Building Materials And Composites
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Lecture – 05
Stone (Continued)

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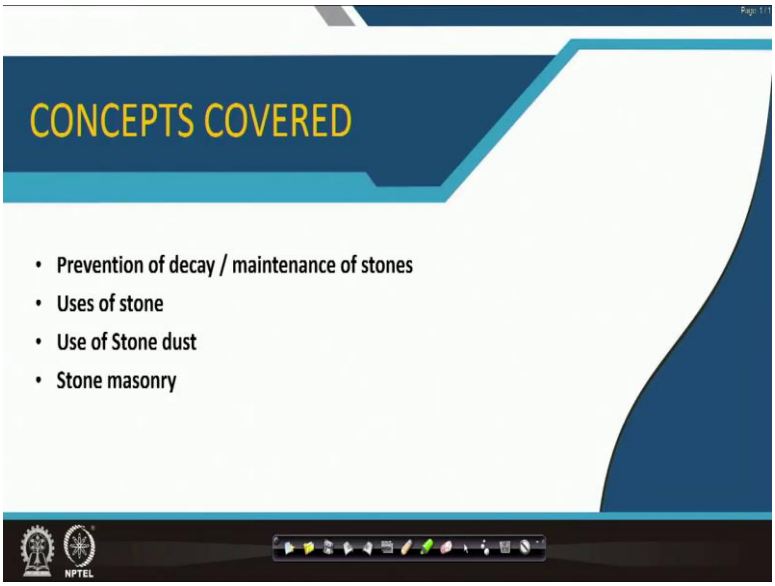

Hello, everyone. So, we are at the last lecture of this module, and it is a continuation with stone. Here, we are going to cover the prevention or the decay of stones, including the maintenance and uses of stones, along with stone dust. As I told you- in the quarry, once the stone is dressed, a lot of extra materials are formed- which can be used as aggregate.

The stones leave some dust. Pieces of stones that are not usable can be crushed, and the dust can be obtained from them. These also have specific uses. Lastly, we will be covering the stone masonry, which is similar to brick masonry. Stone masonry is constructed with units (stones), which, although, are different from bricks in looks and properties, but the underlying principles are similar. First, we will discuss the prevention of the decay or the maintenance of stone.

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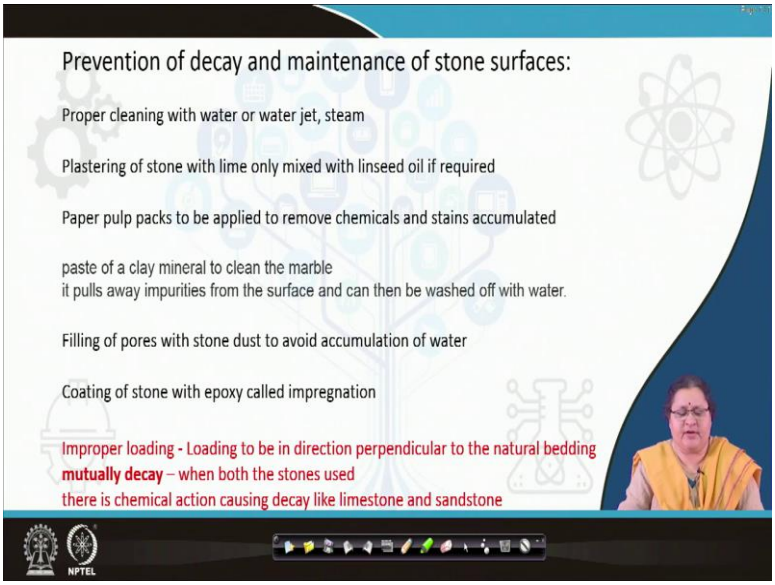

The first point here is the necessity of thorough cleaning of stone by water jet or steam. Some inaccessible portions (crevices, nooks, or cracks in stone) might need the water jet to be forced (or pushed) to the stone surface for proper cleaning. The basic idea is to remove the dust, dirt, and organic matter- that generally accumulates over time. Sometimes, the only option is the plastering of stone with lime (mixed with linseed oil if required).

