Building Materials and Composites
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Lecture - 01
Introduction to the Course

Welcome to all who have enrolled for this course on "Building materials and Composites". I am Dr. Sumana Gupta, as a faculty of the Department of Architecture and Regional Planning, Indian Institute of Technology Kharagpur- will conduct this course. So, our course is an eight-week course, and it has eight modules. It will run through eight weeks, where five lectures will be given in each module.

And I have tried to frame it in such a way so that we can cover our architectural subject of "Building materials and Composites" in this period. First, I will come to the contents. And here there are two terms, one is "building material", and the other is "composite", where the term "building material" directly refers to the materials which are used for the construction of buildings, and "composites" are also similar items when two or more materials combine together to form one material.

Remember, it is not the composition of a material, but when two different materials combine, it forms a composite. Now, our first lecture of this module would be an introduction to the course as we have no other way to introduce you to the course before we move to the several components of the first module (Module 1), which will be "Clay products and Stone".

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So, the concepts that will be covered in this course will be as follows: Clay products and alternate items like fly ash, compressed earth blocks, compressed stabilized earth blocks, stone, stone tiles, stone dust blocks, wood and engineered wood, glass and glazing systems, ceramic tiles, vitrified tiles, fine aggregate, coarse aggregate, cement, and concrete. So, this is module four.

Then we come to precast items: flooring, roofing, walling systems, hollow block concrete, aerated concrete, autoclaved concrete, ferrous and non-ferrous metals, damp proofing material, insulation, paints, and lastly we have plastics, composites, nanotechnology applications into building materials. So, as you can see that the concepts covered are quite massive; we will have to structure our lectures in such a way so that you can get the maximum benefit out of it.

And at the same time, you will be equipped with all the types of materials that an architect has to come across while planning or recommending for the building you are going to design.

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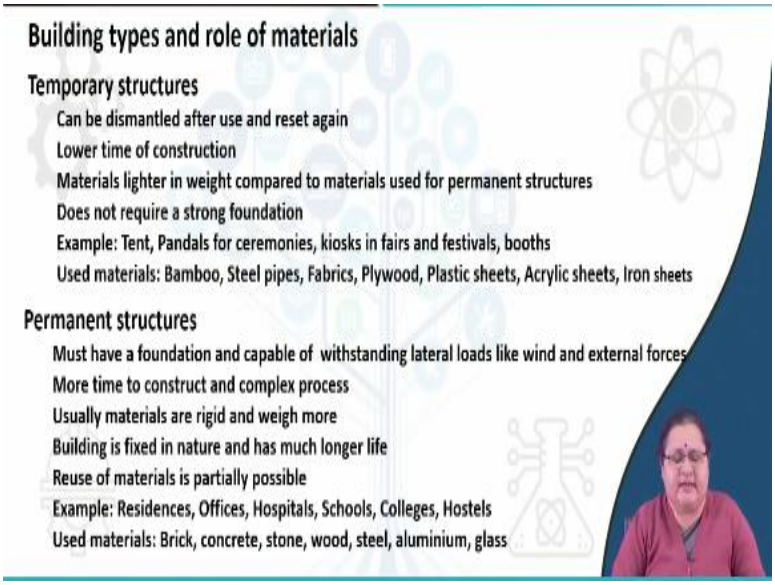

Now before coming to the materials, we are to concentrate mostly on the permanent structures, but there are a lot of temporary structures, where too, the application of materials can be seen. So, how can we define "temporary structures"? It can be dismantled and used again once it is reset. Obviously, the materials should be light in weight. It will take lesser time for construction, and it will not be similar to permanent structures.

These structures may require a shallow (very low) foundation or not so stable foundation, such as the pandas you may find in your surroundings. You can see festivals or fairs being conducted in temporary structures. You can see booths being erected for some particular purpose (such as elections), and then it is dismantled afterward. It may be any kind of temporary event where such temporary structures may come up.

