricks and blocks on this side. And this kind of a feature is called toothing. You are leaving behind gaps, which are unfilled so that you can continue the next day's work filling up those gaps. That is called as toothing.

So now let us look at a typical brick masonry structure, or typical brick masonry appearance of the elevation and look at what are the different components of this. So once again, the names are quite similar here. These blocks which are in the direction of the wall, they are obviously called stretchers, and in this brick masonry arrangement, all the bricks in the first row seem to be arranged as stretchers.

That is why the first row is also called a stretcher course, this is only one of the arrangements. I will show you different arrangements later. But this is only one of the arrangements of brick masonry. So this is a stretcher course where all the bricks arranged as stretcher. The joints that are there between the stretchers or between the bricks, those are vertical joints. We have talked about bed joint, vertical joint and cross joints. So what is the bed joint here? Those are basically bed joints.

Now, then second course, if you see or second layer of the masonry of the brick, has all the bricks appearing as headers. So that is why it is called header course. We will see later that this is an English bond arrangement of bricks. We will come back to this later, but

essentially, this is an English bond arrangement of bricks. So all the second layer bricks are headers.

And third layer once again a stretcher, fourth layer once again header, fifth layer stretcher and so on. So every odd layer appears as stretchers and every even layer appears as headers. Now what is you need to note here. As I said, when you reach the end of the wall and start going in the other direction, you need to close the wall and one of the special bricks that we used to close the wall are called queen closers or quoin closers.

And that is what is marked here. So this block here is a quoin closer. So, if you take the modular size of the brick, this dimension will be 5 centimeters. For a header, this dimension is 10 centimeters and for a stretcher, this dimension is 20 centimeters. So if you take a brick, the length is 20 centimeters, the typical thickness and height in a modular brick are 10 and 10.

Whereas of course in a traditional brick it is 23 centimeters length, 11 centimeters thickness and 7 centimeters height. Nevertheless, here we are looking at a brick that is modular, so that you can actually say that the queen closer which is exactly divided in the center of the brick and that becomes 5 centimeters, what is the length of a queen closer, it is again the same as the length of the brick that is 20 centimeters.

So, what is this 5 centimeters do? It simply ensures that your overlap of the vertical joint is avoided. So, if you have this header, the vertical joint comes down, next joint is here, next joint may be here, here like that and so on. So essentially you are staggered the joints again to ensure that you get good strength from the masonry wall. So, a queen closer or a quoin closer is important to ensure that you get this arrangement which staggers the joint.

The last headers at the end of the wall are also called quoin headers. Quoin as I said is a corner of the wall, they are called quoin headers. This imaginary line which is drawn through vertical joints in every alternate course is called for perpend. It is an imaginary line joining the joints in every alternate course. This sort of a step like arrangement is also called a racking back.

That is the arrangement that we leave the day's work in, so that next day, you can continue to work from that location or when you leave gaps between the layers, it is called toothing. So we have looked at several different definitions of terms in a typical brick masonry structure. But now let us look at how brick masonry can be arranged. This is just one of the ways as I said, it is an English bond arrangement.

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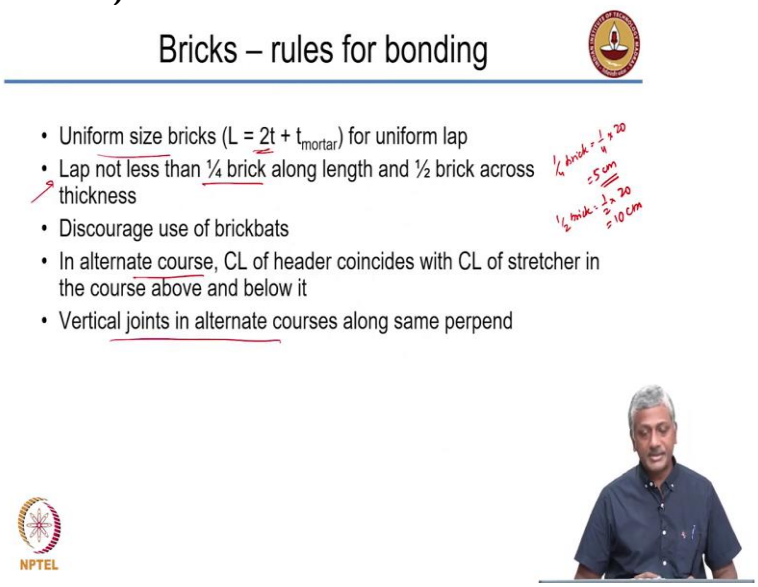