Plastering of stone is not usually advisable; however, if done, it should be performed only with lime and not cement, since cement chemically reacts with the minerals present in the stone, thereby degrading it. Therefore, it is generally best to leave stone unplastered and just remove the accumulated dust and organic products, chemicals, oils from the surface, which get deposited over a long period of time. We cover the entire stone surface with paper pulp.

When the paper pulp is stuck on top of the stone and left for a considerable period of time, the oil, dirt, dust, and chemicals- all get gradually absorbed. Later, we have to remove the remains with a water jet, which gives back the old color (natural look) of the stone, which was getting ruined due to the deposition of dust, dirt, or chemicals. Now, once the impurities are removed, the stone appears clean with its original shine.

Stones may have a lot of pores (voids) within them, which need to be filled in because those are potential accumulation points of water. Hence, to avoid water accumulation, it is always better to fill in the pores with stone dust paste (made by mixing stone dust with linseed oil). A final coating of the stone is done with epoxy (this process is called ‘impregnation’) to avoid any chemical action directly affecting the stone surface.

It is also important that the loading on the stone must be put in the direction perpendicular to its grain (natural bed). So, if the natural bed of the stone is in this (see video) direction, the compressive force (loading) should be acting in this opposite (see video) direction. Otherwise, it will lead to a split of the stone's layers.

Thus, stones must be aligned on their beds in such a manner that the pressure on them is at the perpendicular direction to the natural bed. Another significant issue is 'mutual decay', which may happen when two different stones are used together. Minerals of one stone may chemically react with the minerals of the other stone- mostly observed between limestone and sandstone. So, we should not use these stones in a combination; otherwise, they will mutually decay each other (corroding effect).

All these constitute the main points to remember in the case of stone masonry and the maintenance of stones.for longevity

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Use of different stones in buildings

	Purpose	Type	Reason
1	**Heavy engineering works** such as bridge, piers and retaining walls	Granite	It is heavy strong, durable and is capable of resisting large thrust
2	**Building facing the sea**	Granite, compact sandstone	These are not affected by the weathering action of sand particles blown by wind
3	**Building in industrial areas**	Fine grained sandstone	These are resistant to acid fumes and smoke
4	**Arches**	Marble, close grained sandstone	Strong, durable
5	Building face work, carved work, ornamental works and statues	Fine grained granite	These are light weight, soft and easy to work and have pleasing colour and appearance
6	**Fire resisting structure**	Compact sandstone	It takes high polish
7	Road metal and aggregate for concrete	Granite, Basalt, Quartzite	Fireproof
8	**Railway ballast**	Coarse grained sandstone, quartzite	Hard, tough and has high abrasion resistance
9	**Electrical insulation like roof tiles**	Slate, marble	Poor conductor of electricity

Now, coming to the applications of stones in buildings; we have already discussed the geological classification. Igneous rocks, such as granite, are the hardest ones- and are used for heavy engineering works. They are durable, strong, resistant to large forces- they can stand submerged in water for long durations (several years) without significant damage. So, granite and basalt- are the best types.

In the case of a building facing the sea, the wind (laden with sand) hits the structures. The regular sea breezes can affect any sculpture nearby. Bare surfaces of stones get affected through a process called ‘attrision’. In such situations, we need a compact type of stone. Granite and sandstone (a metamorphosized rock) are useful in such cases. For buildings in industrial areas, fine-grained, compact sandstone can be effective since they can resist chemicals and toxic fumes from the factories.

These are strong, durable, and resistant to smoke and acidic fumes. Another important application is in arches or vaults, which are semi-circular (or similar) in shape.These are constructed with small stones joined together. Marble or close-grained sandstone are beneficial due to their strength and durability. For building face-works, carved works, ornamental works, and statues, marble and fine-grained sandstone are popular constituents. They are light in weight, soft, easy to work with, and have a pleasing appearance.

They may be available in different colors. Compact sandstones are suitable for fire-resistant structures. Coming to aggregates, crushed stones (such as granite, basalt, quartzite) can be used as road metal and as aggregates for concrete. They are also fireproof also, so igneous rocks are beneficial in high-strength applications and fireproofing. Although not within our domain, railway ballasts are made of coarse-grained sandstone and quartzite. They are hard, tough, highly abrasion-resistant.

