Course Name: Building Materials as a Cornerstone to Sustainability

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Week: 02

Lecture 04

Binders

Hello everyone. In our last class we looked at how bamboo is a versatile material. It's a very traditional material but it has a lot of contemporary applications and we saw along with a couple of case studies. Today we will look at how binders which had been used in the olden days or in vernacular architecture still have relevance. And why do they still have relevance? Their environmental sustainability context we will see. So, in this class we will see what are binders, what are the types of binders; we will look at lime as a binder and cow dung as a binder.

So, we will primarily focus on two binders which is lime and cow dung because even when we were dealing with mud we were talking of a lot of use of lime as a binder and cow dung as a binder. So, first let us understand what are binders. So, binders are materials that act as a bonding agent that when mixed with aggregate and water form mortar which is used to bond various masonry units together playing a structural and decorative role in a building. There are four main binders that have been used throughout masonry history.

First is lime, second is hydraulic lime, third is natural cement and fourth is Portland cement, all of which is derived from limestone. Binders affect the physical and chemical properties of the mortar including its strength, how quickly it hardens or sets and how it reacts with surrounding materials. In the 18th century, Significant strides were made in comprehending cementitious materials, marking a notable departure from the Roman times. Reverend James Parker's 1796 patent for Roman cement, characterized by its swift setting, heralded a new era. Various natural cements derived from argillaceous limestone with over 25% clay content emerged each with distinct attributes.

These cements deemed natural utilize limestone's inherent components undergoing kiln firing at 1000 to 1000 degree centigrade akin to hydraulic lime. Post firing, the calcinated rock is finely powdered, distinguishing natural cement from lime as it resists slaking. Functioning as a hydraulic binder, natural cement exhibits rapid setting facilitated by the

formation of calcium aluminate hydrates resulting in superior compressive strength compared to the mortars while remaining vapor permeable. Its hydraulic nature and quick setting has made natural cement a favoured mortar in 19th century civil engineering and general construction, persisting until the advent of Portland cement in the mid-1800s. The distinctive properties of natural cements stem from the limestone's clay content and composition.

Binding materials are used in buildings with the aim of making structural elements for construction, increasing the resistance of the construction by linking the structural and architectural elements, increasing waterproof and protecting masonry surfaces from environmental degradation, preparing substrates for artwork and decorative purposes. let us look at the various types of binders that are employed based on the specific requirements of a given application. So, here are several types of binders commonly used in practice. Though we will be focusing on cow dung and lime, but we will just generally see all the other binders also. Now, when it comes to say portland cement, now portland cement is a widely used hydraulic binder in construction.

It undergoes hydration to form a strong and durable matrix. It is commonly used in concrete for buildings, roads, bridges and other infrastructure projects. When it comes to lime, Lime including quick lime and hydrated lime have been used historically. Lime is known for its breathability and flexibility. It is used in mortars, plasters and restoration projects providing flexibility and accommodating movements.

When it comes to gypsum, gypsum binders like plaster of Paris are derived from calcium sulphate. They set through a process of hydration. They are used in plastering, casting and as construction material. Gypsum board is a common application. Next is bitumen.

Bitumen is a black sticky substance which is derived from crude oil. It is known for its waterproofing properties. It is used as a binder in asphalt for road construction, roofing materials and waterproofing. Polymer binders are yet another type. And various synthetic polymers including acrylics, epoxies and latex can act as binders.

They offer enhanced durability and adhesion. They are used in paints, adhesives, coatings and some specialized construction materials. When we look at epoxy resins, epoxy resins are synthetic thermosetting polymers that cure to form a strong durable bond. Their applications commonly used as a binder in adhesives, coating and composite materials due to their high strength and chemical resistance. If we look at polyurethane binders are versatile and can be formulated for various applications providing flexibility, toughness or elasticity.

They are used in adhesives, sealants, coating and as binder in some composite materials. Clay, it can act as a binder when mixed with water forming a cohesive mass. It is used in traditional earthen construction, adobe bricks and in some ceramic application. Magnesium oxide is yet another binder. It is a versatile binder and it can set and harden rapidly.

It is used in some types of specially made cement and construction materials. Now, these binders serve various and diverse purposes and are selected based on factors such as strength requirements, environmental conditions and the intended application. The choice of binder significantly influences the properties of the final product. Let us now look at lime as a binder. Now binders are materials that act as a bonding agent that when mixed with aggregate and water form mortar which is used to bond various masonry units together playing a structural and decorative role in a building.

