Course Name: Building Materials as a Cornerstone to Sustainability

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Lecture 01

Stone

Hello all. So, we will look at stone and thatch as a building material in today's class and the next class. In our last class, we saw how mud is used in masonry, what are the various ways of techniques of using mud in masonry. We saw about cob walls, adobe, CSCD and so on and we ended up with learning about mud as a mortar. In today's class, we will see how stone is used as a building material. Stone which is considered a traditional or vernacular building material.

So, throughout history, stone has played a pivotal role in the evolution of construction. Ancient civilizations such as Egyptians, Greeks and Romans, they have utilized stone to create enduring structures like the pyramids, the Parthenon and the Colosseum. The durability of stone made it a preferred choice for fortifications, monuments and temples. The craftsmanship evident in the structures showcases the timeless appeal of stone in architecture.

The Brihavadeshwara temple is a testimony to it apart from many other temples including the Gangai Konda Cholapuram temple, another very magnificent creation made with stone. Over centuries, various cultures around the world have continued to use stone for its robustness and also its ability to withstand the tests of time. It is very difficult to pull down stone structures as compared to any other building material. In Medieval Europe, castles and cathedrals were often constructed with stone emphasizing its association with strength as well as permanence. The Renaissance period saw a revival of classical architecture further solidifying the use of stone as a symbol of grandeur as well as sophistication.

Even till date, stone continues to be valued for its aesthetic qualities and historical resonance. While quarrying and transportation have environmental implications, stone is inherently sustainable due to its longevity and recyclability. Buildings which were built or structures that were built even thousands of years ago still stand testimony to the fact that stone has such long life. Proper sourcing and quarrying practices can minimize its ecological footprint. Recycling is a very good option when it comes to using stone in

contemporary buildings.

Stone exudes a timeless elegance and adds a sense of permanence to structures. Its versatility allows for various finishes from very rough hewn to polished, catering to a range of architectural styles as well as finishes. Let us briefly look at the classification of stones so that we understand that on the basis of how certain stones are formed, their texture and therefore, their application and architecture is impacted. Stones are classified into three main categories based on their origin and formation processes. We have the igneous sedimentary and metamorphic rocks.

Let us look at igneous stones. Ignition stones are formed from the solidification and cooling of molten magma or lava. This process can occur either below the earth surface which is called as intrusive or it can happen on the surface which is called as extrusive. The texture of igneous stones depends on the rate at which it cools. Slow cooling results in large crystals while rapid cooling leads to smaller crystals or a glassy texture.

For example, granite, basalt and pumice are examples of igneous stones. All these three have various textural characteristics, but they are all igneous depending upon the time taken to coal and the quality that it comprises of. Then you have the sedimentary stones. sedimentary stones are formed through the accumulation and cementation of mineral and organic particles typically in layers over time. So, sedimentary rocks they occur as layers.

They are compacted layers of rock. This process involves the compaction of sediment in various environments, say sometimes in rivers, lakes, oceans. Their texture is often to have a layered structure and this texture can range from very coarse to fine depending on the size of the particles and the conditions during formation. For example, sandstone, limestone and shale are common types of sedimentary stones. Then the third type of stone is metamorphic stones.

Metamorphic stones are formed through the alteration of pre-existing rocks which could be either igneous or sedimentary or other metamorphic rocks under high temperature and pressure conditions usually deep within the earth's crust. So, the texture of metamorphic stones exhibit a wide variety of textures ranging from foliated that is layer or banded to non-foliated. Foliation occurs when minerals align in parallel layers due to directional pressures. For example, marble which is actually made from limestone. or slate and schists are example of metamorphic stones.

So, igneous stones could be very porous and soft say for example, pumice. Pumice is a very porous kind of and a very lightweight stone or we can have sedimentary stones which is nothing but accumulation and combining or compaction of various other

particles. So, they are in the form of layers whereas metamorphic stones they are formed because of an alteration of already existing stones and these are found much deeper the earth surface. So, this is the basic classification of stones. From an architectural point of view, let us look at the various types of stone masonry.

The first one is the rubble masonry. In rubble masonry, what happens is irregularly shaped stones, they are used without any dressing. What is meant by dressing? Dressing means shaping or cutting a stone. So, in rubble masonry the stones are not dressed or cut. These stones are laid in random patterns with mortar filling the gaps.