Slate finds applications as roof tiles in hilly regions. Since it is an electrical insulator itself, slate does not conduct high-voltage electricity, keeping the building safe from electrocutions during thunderstorms. Since slate is a foliated rock, thin laminas may be obtained (see image in video). Thus, slate may be recommended for any layer which needs insulation against electricity.

Hence, slate is recommended for the roof (tiles), and also a useful stone for the construction of electrical conduits through it.

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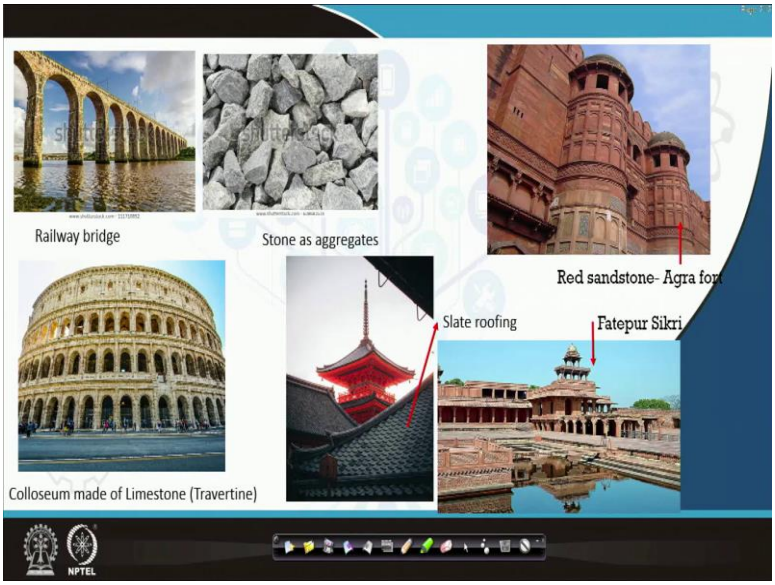

In the pictures (see image in video), you can see the vast arches below the railway bridge; this is possible due to the strong structure of basalt. The famous Colosseum of Rome is made of a particular type of limestone (travertine limestone), which made it durable enough to stand for thousands of years and still is mostly intact today. Check out the applications of red sandstone at Agra fort and at Fatehpur Sikri. The usage of slate tiles are also shown; they are laminar in structure and installed using similar kind of principles as clay tiles.

The lowest layer is the bottom-most layer of tile, and the starting point, on top of which the subsequent layer is placed, and this pattern is followed. There is an overlap at the edges to prevent water from seeping in. This arrangement is usually made on top of a wooden support system. Also, wood is a thermal insulator. So, the overall structure provides both electrical (due to slate) and thermal insulation (due to wood) of the sloped-roof house (prevalent in hilly areas).

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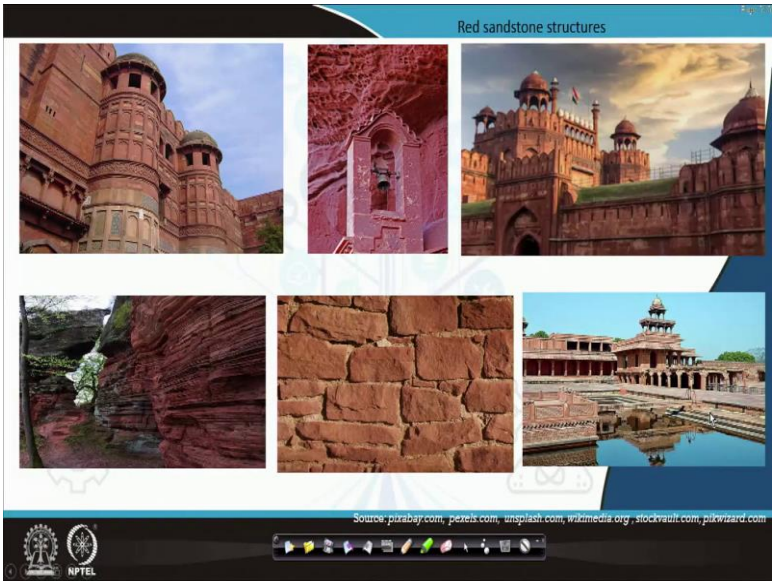

Here are some more pictures demonstrating the applications of stone as a building material.

