Course Name: Building Materials as a Cornerstone to Sustainability

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Lecture 01

Introduction to Building materials, their classification, environmental issues,

Hello all. So, I welcome you all to the course which is about understanding the various building materials. So, why is it important for us to understand about building materials and its use in buildings? It is because a large part of the embodied energy is contributed by the building envelope system and in that use of building materials contributes a lot to the embodied energy of the building. In order to go carbon neutral it is very important that you are aware of the selection of building materials. It is with that intent that I have developed this course to expose you to the various building materials and how selection of those building materials is very important. Also this course must also help you understand that you can yourself develop a new innovative building material if you want to, if you want to go carbon neutral.

So let us start this course. So, in this PPT, we will be looking at the various classifications of the building materials based primarily on its environmental strengths. So, I will not dwell more into the physical properties or chemical properties of the building materials. Because once the building material has come out to be an accepted one and its application is shown in buildings, we need to understand and assess its environmental benefits primarily.

We will look at traditional building materials. We will look at the characteristics of traditional building materials. What are green building materials? What are the characteristics and significance of materials in green buildings? We will also discuss a little bit about carbon negative building materials and we will end with the summary. So, now what is the significance of having to understand about building materials? Now, there is growing population and urbanization and this is changing the face in developing countries. As more people move from rural areas to urban areas, there is a growing demand for many buildings, especially housing, commercial buildings and also infrastructure projects.

Say like you need to add more roads, bridges, railway stations etc. In developing

countries like India, China, Brazil and some of the African nations, this urbanization trend is particularly very high and it is very pronounced. And that has a direct implication on the requirement of number of buildings. So, growing number of buildings, you can see the trend here. Right from 1960, the number of skyscrapers, there is an exponential increase and that increase is significant in the last two decades or rather one decade.

From 2008 to 2018, there has been a significant rise in the requirement of number of skyscrapers and more skyscrapers have come up in the world. And because of this the requirement of building materials has also escalated tremendously. So, in order to meet the demand of these skyscrapers, there is a humongous surge in the need for building materials. And growing population and urbanization are driving the global markets in terms of materials such as steel, cement, especially concrete. It is said that after water, the most sought after material is cement in the building industry.

So, that is the amount of demand for cement and you know very well what cement contributes in terms of embodied energy. Its embodied energy is extremely high. Now, the development of infrastructure is accelerated by the global market and also by government programs and the investment Government is doing to help buildings. Many developing nations are aggressively pursuing infrastructure projects to increase the meeting demands and what is the relationship between the growing number of buildings and the emissions that they are causing to the world? You can see along with the number of skyscrapers, the emission just from cement production is also increasing exponentially. So, this exponential growth in emissions Emissions is carbon dioxide emissions is directly related also to global warming.

So, if you are in any in any case -if you are a little aware of the emissions that are being caused. and the consequent global warming, then you have to be extremely aware of the building materials that you select for use in your buildings. Now the developing nations are increasingly adopting eco-friendly construction materials in order to fulfill the sustainability goals. In the COP, There is a commitment by every country about how much emissions they would cut in order to decelerate the global warming. So, what would be the contribution of every country? India has committed to at least 30 to 35 percent reduction in its emissions by 2030.

And all other countries have also given their commitment. And in order to do that, we need to understand alternate building materials which will cause less emissions. Now, cement manufacturers are doing their small bit by developing green and low carbon cement products. And these are also finding a lot of place in the market. So, there are many ways in which they are doing this.

Now, sometimes the fuel that is used, they try to go for an alternate fuel and so on. But everyone is trying their bit. The way that we as architects, designers and civil engineers have to do our bit in trying to understand which building material is going to give less emission and cause less harm and therefore contribute to our sustainability goals. The rise of international trade and investment in construction projects has further boosted the global cement market. I am just taking one example of cement here to say what all can be done and what all it causes.

So, this increase of construction activities in developing nations is a pivotal driver for the global building industry market. And this is also a global driver for the extensive emission that is being caused. So, what should we do? We need to go for a transition of building materials over time. We cannot stick to the same thing that we have been doing and expect any results. So, building materials which are the essential components in construction are pivotal in determining a building's life as well as quality.

