**Course Name: Architectural Approaches to Decarbonization of Buildings**

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**Lecture 01**

Basics of Embodied and Operational Carbon- Part 2

Hello all. So, in our last class We had seen some of the principles of embodied energy and embodied carbon and how our choices of building material can make a very important and major difference to the GHG emissions. Now, in this lecture, we will look at some of India's framework for tackling embodied carbon. Now, there are a number of current and planned policy measures that India wants to take. But before that let us look at the basis or the reason for why India wants to look at this. So, India has launched the National Hydrogen Mission in 2021.

which is expected to spearhead India towards the status of becoming a hydrogen exporter in the world. Though India was the net exporter of crude oil, it will become the exporter of green hydrogen. One of the biggest advantages of green hydrogen is that it reduces the emission of carbon dioxide into the atmosphere, thus contributing to reducing greenhouse effect. But the background or the reason for this initiatives of the government of India is that as I had already said in the previous classes, the 2015 Paris Agreement aims to limit global warming to 2 degree centigrade above pre-industrial revolution levels.

It is negotiated by 197 states and signed by 191 countries to intensify actions and funds for a sustainable low carbon future. So what are India's plans? In order to limit global warming to 2 degree centigrade above pre-industrial revolution levels, India plans to reduce emission intensity by at least 33% by 2030 and to generate at least 40% of electricity from non-fossil fuel sources by 2030. It also plans to create an additional carbon sink of about 2.5 billion to 3 billion tons. In order to do all of these, in order to achieve these, India has taken several initiatives.

One initiative is the green hydrogen initiative. India has also come out with ethanol blending targets. India has enumerated that it would achieve 20% ethanol blending with petroleum by 2025. Additionally, India has also laid much importance about carbon storage and capturing to remove greenhouse gas before they enter the atmosphere. India is planning large-scale interventions in five sectors.

Energy and electricity, transport, urban design, industries and forestry. Having said that, India is currently and in the near future planning certain policy measures with respect to buildings. And they are the National Building Code of India 2016 which is coming out with the ECBC Code, Energy Conservation Building Code which is a voluntary code. Next is Eco Samhita which is also a voluntary code. Star rating of commercial buildings.

Green rating of integrated habitat assessment also called as GRIHA. Initiatives of the Ministry of Housing and Urban Affairs. The National Mission on Sustainable Habitat. the green credit program and retrofitting existing buildings. So, these are some of the framework or these are some of the policy measures that India is working very hard on.

So, first we will look at the ECBC which is Energy Conservation Building Code. Now, ECBC or energy conservation building code compliant, it shall demonstrate compliance by adopting the mandatory and prescriptive requirements under the ECBC compliant building requirements by following the provisions of the whole building performance method. The ECBC code plus It shall demonstrate compliance by adopting the mandatory and prescriptive requirements listed under ECBC compliant requirements or by following the provisions of the whole building performance method. There is also something called as super ECBC, but all these codes are currently only prescriptive and not mandatory. And these are applicable to buildings or building complexes that have a connected load of 100 kilowatt or greater or a contract demand of 120 kVA or greater and are intended to be used for commercial purposes.

Buildings intended for private residential purposes only are not covered by the code. Next is the Eco-Nivas Samhita Code. The Eco Niva Samhita Code is again an energy conservation building code for residential buildings. Any effort to achieve India's target is contingent upon the increase in efficiency of energy use across all sectors, especially in the building sector. The building sector in India consumes over 30% of the total electricity consumed in the country annually and is second only to the industrial sector.

With nearly two-third of the built infrastructure yet to come up till 2050, the nation calls for advancement and innovation in the construction sector. Out of the total electricity consumed in the building sector, about 75% is used in residential buildings and also energy intensive buildings. And this demand is bound to keep on increasing, especially in the urban areas. In this current and anticipated rapid growth in the residential building stock across India and the consequent opportunities as well as the necessity for energy conservation in this sector, The ECBC for residential buildings also called as Eco-Nivas Samhita was launched by the Ministry of Power to set minimum building envelope performance requirements to limit heat gains. So, if you limit heat gain then the load for

active cooling gets reduced and that is the intention of this code which focuses primarily on say natural ventilation and daylight potential.

And if you look at know India's stand You can see that eco-nivas samhita has been their priority for quite some time. And this has been prepared to set minimum building envelope performance standard. Because of the decreasing load on the active means of cooling a building, the load on electricity consumption also comes down. The part 1 building envelope of Eco Niva Samhita is designed in a simple to apply format and it requires only simple calculations based on inputs from the architectural design drawings of buildings. This can be used by architects and engineers and it will not require any simulation software.