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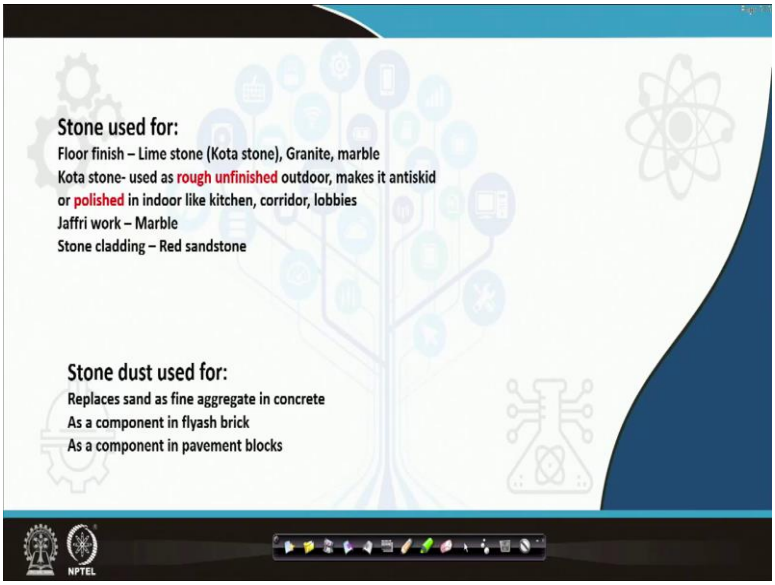

Stones also have several other applications in the building industry. Other than walling materials, they can be used as floor finish (usually limestone, Kota stone, etc.). Kota stone is abundantly available in Kota (a town in the state of Rajasthan); granite, marble, etc., are the most popular stones for flooring applications. Marble is a soft stone and thus is preferred in areas where the footfall is low. For example, it will not be beneficial for institutional buildings (say in schools or colleges- where a lot of students are moving in and out on a regular frequency). Thus, marble is not recommended in high-traffic areas because it withers away; instead, granite is a better choice.

On the contrary, limestone can remain exposed to extreme weather for a long duration (several years) with minimal damage. You can use limestone, and notably, Kota stone for any kind of regular floor finish- indoor as well as outdoor. Now, when a stone is used as a floor finish, it may be used in unfinished form or finished (polished) form. Usually, for outdoor uses, we prefer rough and unfinished stones (which provides the additional advantage of being anti-skid), whereas polished stones are favored for kitchens, corridors, lobbies, hotel rooms, etc.

Marble can be used for intricate Jafri works. With marble being soft, it is easy to work with specialized carving tools. Stone is also used as a walling material (not as a structural wall, but as wall cladding). The term 'cladding' implies covering the structural wall (say, made of bricks) with stones (for example, red sandstone). Clamps are inserted into the structural wall, which supports the thin pieces of sandstone (cladding). The stones hang in an interlocking arrangement between each other. These clamps help the stone cladding to stay separate from the actual wall surface and hang, forming a uniform façade.

Stone dust finds applications in aggregates. Larger pieces of stones from the quarry are crushed down to particular smaller sizes- all these stones below the size limit form the coarse aggregates or large-sized particles. The dust portion of the stones constitute the component for fly-ash bricks, as fine aggregates in concrete, and also used in making paver blocks.

Hence, stone dust is used as a replacement for sand. Artificial stones are made by putting a high proportion of stone dust in the mixture, giving it a stone-like finish. Thus, the use of stones encompasses a wide range from structural walls, floor finishes, wall cladding, and ornamental works (such as Jafri work).

It can be used as roof tiles. Moreover, stone dust and stone aggregates also do find their uses in the building industry.