However, we as architects need to know these materials also and also more towards the permanent structures. Now, particularly for temporary structures, what could be the materials? They could be like bamboo, steel pipes, fabrics (for example, tarpaulin for covering a space), plywoods to define spaces/areas, or plastic sheets to cover the roof (for example, by use of acrylic sheets).

It may be the case of temporary shops being constructed, where you can put acrylic sheets. It can be cycle shades, bus stands (where we can use iron sheets too). These also are applied in permanent structures. However, we confine our focus only on the

temporary structures using such kind of materials. So, the crucial point is they are utilizing less time of construction, and they are not much weighty (they are lightweight).

But when we look into the permanent structures, it must have a foundation, and it should live (sustain) for a longer period of time. And at the same time, it must protect you from all the weathering actions by the atmosphere in the surroundings. These effects may be due to blowing of the wind, or rain, or excessive sunlight. So, you must keep the inhabitants (users) of the building protected against all these natural calamities.

The building or the structure will be subjected to lateral loads, and it should be capable of withstanding the force. It utilizes more time to construct, and obviously, it is a complex process, and very difficult to dismantle. Usually, the materials are rigid and having higher weight compared to temporary structures. They are fixed to the ground. The reuse of the materials is only partially possible.

Sometimes you can retrieve some wooden frames from the windows, or maybe some iron rods from the castings, or a few bricks from the walls. These examples are of the permanent structures like offices, institutions, schools, colleges, hospitals, etc., i.e., the buildings where we as architects usually confine or need to study.

So, brick, concrete, stone, wood, steel, aluminium, glass, plastics- these are mostly the materials used for building such permanent structures, and we will concentrate mainly on these items.

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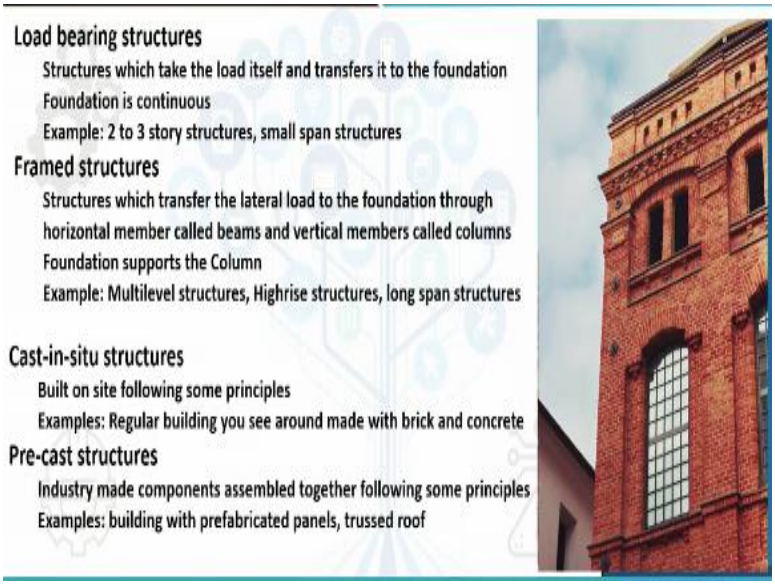

Now again, we come to another aspect. Amongst the permanent structures, we have load-bearing structures where we see a picture on your right-hand side. The load is taken by the entire building. You can see it is made of brick. The building is not so high, and the foundation in such kinds of buildings is a ‘continuous’ foundation. Also, look at the region at the top of the windows (where usually a concrete beam or a ‘lintel’ is seen in modern buildings).

Here, you see, it is also made of brick. This is a load-bearing structure where the bricks are taking the load of the building and is transferring it to the foundation directly. Here, you need a continuous foundation, and this can be two to three-story high and spans are not so vast. A ‘span’ implies the region from one support (or end) of the building to the next support.

Between the two supporting walls, the slab or the floor plate rests, and its span is not very large.