But there are several ways in which you can arrange it, but you need to follow certain rules for arranging them. So first of all, you need to use uniform sized bricks, the length of the brick should be twice the thickness and you need to add the thickness of the mortar joint to it. As I said earlier, the mortar joint has a thickness of 1 centimeter, typically, we use 1 centimeter mortar joint.

So we want to get uniform lap uniform bonding between bricks, as a result of which we need to satisfy this rule that the length of the brick should be twice the thickness plus the thickness of the mortar joint. So does this meet our needs, for example, if you consider a modular brick, as I said, it should be 19 * 9 * 9, if you do not consider the thickness of the mortar joint. So this 19, obviously, is equal to (2 times 9) + 1.

So it satisfies our requirement, even if you consider a traditional brick, which is 23* 11 * 7. This 23 is equal to (2 times 11) + 1 that is thickness of the mortar joint. So this again satisfies the requirement of brick bonding. So you need to satisfy this requirement of uniform size bricks. The lap, that means the connection between bricks, the bond between bricks should not be less than a quarter of the brick along the length.

Quarter brick means, quarter of the length of the brick that is one fourth of twenty or 5 centimeters. Half brick is half of 20 or 10 centimeters. So along the length, the bricks should have a lap. That means they should have a bonding area or bonding length of at least 5 centimeters and across the thickness of the wall the brick should be at least 10 centimeters bonded together. Generally, brickbats as I said, brickbats are nothing but, you take a brick and break it into either half or 3 fourths and generally, these brickbats are discouraged.

And why that is because when you start breaking a brick into multiple pieces, you increase the amount of mortar that is used. And when you increase the amount of mortar, obviously a wall gets weaker. So generally, brickbats are discouraged. In the alternate courses, that means in every second layer, the center line of the header coincides with the center line of the stretcher in the course above and below it. So let us look at all these rules here.

First one anyway, we saw that our bricks actually satisfy that and second rule is lap should not be less than a quarter brick along the length and half brick along the thickness. So let us see if it satisfies that. So if you take this, what is the lap along the length here? Between this brick and this brick along the length the lap, this is the overlap, which is equal to the thickness of the header that is 10 centimeters.

Even between the queen closer and the stretcher below, this much bond is still 5 centimeters, so it is of no problem. If you look at it and plan, the bricks will be bonded by at least 10 centimeters. So if you look at in plan, so let us say these are 2 layers of bricks joint together. So that is what the rule of bonding is. What about alternate courses, the center line of the header coincides with center line or stretching the course above and below it. So let us look at that.

So let us look at this center line of this header coincides with the center line of the stretcher above and coincides with the center line of the stretcher below. So that is how you need to arrange your bricks. It needs to follow some sort of a geometrical pattern. And finally, vertical joints in alternate courses should be along the same perpend. As said, perpend is the imaginary line that is drawn to check the verticality of your wall.

You will see often when people are constructing this brick wall that they will have a string with a heavy weight attached to the bottom, that is called the plumb bob. So what they will do

is, they will put or hold the plumb bob here and see whether all your joints are perfectly vertical or not. So every alternate joint should be along the same perpend, that is one of the rules of checking the brick line. So these are the rules for bonding.