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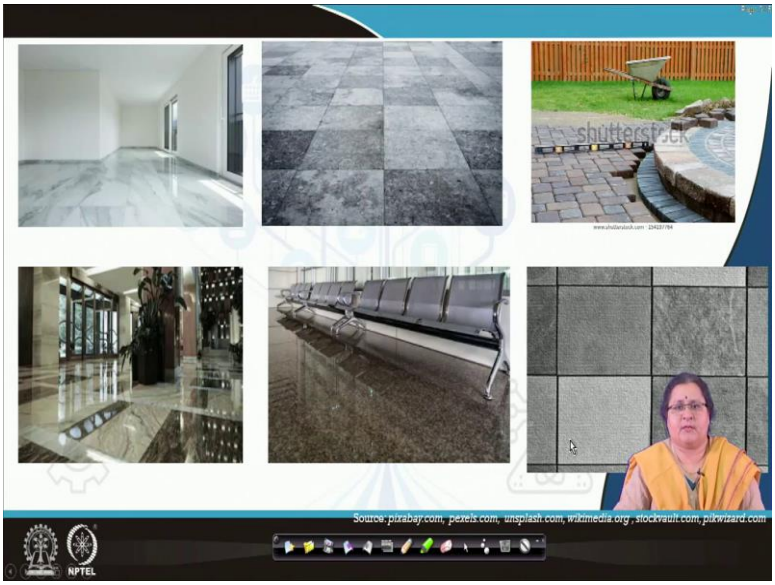

We will now discuss the looks (appearance) of stone flooring. In the picture here, there are many line marks (apart from the tile lines in the square grid) on the stone. These lines are the veins of the marble, caused by the deposition of minerals over time, in a specific pattern, giving such a look. The price of the marble varies depending on these veins. Also, you can see that this marble has a characteristic shine, indicating that this is polished marble.

In the other picture (see image in video), you can see a granite floor. The texture is different. In the upper picture, the tiles are of a smaller size, and hence you can see the square pattern. In the image below, the tile sizes are bigger. Here, the flooring appears continuous. There are a series of seatings, indicating that it is possibly not a residential building but maybe a public waiting area, in a hospital or an office. Such continuous flooring is expensive, whereas smaller tiled floors are less costly since they can be mined easily.

Squaring out large pieces of stones is a difficult task, which promptly reflects by the higher cost. Here (see image in video), you can see another kind of marble flooring, placed in a repetitive pattern along the floor, having a different look and color from the upper one. The four images on the left side are all polished floors, whereas the pictures on the right side show stone pavings.

This (upper right side picture) shows stone paving blocks used for an outdoor area. The image below (see image in video) shows Kota stone flooring (unpolished) in an outdoor setting. So, depending on the location of use, the recommendation of stone should vary.

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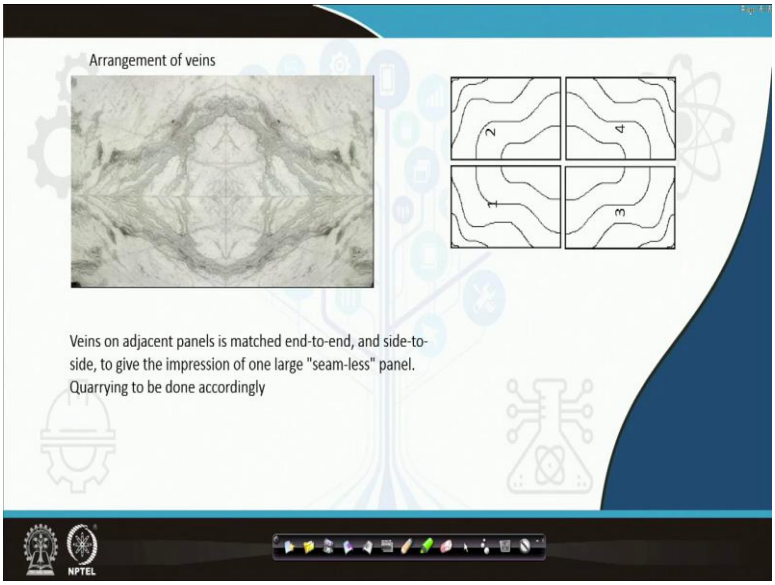

Particularly for marble, the veins must be aligned to get the pattern (see image in video). Matching the labels 1, 2, 3, 4, and following the alignment will generate the seamless pattern, and the area will appear like a single continuous piece of stone. These stones with specific directional vein patterns are custom-made and have to be specially ordered from stone merchants. These pieces have a larger size and must be carefully handled, and hence their transportation cost is higher, adding to the overall cost.