Lime mortar which is a crucial material in construction is crafted from limestone rich in calcium carbonate. It is subjected to temperatures exceeding 700 degree centigrade in a kiln and limestone undergoes calcination shedding carbon dioxide and 40% of its weight to yield quicklime. Mixing quicklime with water generates an exothermic reaction forming calcium hydroxide or slaked lime. Historically, this occurred in ground pits, allowing for a gradual breakdown to achieve desired characteristics. Modern slaking employing steam results in hydrated lime powder.

Blending slaked lime with sand in specific proportion yields lime mortar applicable in masonry or as plaster. Carbonation initiated by contact with atmospheric carbon dioxide facilitates the mortar's setting and hardening. Lime mortars possess benefits such as high vapour permeability, flexibility to accommodate structural movements and autogenous healing where cracks are remedied through dissolution, transport and precipitation of calcium compounds. Despite limitations in damp environments, lime mortars contribute to durable, breathable and resilient masonry systems. Let us look at lime as a binder in plaster.

Lime plaster is made up of sand, water and lime. It is usually non-hydraulic lime. It is a highly durable building material and proof of its use is even back in 7200 BC it was used and we can still find its traces. Often products can be used both as lime plaster and as lime render. It is durable enough to withstand the weather conditions when encountered in external use.

It is just one of the many benefits of using lime plaster or lime render. The moisture in lime plaster can diffuse and evaporate through the porous nature of lime plaster which is the most important benefit of lime plaster. Because lime plaster has a high TH and

functions as a fungicide, mould cannot grow on these. Lime plaster does not need expansion joints and is less brittle and prone to cracking than cement plaster. Unlike gypsum, drywall and earthen plaster, lime plaster is less susceptible to water and won't dissolve or soften.

Lime plaster is strong enough to be utilized as a lime render on the outside of structures unlike gypsum or clay plaster which can be used but it is definitely not as strong as lime plaster. Here we will just have a look at a case study of Farabag. Archaeologists studying Farabag, which is a 16th century summer palace of the Ahmednagar Sultanate, have found that the building used a unique lime technology that kept those staying there cool in the blistering Deccan summer. This was built in 1583 by the Nizam Shah rulers. and is in the center of a huge palace complex.

So, the National Museum Institute of the History of Art, Conservation and Museology and the ASI, Chennai, they analyzed the material used in the palace's construction and they found that its 13 centimeter thick lime plaster was embedded with stone, fired pottery and brick pieces that just improved its permeability. sand, jute fiber and dry paddy stem increased its porosity, durability and flexibility, helping the plaster to absorb moisture from the surrounding water fountains. So, in the summer heat, the moisture escaped slowly through the plaster cooling the interiors. The geologically diverse sample that make up the lime plaster are embedded with porous pot sherds and brick fragments. In dry hot seasons, the unique kind of plaster may absorb moisture from nearby fountains and slowly release it through the upper layer creating a cool environment.

So, the plaster possessed the appropriate porosity, strength, durability and flexibility due to the combination of heterogeneous aggregates, local sand and organic additions such as dry paddy stem and jute fibers. So, the natural cooling techniques used in this building because it had used lime kept the temperature inside the building up to 8 to 12 degree Celsius lower than the outside temperature that went even up to 46 degree centigrade. The high percentage of air pores in the plaster mix also contributed to the diffusion of moisture from the underlying building materials. Researchers said that the construction technology of Farabag is rare unlike palaces in India that used wind to cool its interiors. Let us now look at cow dung as a binder.

Now, there are a number of alternates for traditional materials that can be used in place of modern materials and cow dung is one of these. Sometimes we use cow dung brick. These cow dung bricks are made same as normal bricks except the material used in brick formation is cow dung. What we must consider when cow dung bricks are made? Cow dung can be used to manufacture bricks which are eco-friendly and much cheaper because it acts as a binder. These are made similar to normal bricks and these bricks are

made from a mixture of cow dung, lime and cow urine.

The amount of one fourth lime is mixed with three fourth amount of cow dung. The mixture is thoroughly mixed. The color of the dung must change after mixing of lime. This mixture should be covered for one day for better strength. There are many materials which can be used in building construction which have cow dung.

And these are cow dung brick that we just saw, the Vedic plaster, mortar, tiles, slabs and fiber boards. Now, these binders can be used to stabilize earth for construction and cow dung is one of them. A paste of cow dung and mud is sometimes applied to floors and walls in rural houses in India which forms a waterproof layer that helps to insulate the house from entry of heat. In order to make cow dung brick, one needs to mix cow dung should comprise about 78 to 80 percent with 20 percent lime and 1 to 2 percent cow urine. A brick made from cow dung is totally stabilized and some amount of lime is added into it and little amount of cow urine is added if required.