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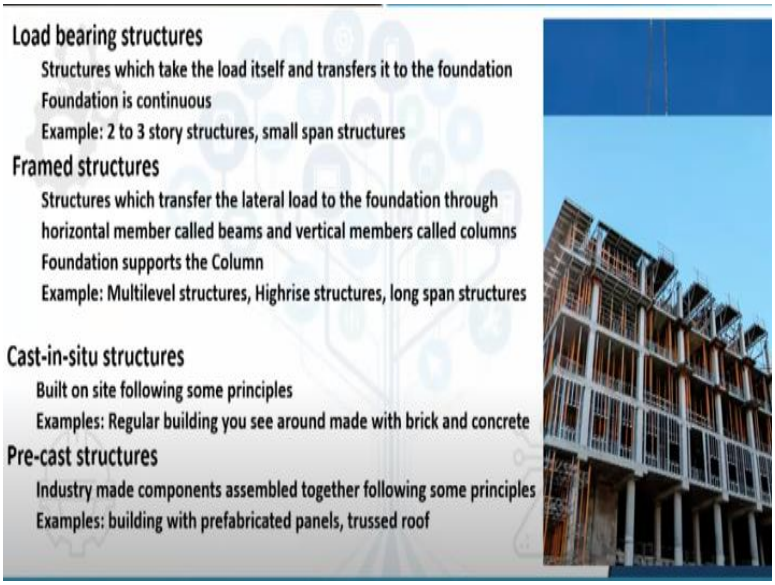

Let us move on to the 'framed' structures, where loads are transferred to the foundation through beams and columns. Here you can see, in the picture, the columns and the beams are visible. Some supporting structures (orange color rods) are present here. These are intended to support the floor because the casting is currently being done, and between these columns and beams, there is no wall at present.

So, these columns and beams transfer the load to the foundation. The foundation is holding or supporting individual columns. Now, this foundation may be made 'continuous' when the columns are very close. There are various types of foundations that we will not discuss in detail because they are beyond the scope of the course.

So, if you want to construct high-rise buildings, multi-level, or large-span structures, you have to adapt such frame structures. Another concept is 'cast-in-situ' structures. Here, the primary two items- the load-bearing structure as well as the frame structure, both are cast *in-situ*, meaning that they are constructed on-site following the principles of construction, such as any regular building you will find in cities or towns- made of brick and concrete.

The concrete is cast and is supported for setting, as you can see, with props (the orange-colored rods). We will go into the details later. These structures are all cast *in-situ*. We have another kind of structure, which is 'pre-cast' structure.

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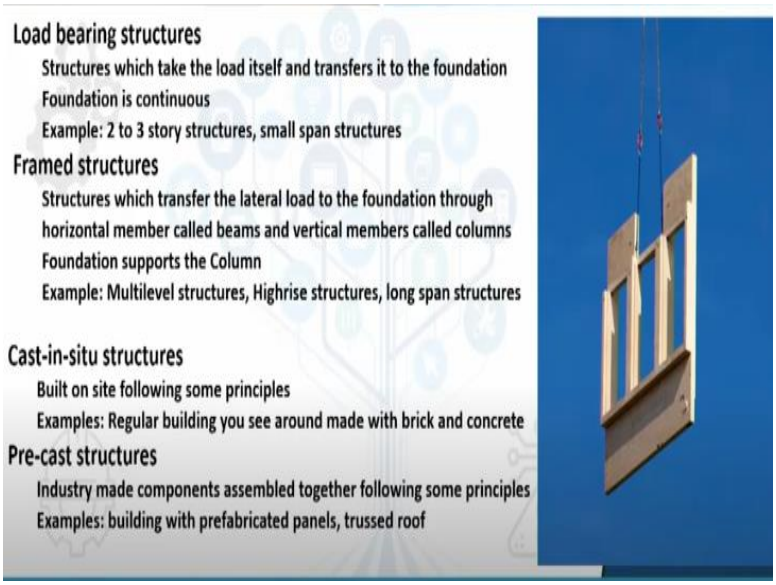

In the picture here, you can see that an entire wall is being placed on-site with the help of a crane. It will go and fit into some designed space or slot. So, it is a precast structure. But, in case of brick walls, you cannot pick it up with a crane in this manner, and carry it to the site for fitting in a particular slot. In the picture shown, the entire thing is pre-cast, or industry made, following some given specification, using appropriate materials. In these, you may see gaps or holes already created in the wall.