Many times even mortar is not used the stones are laid in a random pattern. It is a very inexpensive method and is often used for foundations and walls. So, in this method more or less the stones get interlocked within each other. So, when while using rubble masonry one should ensure that there are not gaps between the stones, but they are placed as close and compact as possible. Then we have what is ashlar masonry.

in Ashlar masonry dressed and cut stones. These are squared and finished for a very precise fit. It is more or less like using bricks, but the sizes of the stones can vary. Stones are laid in regular courses with mortar resulting in a more uniform and refined appearance. This is commonly used for very high quality and decorative structures.

The third type is the coarsed rubble masonry. This is similar to rubble masonry, but the stones are not extremely well cut. These stones are roughly dressed or squared only to some extent. Here stones are arranged in courses adding some level of regularity to the structure. So, One can see that in Ashlar masonry whereas the stones are very fine cut and laid in courses in coarse rubble masonry.

The stones are not very well cut. The way the stone is dressed is very different. So, this is the major difference and then the fourth type is the random rubble masonry. In Randall Rubham masonry, it uses irregularly shaped and sized stones without any systematic arrangement. It provides a very rustic and natural look and is often used in landscaping and traditional construction.

Construction where you would want to have a very natural look. The next type of masonry is coursed ashlar masonry. Coursed ashlar masonry involves precisely cut and squared stones of the same height in each course. So, this creates a very uniformly and formal appearance and this is mainly used in classical architecture. This is the main difference between all that we saw previously and this that even the layers are very similarly dimensioned.

The sixth type is the polygonal masonry. It features stones cut in polygon shapes and they are fitted together to form irregular patterns. These are found in historical structures, especially in ancient civilizations. The seventh type is the slip form stone masonry. This utilizes a formwork system to pour concrete and stack stone simultaneously.

The continuous pouring and stacking process results in what looks more like a monolithic structure. last one in which stones can be used which is not actually a masonry form. Technically, we cannot call it masonry, but it looks like masonry and that is the veneer masonry. This involves the facing of thin stones attached to a backup structure made up of different material. So, here stone is used more for facing and therefore, It appears that the masonry is made out of stone, but it does not have the weight and cost of a stone because it is only a superficial material which is attached to another structure.

The ninth type of masonry we call as the dry stone masonry. Here you do not require any mortar or adhesive, stones are stacked and balanced to form a stable structure. This is commonly seen in retaining walls, fences and historical structures. And the last type is called as the mosaic masonry where the stone is dressed and cut. Small irregularly shaped stones are used to create intricate patterns or images.

This is often used for decorative purposes in floors, walls and artwork. Now, let us look at the broad major types of stones that are used in construction. Each of this possessing unique characteristics that influence their suitability for specific applications. First, we will look at granite. Granite, it is a very hard and durable stone which is resistant to weather and erosion.

It is used for countertops, flooring and exterior cladding. It is common in monuments and sculptures due to its aesthetic appeal. Second is marble. Marble is soft, elegant and available in a variety of colors. But since it has limestone properties, it is vulnerable to acids as well as weathering.

It is very popular for flooring, countertops and decorative elements. It is often used in high-end construction and monuments. The next type is limestone. Limestone is composed mainly of calcium carbonate and is highly likely to contain fossils.

It is porous, but it is durable. It is widely used for building facades, flooring and in landscaping. It is also commonly used in historic structures. Then the next one is sandstone. Sandstone varies in hardness. It is often porous and is available in various colors.

These are used in construction of walls, flooring and paving. It is frequently seen in

historical buildings and monuments. Then the next type is slate. Slate can be fine grained and foliated with excellent splitting characteristics.

It is also resistant to staining. Its application is in roofing, flooring and wall cladding. It is also known for its natural cleft surface. Let us also look at basalt. Basalt is a igneous rock, dense and durable.

It is dark colored with fine texture. It is commonly used in the construction of roads, bridges and as aggregate in concrete. It is also used for exterior cladding leading to very maintenance free surfaces. Next, we have Travertine. Travertine is a type of limestone with distinctive porous veins.

It often comes in beech or ivory tones. It is very popular for interior flooring, countertops and decorative features used in both traditional and modern architecture. Let us now see about quartzite. Quartzite is a metamorphic rock which is hard and durable. It is resistant to chemical weathering. It is suitable for flooring, wall cladding and countertops and it resembles marble but offers better durability.

We will see what is schist. It is a medium to coarse screened metamorphic rock with foliation and it comes in a variety of colors. It is used for landscaping, walls and flooring and it offers a unique aesthetic due to its foliated texture. And the last type of stone we will see today is the soapstone. Soapstone is a metamorphic rock which is soft and talc rich. It is resistant to heat and acids and it is since it is soft as its name suggests, it is commonly used in sculptures because it is known for its smooth and soap like feel.