These bricks are fully sun dried. Two sizes bricks are made. One is same as normal size and another is two and a half times the normal size. The strength of cow dung brick is between 2.5 to 11 MPa which is better than normal mud bricks and AAC blocks. No heat transfer from one side to another side of the brick has seen to happen and minimum 2.

5 kg dung is required for one brick. Let us now look at cow dung also as a binder. Cow dung has been used in building construction as a building material from the Vedic period in India. Cow dung has some natural contents like fiber, water, iron, magnesium etc. A paste of cow dung and mud is sometimes applied on the floors and walls of rural homes in India which forms a waterproof layer and this insulates the house. Cow dung helps in making a breathing structure that can easily survive in hot regions and does not smell unpleasant.

There is a new process of making bricks from cow dung mixed with soil and straw dust. These bricks are much more eco-friendly, lighter and affordable and cow dung is rich with minerals such as potassium, magnesium and phosphorus which acts as a good binder. It also improves the texture of soil and help it to maintain moisture. Cow dung is an eco-friendly binding and additive material which does not emit toxic gases and protects human health from hazardous environment. Cow dung is a relatively thin fibrous low density material.

It is sustainable material which is both additive and binding characteristics and can provide better compaction of moulding sand. Cow dung is not only a good binder, but the fibers present in the dung also help in creating a smooth, fine floor finish. The fibers

prevent cracking in floors and also increase the insulation property of the plaster. The 3.5 crore microbes per gram of cow dung means hordes of good bacteria.

Cow dung is an antifungal insecticide which is why we can confidently use them for disinfecting our homes and floors. For fibers, often cow hair is added to the plasters to prevent cracking. Apart from cow dung, cow urine is also used as an additive for plastering because of its antifungal property. It prevents the growth of harmful fungi in the walls and floors which is a cause of harmful diseases. It is an extremely good sealant of earthen floors.

Using cow urine for sealing the topmost coat of the floor avoids cracking of the finish. Dilution of 1 is to 10, cow urine is to water shows an effective fungicidal property. Let us now look at a case study made with cow dung. This is located near Sheela Bypass in Rohtak, Haryana and is built by Dr. Shivdarshan Malik in the year 2018. It is called as the Vedic Bhavan and it is the first office in India which is totally built with Kaudang building materials. Vedic Bhavan is the official branch of Vedic Plaster and Gaukreet Research Institute. They help people, those who seek to know about cow dung benefits in construction and also deal with the products they offer. So, Dr. Shivdarshan Mallik's innovative approach combines traditional and modern architectural styles in the construction of this commercial building.

With a keen eye on materials and climate considerations, the use of cow dung bricks, Vedic plaster and Vedic paint which are again based on cow dung ensures optimal thermal comfort throughout the year. The Vedic Bhavan serving as the official branch office of VPGRI in Rohtak is a remarkable structure entirely crafted from cow dung materials. The mortar used in this construction comprises a blend of cow dung, mud, lime and cow urine. Similarly, the bricks are a mixture of lime, cow dung, mud and cow urine. Vedic plaster is a powerful composition of 60 to 70 percent gypsum, 20 to 30 percent cow dung, 8 to 9 percent mud and 1 percent citric acid which adorns the walls.

The application of Vedic paint derived from cow dung and cow urine further enhances the building's unique features. Beyond aesthetics, the use of cow dung materials ensures Vedic Bhavan is filled with fresh air, distinguishing it from neighbouring RCC buildings that contribute to higher levels of air pollution. The Vedic plaster is a powerful composition of 60-70% gypsum, 20-30% cow dung and 8-9% mud and 1% citric acid as it adorns the wall. The application of Vedic paint derived from cow dung and cow urine further enhances the building's unique features. Beyond aesthetics, the use of cow dung materials ensures Vedic Bhavan is filled with fresh air, distinguishing it from the neighboring buildings.

And how do we know that? A study has been conducted and the techniques and materials used in Vedic Bhavan are totally cheaper and eco-friendly. Proper maintenance and use of cow dung and cow dung building materials happen here. All the cow dung materials made houses or buildings have courtyards which help in thermal insulation. And when meters were placed in the adjacent RCC buildings and in the Vedic Bhavan, it was found that the indoor air quality overall was much better in the Vedic house. So, the Vedic plaster and Gaukrit Research Institute which is a research institute manufactures various materials such as Vedic plaster, mortar made up of cow dung, cow dung brick, normal sized brick, large sized brick, cow dung tiles and Vedic paint made from cow dung.

So, in this class, we have seen two important binders of vernacular architecture, lime and cow dung and how in the contemporary era, these two eco-friendly carbon neutral building materials have been used. With this we will stop the class and we will continue with yet another building material in the next class. Thank you.