Now, there has been a notable shift from predominantly natural materials to a diverse range of manmade materials and even sometimes composite options that we have been using in our buildings. We have also tried to explore biodegradable or imperishable choices. The globalized nature of modern construction has transformed material sourcing from indigenous to international because of the advent of international style of architecture around 1920s which said that all building materials are available throughout the world. Everyone has equal access to cement, steel, glass, concrete and also the technology to use these building materials. So why not use these building materials all over the world? Now what has happened is two important changes have happened because of this kind of an approach.

First is we have started designing buildings which are not relevant to the climate. And second thing is we have forgotten our indigenous building materials. This has impacted the availability and characteristics of building elements itself throughout. So these choices are influenced by factors such as say cost, local availability, environmental impact and specific performance requirement including how much they are earthquake-prone, whether that is we call as seismic or fire resistance. So examples of building materials which encompass masonry, concrete, wood, steel, glass and more, these belong to this category.

In the contemporary landscape, sustainable practices, technological advancement and a focus on this kind of very specific being earthquake resistant or fire resistant building materials. These are shaping the trajectory of building material use and the dynamic structure of these choices. And these choices underscores the need, consideration along with balancing our economic requirements, the desire and the need to fulfill

environmental requirements and various factors for successfully executing a building construction. We need to become more aware of the choices of building materials that we make and we should also understand why this transition ever happened. Let us now look at the changing requirements of building materials.

Now, an environmentally friendly recyclable or high performing material that minimizes its effects on the environment and human health over the course of its life cycle. This is what we require. So, the building material has to be extremely environmentally friendly. It should not be emitting too much of carbon dioxide. It should be recyclable and it should have low embodied energy.

It must lessen or make less the pollutants which are indoors and specifically formulated from non-toxic organic and natural materials. Otherwise, it leads to a lot of health issues and health problems of the occupants. That is why even paints are going low VOCs. So these building materials must not only be eco-friendly in terms of it's environmental impact but they must also cause no harm to the inhabitants. They must assist in rerouting indoor air quality liability claims while satisfying customer demands and legal standards.

So, IAQ is very important to avoid sick building syndrome and therefore the building materials that we select must also be supportive of it. The conservation of non-renewable resources and reducing the environmental impact must also be imperative. These building materials must be recyclable products that improve the production environment and quality of life. They must not have natural resource depletion. It should be very, very minimum.

So, depletion of natural resources should be minimum. They must not cause atmospheric pollution and they must not contribute to climate change. They must also prevent loss of biodiversity and contamination of fresh water resources. So, the building materials choices must be dominated by the ones that avoid natural resource depletion, atmospheric pollution, climate change and they must prevent biodiversity and contamination of freshwater resources. So, these are the major requirements that we should look at when we select building materials.

What must be the characteristics requirements of building materials? Now, green building materials are characterized by many of these factors. They must be sustainable which means they must be derived from renewable or recycled resources which should aim to reduce reliance on finite resources that we have. They must be highly energy efficient. They must have good insulating properties in cold areas and they should contribute to overall energy efficiency. So, apart from being renewable or recyclable with their reduced reliance on finite resources, they must have superior insulation properties as

well as contributing to overall energy efficiency.

They must have low environmental impact. That is they must be manufactured using processes which have minimum polluting. So, the process of producing the building material itself must not cause pollution and they must have minimized impact on ecosystem. So, ecosystem damage must be minimal. The building materials must be recyclable because recycling building materials will reduce waste and it will help in resource conservation.

Also, the building materials must be durable. They must be designed for a longer lifespan. They must be capable of reducing replacement otherwise embodied energy of the building over a period of the building's lifespan itself will keep on increasing which is not a good thing because again you are pumping in too much of embodied energy into the building and therefore, which is directly related to no emissions. It should minimize resource consumption over a period of time. So, have building material choices which has less maintenance and upgradation.

The building materials must be non-toxic that is it should be free from harmful toxins and It must improve indoor air quality. So, the building material could improve IAQ or at least it should not harm the health of the individuals by creating poor IAQs. It must be water efficient and therefore, it should promote water conservation, avoid building materials which consume more water in terms of their extraction or their production and we must have low flow fixtures and should think of rainwater harvesting. These are just extra things beyond the building materials. The building materials after the life of the building should be capable of naturally decomposing and should go back to nature.

This will reduce the environmental impact at the end cycle of the building. The building materials must be locally sourced so that the transportation energy is reduced. So, in order to focus on low transportation energy have building materials which are locally produced and these materials will also support the local economy of the place. The building materials may carry certifications and therefore, these are all brownie points. If you choose building materials that kind of have a green building certification, if you want to go for labeling, eco-labeling like LEED or GRIHA and so on.