Kota stone does not get stained, and hence it may be recommended for kitchen areas. Due to being chemical resistant, Kota stone is also suitable for chemical laboratories where there is a possibility of spillage of acids or alkalis. So, before recommending a stone, it is essential to identify the purpose, specific location of use, footfall (or traffic), and climatic conditions of the site (for outdoor applications)

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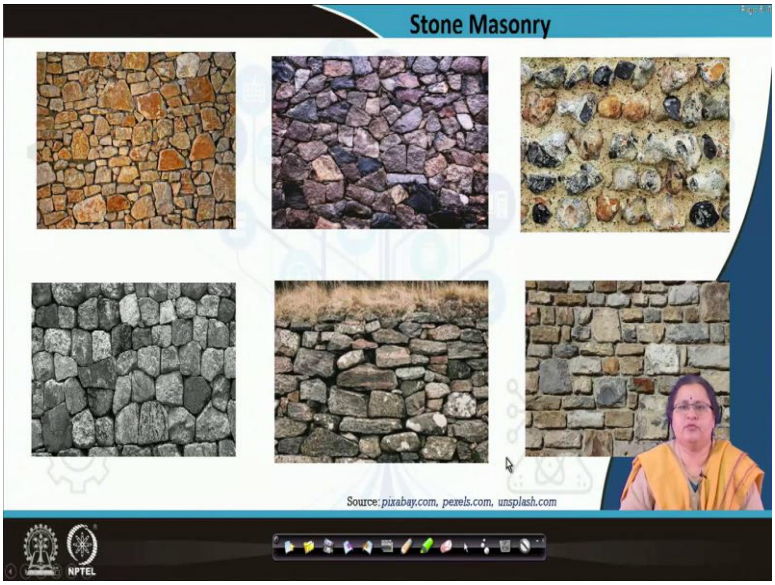

We will now cover the last part, which is stone masonry. You have already learnt the methods for brick masonry in the earlier lectures, but stone masonry is a bit difficult to demonstrate. In these pictures, you see lots of haphazardly arranged stones. Try to find out regularities in the structure; identify the courses (layering). Even though some stone pieces are rectangular (see image in video) and some polygonal, there are some lines (layers) that have been approximately maintained during construction.

If you compare them with the other images, you may recognize that they are different by style (even if not by color). In one picture (see image in video), a lot of small stones have been arranged to fill in the gaps, while in the other image, all the stones are more-or-less of a similar kind and precisely selected.

In this picture (see image in video), the small-sized stones are missing, and the stones used are polygonal in shape, arranged such that some of the faces match and they become like regular polygons. In flint masonry, lots of mortar (or binder) is used, whereas the number of stones is less, unlike in random rubble (which uses lots of small stones).

Here, a regular line is maintained, using a different approach- at every two courses (layers), of which one may be in the longer direction and the next layer in the shorter direction. A square pattern was generated, and hence the name ‘square masonry’. What you can see is (see image in video) a continuous wall from the front.

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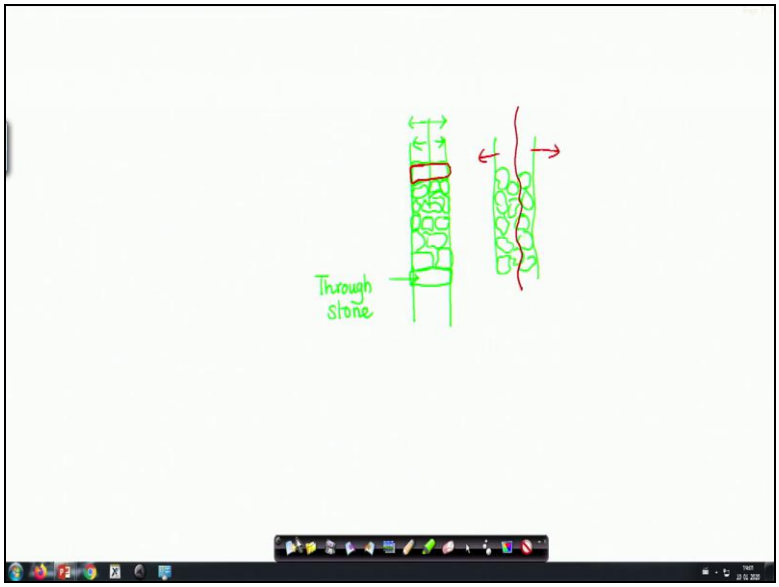