So, these may be window locations, or door location, or whatever that was pre-planned. Based on that planning, the item has been fabricated on an industrial setup, and it has been brought to the site by some mechanism, and now it is being put up by means of a crane to bring it to the designated position. Now, here you can understand it is very much weighty, and it has to be operated with the help of a machine (crane).

You cannot transport it using human labor. For a trussed roof, you need a large span. A large span means implies that space (gap) between two walls is large. Think of an auditorium or a cinema hall where you have been to. The edge (side) walls are quite far away from each other. There you need a trussed roof to support the load on top of the roof.

A trussed roof is a pre-cast item that sits on top of the roof. It may come in pieces. They are assembled together like the unit that you see. They will be placed one after the other and will fill in the gaps against a given framed structure. The reason why I am discussing these is to make you aware that if you go on reading the building

materials' topics one after the other, you may be indecisive while recommending appropriate materials to your clients depending upon the type of building.

So, when you are going to design a load-bearing structure, you have to remember the wall should be rigid enough to take the load of the wall itself. If you are planning a framed structure, you can make any glass façade of your choice. A framed structure will give you that advantage whereas, for load-bearing structure, you need to have adjacent brick after brick (or building block after block) so that the load gets adequately transferred to the base (or the foundation) very uniformly to avoid any building defect cropping up in future.

And other is the pre-cast structure where everything is pre-planned, every dimension needs to be perfect and you have to bring items which are made in the industry and they are placed into the slots. These are the implications why you need to know about the kind of structure you are going to build. You will be directed by your client when you will be practicing as an architect, and you have to understand what your client wants.

You will also need to know about the client's budget. Okay, we will come to that afterwards.

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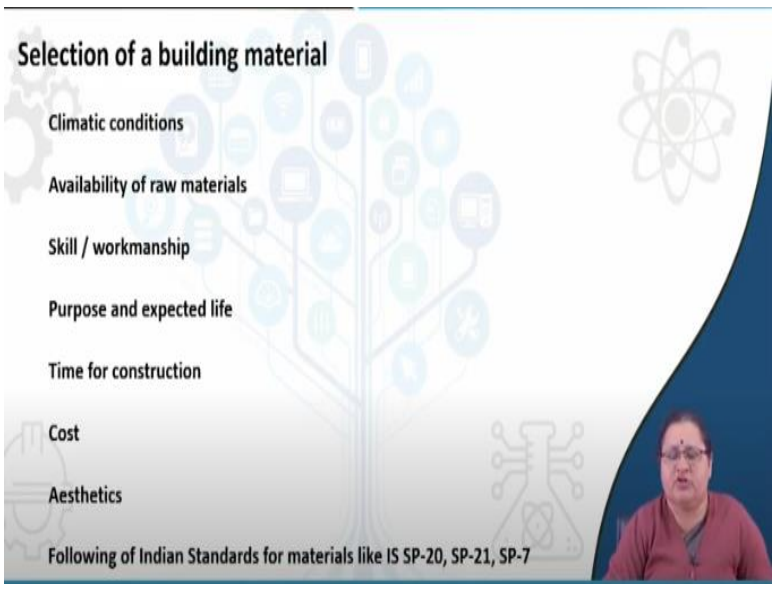

When you are selecting a building material, as we discussed in the section on building types, you must be aware of the kind of building that is going to be built . Mostly, you

will have to deal with cast-in-situ structures. If it is a small structure, it is usually a load-bearing structure. If it is a multi-level structure, it will be a frame structure. Also, here are the other aspects we need to know.

When we are sure about the kind of building that is going to be constructed, we have to look into the climatic condition. Information about the site location -where are you building this structure, is thus essential. It may be a rainy area, a desert area, or a snowy area. It may have a tropical climate (hot and humid). So, you have to look into what kind of weather or climate your building is going to face, the range of temperature difference it is going to face.