We have seen all these types of stones because, choosing the right type of stone depends on factors such as the intended application, aesthetic preferences and the regional availability. It is crucial to consider the specific qualities of each stone to ensure optimal performance and longevity in construction projects. Let us now look at the advantages of stone. The first advantage of stone is its durability.

Stone is resistant to weathering, erosion and pests. It can withstand harsh environmental conditions making it suitable for long lasting structures. Second is longevity. Stone structures have a timeless aesthetic that transcends architectural trends. They can stand for centuries, hundreds of years, sometimes even thousands of years without losing their visual appeal. It's a very low maintenance material compared to some other materials stone requires very minimal maintenance.

It is resistant to decay, rot and insect damage reducing the need for frequent repairs. It has a very high thermal mass and it helps to regulate indoor temperature. It absorbs and

stores heat releasing it slowly which can contribute to energy efficiency in buildings. That is why you will find it very cool in palaces or temples which are built with stone. Even though the outside may be very warm, the inside of these palaces or temples built with stone is very cool.

Next is stone is a very versatile material because we can use it for a wide range of applications. Stone can be used in walls, flooring, cladding and landscaping. Its versatility allows for diverse architectural styles. Stones also have an aesthetic appeal. Each type of stone is varied in color and this natural color, texture and pattern of stones they contribute to its aesthetic appeal.

Stone enhances the visual character of buildings and landscapes. Besides stones are fire resistant. Stone is a non-combustible element and has a high resistance to fire. This property makes it a safer choice for construction in areas which are prone to wildlife fires and fire hazards. It has structural stability, load bearing capacity and is excellent to build buildings which have to be load bearing.

It makes it suitable for supporting heavy structures. It provides stability and strength to buildings. An example of it is the pyramids. It is a mass supporting mass stones with no masonry in between. Stone is resistant to fading. Many types of stone exhibit excellent color retention over time, maintaining their appearance even when prolonged exposure to sunlight.

Besides, stone can be cut and carved into various shapes and sizes, allowing for intricate architectural details and personalized design. Therefore, we can find centuries old buildings such as the pyramids made of stone, monuments and temples and structures such as the Brihadeeshwara temple, the Gangaikonda Cholapuram temple also made up of stones, the prehistoric buildings such as dolmens are made up of stones and today stone can still be used even as a veneer. The versatility of the material lies in the hands of the designer. Let us look at the application of stone in modern construction. Stone continues to be a versatile and timeless material finding applications in various architectural and design contexts.

Here are some of the applications of stone. Stone can be used in exterior cladding. In modern buildings where stone is not the primary building material, we can still get the look of stone by using it as a external cladding material which can add a touch of sophistication and durability to the architectural designs. Stone can also be used in interior flooring. So, stone flooring such as marble or granite tiles is popular in modern interiors. It provides a sleek and elegant look and offers durability as well as maintenance free usage.

Stones can be used for countertops and surfaces. So, luxurious kitchens use stone particularly granite and quartzite. These are commonly used for kitchen countertops because of its natural aesthetics, durability and resistance to heat making it a preferred choice. It can be used for accentuating spaces. Stone accent walls either with natural stone or veneer are used to create focal points in interior spaces.

This adds texture and visual interest to modern designs. It can be used in fireplace surrounds in a modern hearth. Stone is often used to create sleek and contemporary fireplace surroundings, adding a touch of warmth and sophistication to living spaces. They are used for finishes in bathrooms where luxurious bathrooms especially using marble is utilized for finishes in bathrooms using especially in countertops, shower walls and flooring providing a luxurious and spa like atmosphere. They can be used on staircases and balustrades. Grand entrance stones is employed for grand staircases and balustrades in modern buildings contributing to a sense of grandeur and permanence.

It can even be used in landscaping for outdoor elegance because stone is used in landscaping for features like pathways, patios, retaining walls and decorative elements. It adds a natural and enduring quality to outdoor spaces. Stone can be used as a structural element, load-bearing structures. Stone is used in some modern constructions, providing both structural integrity and aesthetic appeal is merged. Sculptures and art installations are made up of stones in order to have blending tradition with contemporary artistic features.

Skyscrapers and towers also incorporate stone in their design, particularly in the form of cladding to achieve a striking and grandiose visual impact. Stone is employed in the design of high end retail spaces and hospitality establishment creating an atmosphere of luxury and sophistication. It also used in combination with other materials such as glass, steel to create modern and dynamic architectural designs. So, the use of stone in modern construction showcases its adaptability from sleek and minimalistic designs to ornate and intricate applications making it a valuable material for architects and designers.