In the section view of transverse direction, irrespective of the appearance from the front, you will find a combination of three to four stones, which is necessary to achieve the desired thickness. But after every few layers, it is mandatory to put a continuous stone to support the courses above- to avoid splitting the wall in the transverse direction.

So, if we had only set small stones together forming a wall, it is highly likely that the wall will rupture from the middle (see the sketch in video). Otherwise, the wall may move apart from the center due to any lateral force or movement. However, if it is connected after every few layers by a single stone that passes throughout the entire continuous thickness, the whole wall remains bound together. This continuous stone is called a ‘through stone’.

As in brick masonry, for stone masonry too, you must ensure that there is no continuous vertical line (joint)- in both longitudinal and transverse directions. Also, a ‘through stone’ must always be placed at regular intervals between layers.

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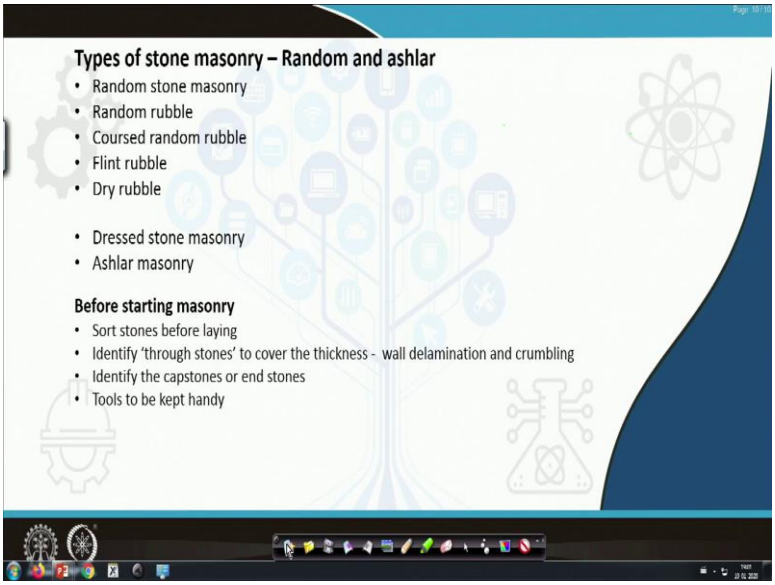

Thus, the major types of masonry are random masonry and ashlar masonry.The first type has some sub-types (random stone masonry, random rubble, coursed random rubble, flint rubble, dry rubble). In dry rubble masonry, no mortar is used. It is basically built by simply arranging the stones judiciously. Dry rubble may be used for low-height boundary walls. In general, random stone masonry is seen for low height walls (for example, one-story structures), or as retaining walls.

For making a building (say a residence) out of stone, dressed stone masonry or ashlar masonry is used. At first, we should check that the stones on the site are sorted. We had to make brick-bats (in brick masonry) that were used as closures to end or turn the wall at an angle. Similarly, in the case of stones, they must be sorted before laying so that you can keep all sizes of stones ready for use depending on the situation.

Stones similar in thickness and form are identified. When the desired wall thickness is known, you also have to search for 'through stones' which can run along the continuous thickness. Capstones (ending stone of a wall, placed at the top layer) are also required, which must be regular in shape. In the section view of a well-built masonry wall, at the top, there is a capstone, followed by multiple stones placed in subsequent layers, with 'through stones' at regular intervals.