Every material will have expansion and contraction properties. You have to remember or take note of all the items. Because India is a tropical country, we may not require such details. But, if you are stepping out of the country and designing for, say, a middle-eastern city like Dubai, you have to consider the vast temperature difference during design.

Or else, if you went to Canada and practiced architecture, where it faces mostly subzero (around -20° C) temperatures, you will have to look into the expansion component of the building material also. Next is the availability of raw material. The availability of the raw material impacts one crucial factor in the list - in the end, it is the overall cost that gets reduced. So, if a material is locally available, then it automatically brings down the cost of construction.

Now, if you have a client who is willing to spend a lot, then you can always experiment with that component. For example, you can transport Makrana marble, and you can build something in the far-east regions of our country. So, depending on the spending ability (budget) of the client, you can look into the raw materials available.

You may go for more pricey materials, but mostly the primary building material should be as per the available raw material because the next factor is the availability of skill and workmanship. You need labor to construct your building. So, when we are talking of labor or skill or workmanship, you have to understand that the people of the

particular area (near your site) already possess the traditional knowledge of building by using that item.

We, in the plains, go for brick for our structures. Where there are stone quarries or mines are present, architects consider stone construction to make use of knowledge of local laborers. So, stone construction is something. In brick-based construction, skill is essential, because you cannot make a building using only one brick. You need to know how to bind the building material to form your desired structure.

The other component is time for construction. If you are asked to build something very quickly (that is, the delivery of the finished product has to be done in a short time), you may even choose pre-cast items, because that is already made; so you can just purchase and transport it to your site, and assemble it- to achieve a short time construction.

Some pre-cast items which are available in the market, you have to buy multiples of that dimension to comply with your building plan, and then you deliver a fast construction. Even though that gives you some restrictions to your thought process (or your design process), you can achieve something within the client's given time limit. Now, obviously, the last point here is aesthetics.

To every architect, no two buildings look the same. Aesthetically, the exact selection of the material you are making is very important. Remember that the 'material', which I am talking of here, does not necessarily mean brick or stone or concrete or wood- it may be color or texture, it may be construction technique, which gives you a different aesthetical meaning to the building.

Different color compositions of the same building can make it more aesthetically pleasing. Different texture within a surface or just a different kind of color composition with texture can give a different feeling to the client or the viewer. So, when we are concentrating only on the usage of the building material, we have to look into all these aspects.

Aesthetics is the final product- which is what we (or the viewer) actually sees. Now we will come to a crucial point- the necessity of following standards or codes for materials. When you (as an architect) are recommending a building material, be it brick, concrete, steel, wood, or glass, you have to follow the standards. You have to suggest from among those materials which are acknowledged by the regulating organization.

Because in case a building fails, the material will be responsible for it. The building material is taking the load- so if the material is not time tested, or if the specifications are not followed- the building might collapse, maybe not in one day, but in a stipulated period of time, and the architect will be legally responsible. Thus you (as an architect) have to be careful with your decisions from the first stage of the project.

You always have to recommend items that are acknowledged and considered as building materials by the Indian standards for materials. Apart from this, there are also risks of fire. Your building may be involved in a fire incident where the inhabitants need to be evacuated. Thus your building must be capable of withstanding the fire for a considerable period of time.

When certain materials comply with the Indian standards, it falls within the recommended list. Exploration or experimentation with different materials is okay, but when you are in a profession where you have to recommend a material, it should be supported by the Indian standards.

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Next, the material properties are also an essential factor for several reasons. First is the physical property- that is, the appearance. You must be knowing the color of clay brick. Also, I am sure that you know that the color of the concrete is gray. Now, the color of the brick becomes red when it is made of clay. Also, the texture is important- you can feel an item and identify it.

The dimension also is a physical property of a material and the form. Certain items are such that you cannot see, but you can feel. If you lift a brick, you can comprehend its weight. You can distinguish that is whether it is a lightweight or a heavyweight material. Usually, when it has a higher density, we think that it is a homogeneous material. But in the context of building materials, we always refer to the "bulk density", because materials are porous in nature.