Let us now look at the significance of building materials in green building. Now, in the context of green building practices, understanding the importance of building materials is very crucial because there is a nexus between urbanization and the heightened demand of building materials. Now, this is also driven by growing urban population. So, urbanization and material demand, it drives the increased demand for building materials. So, the demand for building materials becomes more and this is directly linked to the

growing global urban population because of urbanization.

Also, the non-renewable resource concerns are also very high because this industry heavily relies on non-renewable resources like coal for energy for its production. So, this raising alarms about depletion of non-renewable energy resources and the need of sustainable development in construction also drives us to understand about the various building materials. Now, there are issues with conventional building materials because growing global awareness highlights the hazards from the conventional building materials in terms of, specially, the environment and therefore it is raising an alarm for us considering the fact that we are always going on saying that we need to reduce emissions, we need to reduce global warming and therefore this becomes important. We also have to consider the importance of having to reduce toxicity or having nil toxicity inside and improve our indoor air quality. So, conventional materials- they could contribute to indoor air pollution by say, use of VOC emissions and these happen especially through paints, sometimes even through the carpets.

So, selection of building material for paints and carpets become very important and they pose a risk to both human health as well as the environment. We must also understand the environmental impact and life cycle assessment. So, these materials contribute to environmental burden and human health impacts throughout their life cycle and therefore, we need to understand how life cycle assessment can be used for evaluating the environmental impact. Then, there is an urgent need for innovation no doubt. The industry urgently, quickly requires new materials and technology to align with SDGs and address the negative impacts associated with conventional building materials.

Now, this innovation is imperative to align the industry with sustainable development growth so that we address the adverse effect associated with conventional building materials or modern building materials. Now, let us look at the market requirement. The market's primary driving force is a paradigm shift towards renewable greenhouse materials and also towards ecologically friendly building materials. So, there is a demand in the market that we need to shift our choices of building materials to renewable materials as well as ecologically friendly building materials. So, renewable materials is important and ecologically friendly building material is also a requirement from the market.

Why is it important? Why is it coming from the market? Because green building certification is also becoming very important. So, it is necessary for us to have green building materials in order to go for certification also. Now the market dynamics are boosting sales of products which are say eco-friendly timber or green board insulation in buildings. The dynamics of green building material market are likely to change by

innovation and new generation advanced technologies which must be backed by research and development by making them more effective, advancing the construction techniques and increasing efficiency. Now let us look at the choice and selection of building materials.

The selection of building materials is a critical aspect of construction with choices guided by factors such as performance, qualities and its applicability. The choice of building materials, it considers various factors such as climatic conditions. Now, this is what has happened with the internationalization of buildings. I am using this word internationalization of buildings. Because this is where we started using modern so called modern building materials with very scant respect to the environment and the climate of that place.

So even whether it is a hot and dry climate or a warm and humid climate we ended up using the same building material and therefore the choice of building materials now must entail various factors such as climate. The economic aspects of budget. What is the cost of the building material? Will a concrete block cost same as a mud block? When a mud block is good enough to compensate for a place where concrete block is used. So economics becomes very important.

Availability of materials and skilled labour. So, what is happening now? We are seeing one to one that sand is getting depleted as a resource. So, the availability of the material is reduced. And I am just giving sand as an example. And also there must be availability of skilled labour.

This is also important. When you choose a building material, do not choose a building material which needs so much exquisite skilled manpower to execute it. Because then it will lose its popularity over time. Because the building will not progress for lack of skilled labour. Advances in construction technology must also be considered. So advances in construction technology further expands the array of available materials because it starts introducing innovative options for enhanced building performance.

The properties and so I will number it as five. Then sixth one is the properties and qualities of selected building materials. It directly influences the functional safety aspects, the functional aspect, the aesthetic aspects of the construction project. So, for a construction project to be functionally safe and durable, appropriate building materials have to be used and we will be looking at the classification of these building materials that will form a very important part of this course. So, we have come to understand that there are certain parameters based on which we choose building materials. So, these building materials are an integral part of architecture and they play a crucial role in

determining the visual appeal, structural stability and historic value of a structure.