Another crucial point here is the availability of appropriate tools, which were not very important for brick masonry. For bricks, a person may pick with one hand and subsequently proceed with the construction without any other help. For stone masonry, more than one

person may be necessary for the construction, depending upon the size (since stones are usually large and heavy), unlike bricks. Though the specific density of brick and stone is almost the same, the enormous size (volume) makes the stones heavier in weight.

Thus, the key points are that brick masonry is different from stone masonry, owing to different size and shape, although the underlying principle remains the same. For stone masonry, more mortar is required (for rubble work and flint masonry). Ashlar masonry requires less amount of mortar for the same wall area since the stone units themselves are larger in size than that of a brick, but in general, rubble work comprises around 25% mortar.

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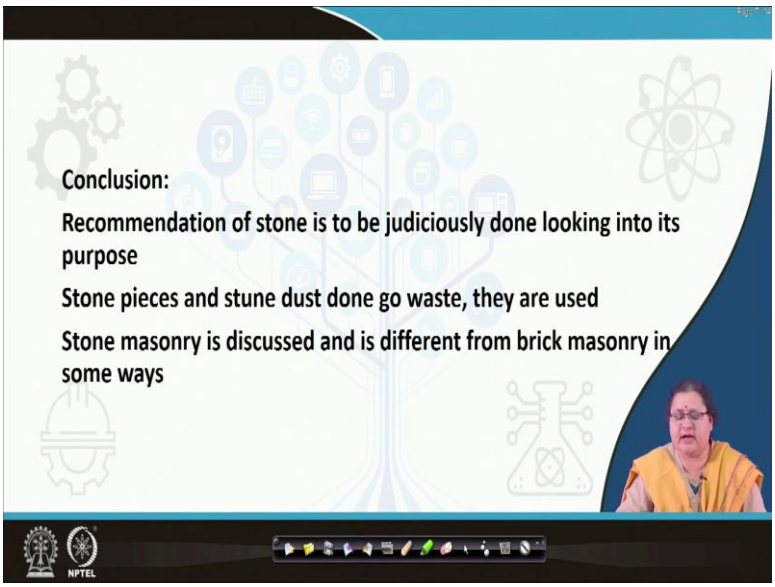

So, we may conclude that the recommendation of a stone must be judiciously made by considering the purpose and location of use. Also, we learnt that stone pieces and stone dust do not go to waste; they also have specific uses. Stone masonry, as you have seen, is different from brick masonry in some ways, although the underlying principle is the same. We also came across some preventive measures (possible issues and their solutions) that need to be taken when building a stone wall.

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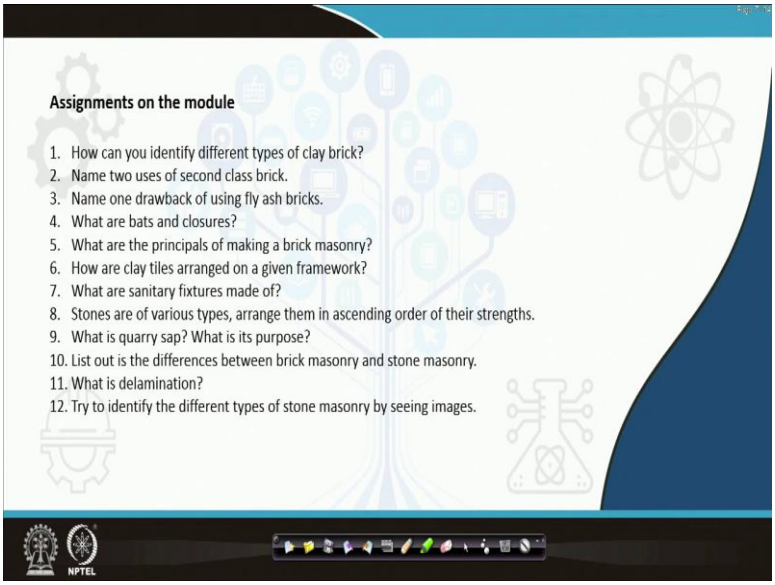

I will leave you with some assignments on the entire module. Once you study the last four lectures (2-5) of this module, you will be able to, hopefully, solve these. I did not deliberately set any questions on the first (introduction) lecture since it was just for background reading. Thank you.