It has air inside it, and so we always refer to or mention the 'bulk density' of it. Next is porosity, which is the volume of pores within the material- that changes the concept of density to bulk density. The next is permeability- that is the capability to allow fluid to pass through. Stone is very much hard. It does not allow water to move through it, whereas a brick allows. But if the stone has cracks in between, water will permeate through it.

As you know, permeability is the capacity of a material to allow fluid to pass through. Again, we need to know the mechanical properties of the material, that is, its behavior under the application of force- say compressive force, tensile force (for example, steel

can withstand tension, stones can withstand compression), brittleness of an item (for example, glass is fragile).

Other mechanical properties are the toughness of the item, hardness, creep. and deformity. When subjected to a particular load for a long time, a material may ‘creep’ (get deformed). It happens in the case of plastics- fatigue and failure. If you keep on subjecting an item to pressure, or force, it may not react all the time. It may not come back to its original form; instead, it may break or fail. So, you have to know the mechanical property of the material too when you are recommending it since you know the kind of forces it may be subjected to.

The next property is Chemical property. It is usually the atmosphere to which our building is exposed. If you keep an iron product outside, it will inevitably rust. If you are not protecting it appropriately, it will rust faster. There are two types of situations- one is the atmospheric action onto the building, and the other is the environment where it is. Say in a chemical laboratory, there are lots of acid fumes, and the items have to face ranges of temperature differences.

So, there the selection of the materials should be such that the items should not get corroded by acid or other chemicals. Concrete gets withered away by petroleum. Thus, in a parking lot, the concrete grade and concrete type should be carefully decided. Then comes the thermal property (heat transmission or the heat-resisting capacity). If the site has a hot climate, the internal (room) temperature should be maintained, and the warm air outside should not be allowed inside.

So, you need resistance to this heat flow. Insulating materials are working wonders for countries- which for example, in Canada. Buildings in all cold countries have thick insulation to disallow the internal heat to escape. Similarly, in hot countries, you will require to maintain the inner cold temperature, and not let the cold air to escape outside. So, your building material should take these into account.

So, whenever you are considering the climate, one crucial issue is the thermal component and also acoustics. Say, you are building a hospital- if you make wide windows- if you install single pane glass, it will allow the sound to enter, but if you

put double-paned glass, the properties will be different. If you are inside an auditorium, you need to avoid the outside noise from coming inside. There you need to have acoustical treatment.

We also have an optical property of materials where transmission of light can be controlled. For example, you may have clear glass to allow full light. You may choose tinted glass- so the glass can be chosen depending on requirement- you may want complete darkness (where opaque items will be should be recommended on such walls). Suppose, you want to guard your room from the hot western sun, so you have to build a solid wall. In that case, you would not consider a window over there. This is what is optical property is about. Glass is used glass, and there are wide variations of glass.

The electrical property is where the flow of the electric current is also to be considered. So, now, you understand these material properties- they are to be considered or thought about carefully when we are you are recommending a particular material for a purpose- that is, making a building.

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The next topics are about material composition and the role of ingredients, material making (how they are made), material types (for example, different types of bricks. Stones also have several varieties), material assembling (the method of joining the

materials to make your building), material defects (since the materials may be defective, and you must be able to identify the defects and their types).

The other topics are- Material use (suggestion of material depending on the specific requirement), alternate materials (which have replaced the conventional or the traditional materials). At the very beginning, I told you that we would learn about clay and clay materials in this module. We will also study the alternate items- that is, fly-ash brick, compressed stabilized earth block, compressed stabilized blocks, and we will try to know the advantages, disadvantages of these. Do remember that we also need to see whether they are included in our Indian standards' or not.

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Now, let us talk about the references for this module. I have given you the names of three books (see the slide), which you may refer to. In the next lecture, we will enter into the details of the materials. We will go into clay products where we will start with bricks directly, and then move on to the tiles. We will also discuss alternate clay materials. We will also discuss the assembling procedure of these materials, the properties (how to identify the type of brick from its appearance and properties), and the applications of it.

Next, we will move to stone. So, when we have covered these two basic materials, then we will proceed as per our schedule. Thank you for today.