The choice of building materials is influenced by various factors such as the site that you have where the building is going to come up, the nature of the surroundings and the type of buildings. Building materials establish a relationship between the visual quality as well as the structural stability which is essential in creating a structure that is both aesthetically pleasing and structurally sound. These building material selection also highlights the theme and the concept of the design. You cannot be designing a building which produces eco-friendly building materials but actually the production of the eco-friendly building materials come from a building which has very high embodied energy- or which has a lot of emission. So, they have to correlate, certain things have to be correlated in spirit.

So, different materials can evoke different emotions in people and convey different messages. For example, the use of wood in structure can create a very warm and grounded feeling which can be very inviting. Whereas the use of exposed concrete can create a very industrial and a very grey and a very modern feeling also. Because the exposed concrete is one of the characteristics of modern architecture and that is something new to the Indian vernacular architecture. So the selection of building materials can enhance the overall ambience of the building.

It can create a very cohesive and harmonious structure. The building materials also play a crucial role in determining the appropriate site for construction project because the availability of building materials and their suitability in design can influence the location of a project. For example, if a project requires a specific type of stone, the site selected must have access to that stone. Otherwise, you are going to increase the embodied energy by means of transportation energy. Though stone is a low emission building material compared to concrete or steel, but all that will compensate in the increased transportation energy. The availability of building materials can also impact the budget of a construction project.

Furthermore, building materials help trace the evolution of the art of construction. The use of different materials throughout history have influenced the development of architectural styles and the techniques. The study of building materials can produce insights into the cultural and historic values of a society and the evolution of construction practices. Example is Brihadishwara temple. The kind of ambience it creates, the kind of cultural and historical ethos it has to the society.

I will now get into the main aspect which is what we will follow. Now, what are the classification of building materials? So, building materials can be classified as natural building materials. Natural building materials are materials that can be found in nature

that require very minimum processing say like mud or wood whereas the synthetic building materials which are based on source, these are man-made manufactured materials and they involve processing. For example, steel. So, based on the source of building materials, we can have natural building materials and synthetic building materials. Based on the composition, we can have organic materials and inorganic materials.

So, organic materials are raw materials that require very little chemical changes. For example, sand or biomass. So, they are very minor, no intervention is there. You have to remove the pellets, you have to remove the things that you do not need and so on. Inorganic building materials- they are processed with added components to enhance their performance.

So, it can be something like lime we could call it as a based on composition. Then based on sustainability, building materials can be classified. We could have composite materials. Composite materials are natural materials that are modified for improved performance.

For example, engineered wood or CLT. So, these are all composite materials from nature because we are talking with respect to sustainability. You can have sustainable building materials which are produced, installed, maintained with very less environmental impact. For example, bamboo. And you can have non-sustainable building material which are intensely modified with high environmental impact.

These can be cement, steel, glass, concrete, aluminum and so on. And finally, we move on to building material classification environmentally because that is the crux of this course. Here we will classify building materials as vernacular building materials. These building materials have been used for a very long time. They have proven to be useful to the human beings in that particular context. These are mud, stone, thatch, bamboo, some binders, straw bale and quarry waste.

Over time, when there was a kind of awareness about being environmentally sensitive, we started developing what we call as alternate building materials. So alternate building materials use certain things which are considered as waste. And because earth is not able to sustain that much of dumping of the waste, these are also incorporated into building materials to produce what is called as alternative building materials. Those could be fly ash, furnace slag, cross laminated timber, construction demolition waste, phosphogypsum, hempcrete, papercrete, aerated concrete, alternate aggregates.

Then the third classification is innovative building materials. So under innovative

building materials something very new which is very striking, attractive has come up and these are bioluminescent paints, milk paints, recycled plastics, carbon dioxide absorbing concrete and maybe agro bricks. All of these are extremely environmental friendly and moving towards low carbon, low emission building materials. We will also look at advanced building materials like fab ash that is building materials which incorporate the some part of fabric or ash of a fabric because fabric waste is another huge burden on the earth. We will look at light emitting concrete, fiber reinforced concrete, mycelium composite bricks, geopolymer concrete, living bricks, bioluminescent paints, eco-bind tiles and permeable concrete. And the last one is the Gen Z kind of building materials which I call as smart building materials.

We will look at certain components as well as certain other aspects like smart windows, use of LCDs in buildings, photochromics, thermochromic, electroluminescent, titanium dioxide, thermotropics and electrochromimics. So, this slide where you see the building material classification based on its environmental sustainability will form the basis of further classes and this course. We will look at each building material separately and that will be the course. I stop my class today with this and we move on to our next segment which is vernacular building materials in the next class. Thank you.