Let us now look at the sustainability aspect of stone. Stone is naturally available. And as a resource, it is found abundantly in many parts of the world. When quarried responsibly, it minimizes the need for energy intensive manufacturing processes associated with synthetic building materials. Stone has high recyclability and it can be reused in various applications. Discarded stone from construction projects or demolition sites can be repurposed for landscaping, aggregate or even as a building material in other projects.

We can source stone locally and this minimizes transportation related carbon emissions

and utilizing nearby quarries reduces the environmental impact associated with long distance transportation. It is energy efficient. The thermal mass properties of stone contribute to energy efficiency in buildings and stone can absorb, store and slowly release heat reducing the reliance on heating and cooling systems and in turn energy consumption. It has very low carbon footprint because compared to the production of many synthetic materials, the extraction and processing of stone can have a lower carbon footprint. Sustainable quarrying practices and energy efficient processing methods further enhance its eco-friendly profile.

Stone typically requires minimal water for production especially when compared to certain other building materials. It does require water when it has to be cut, but when we compare it with many other building materials the requirement is less. Besides the water that is used can also be recycled. So, sustainable water management practices in quarries can further enhance the environmental credentials of stone.

Using sustainable quarry practices helps to mitigate environmental impact. This includes reforestation, soil conservation and rehabilitation in order to restore quarried areas. it can boost local economy support. So, choosing locally sourced stone supports the local economy and encourages sustainable practices within the community, fostering a more environmentally conscious approach to construction. Stone usage can contribute to green building certification also if it has been extracted through eco-friendly practices. Reclaimed stones from old structures or demolition sites can be repurposed, reducing the need for new extraction and minimizing waste.

stone materials typically have low or zero VOC emissions contributing to healthier indoor air quality. While stone has many sustainable qualities, it is crucial to consider factors such as responsible sourcing, quarrying practices and overall life cycle of the material to maximize its positive impact on the environment. Let us now look at stone buildings from all over the world. The first example is the Museum Sush at Switzerland. Now this is a 12th century monastery and a brewery which is combined to create a museum in Switzerland.

And this building is seen as two structures which are protected. The architect has taken great effort to preserve both of them. In this process, approximately 9000 tons of rock was excavated in order to provide more exhibition space. But that meant combining a 12th century monastery which would otherwise would have been perished with a brewery. And you can see the final outcome, which is very rustic.

Next, we will see the Church of San Giovanni Battista, which is again in Switzerland. So, in 1986, an avalanche destroyed a 17th century church, which Mario Botta replaced

with this stunning design. This white marble and dark genesis gives the tiny church an uplifting feel and light floods in from above the ceiling, creating pattern over patterns. And you have the Casa Milla by Antoni Gaudi. The last house that Gaudi ever designed, the structure earned the nickname the Stone Quarry for its unique limestone facade.

And then we see the Nevsehir bus terminal at Turkey which has a stone wall. So, we move now from a very contemporary period. The stone wall that surrounds the steel and glass structure provides shade and shelter inside the bus stop and it has an abstract form which shows that stone can be used in a versatile way too. Then we have the Taj Mahal at Agra which is made using marble and red sandstone. The CST in Mumbai is the elaborate detailing of the heritage building. It has carvings made in local yellow mallard stones blended with Italian marble and polished granite in some places.

The architectural detailing is achieved through white limestones. And then we have the Gateway of India. This monument is built of yellow basalt and reinforced concrete. These stones were locally sourced while the perforated screens were brought in from Gwalior. And then we have the Sun Temple at Konark.

The stone type known as kondalite was used largely for the temple construction. while the high quality chloride was used for the door jamb and some sculptures. The interior core of the temple and other structures were largely constructed using lacterite stones. And then we look at a very modern application of stone. So, hard sandstone called as Jodhpur stone is quarried 45 minutes away from this site which is the stone house at Jaipur. And minimal amount of steel such as tie rods and shear pins reinforce the stone for seismic performance.

Lime mortar which is used in this building is used only to seal the exterior joints and large front and rear facing glazing are shaded by deep overhangs and operable hand cut stone screens to modulate light, privacy and use. So, the use of Jali adds to a lot of drama in the house and it is known that approximately 5 to 7 degree variation can be observed between the exterior and interior of this house because of the thermal mass of the stone. With this we come to end of this class and in this class we saw the various types of stone, the classification of stone, the various stones that are used for various purposes in architecture. We saw application of stone in contemporary architecture as well as in some traditional architecture. With this we come to the end of this class and we will continue next class with that. Thank you.