The reason or why this has even come up is that among various reasons increased use of decentralized room based air conditioning units has been increasing in houses. Whether we call it as split units or window units. In the residential sector there has been a rapid demand for these contraptions. The demand for air conditioning will continue in exponential growth with improvements in household income and this will become the dominant contributor of greenhouse gas emissions. So, along the entire nation if this happens then there is going to be a tremendous impact on the GHG emissions and therefore there is the situation can get alarming.

In order to have a tab on this Econivas Samhita has come out. So, because such a situation could call for an immediate action and also because the government is committed to lowering GHG standards the Econivas Samhita has come. And it has become now a necessity for energy conservation in the residential sector and energy conservation code for residential building had to be established by the Ministry of Power which is called as Econivas Samhita. There are other initiatives also taken by the government of India like GRIHA and Green Building Rating System and many others. Some of these we will discuss briefly.

So, coming back to Eco-Nivas Samhita. This code is applicable to residential buildings built on a plot of greater than or equal to 500 meter square. The residential part of mixed land use building projects built on a plot area of more than 500 meter square. This code is also applicable for all additions made to existing residential buildings where the existing building exceeds the threshold. Having said the Eco-Nivas Samhita gives certain guidelines or annexures for how much embodied energy is quantified in various building materials or products.

So you can see the embodied energy of sheet glass is highest in the list that is given and it gets reduced you can look at each one and then you can see that crushed aggregate and

brick dust have the least embodied energy. Decisions on building material use can be taken based on the quantity that is needed and the material that is chosen. Because, embodied energy in construction in India, especially in formal residential buildings of the sort that are covered under the EcoNivas Samhita Code can sometimes be of the order of magnitude of huge amount of energy use including operating energy use and therefore is very significant to consider when such a code is being developed. However, this was true for non-air conditioned housing stock and it seems likely that like in the developed economies increasing consumption of operating energy due to appliances or common area services or air conditioning etc., may cause the embodied energy to become less significant compared to operating energy.

Still this is an important area to include in the code because even though operating energy increases and stays for 50 years, the decisions of embodied energy also affect greenhouse gas emissions. It is not only about energy, it is also about the GHG. Cement and steel are the major contributors of embodied energy in residential building construction in India. Especially when you consider the combination of their embodied energy and the quantity of the material that is used in buildings. According to the study conducted in Jadavpur University, 98 percent of embodied energy is attributed to the embodied energy of the materials used and two percent of the contribution to actual erection of the building.

Unfortunately embodied energy is often hidden in the industry for the manufacturer and the transport of materials and the transportation of workers. It proposes that embodied energy and operating energy can be combined. In order to combine the capital embodied energy with the operating energy it is necessary to merge the two in equivalent units of a single number that can represent the energy performance of the project. Although, according to the study conducted by Jadavpur University, 98% of the embodied energy is attributed to embodied energy of the material used and 2% is the contribution of the actual erection of the building. It is important to look at the seemingly trivial 2% for the reason that, that there can be a lot of energy wasted and emission and pollution created by bad site practices and also because better site practices can lead to better building and saves cost for the builder- thereby, ultimately resulting in more affordable construction.

So, from this what we can learn is, even though 98 percent (approximately 98 percent) of embodied energy occur before the product comes on site and 2 percent is for the erection. That is because we do not consider the energy of manual labor, because it is supposed to be a renewable energy. Also we need to consider embodied energy per unit of the material into the quantity of the material. So, even though the material may not have very high embodied energy if the quantity of the material is more in a building the total embodied energy is going to be extremely high. So, we have to be careful To use low

embodied energy materials for the materials which are very large in number, which are voluminous in number, we must use a material which has low embodied energy.

Next, we move on to another building code which is again a result of the government's initiative to reduce GHG emission and it is called as GRIHA. Some of the benefits of green design to a building whole owner user and the society as a whole can be It can give reduced energy consumption without sacrificing comfort levels. Reduced destruction of natural areas, habitats and biodiversity and reduced soil loss from erosion can happen. Reduced air and water pollution with direct health benefits.

Reduced water consumption. Limited waste generation due to recycling and reuse and reduced pollution loads. Increase user productivity and enhanced image and markability. Now green building is a very important part of sustainable architecture. These buildings are environment friendly and sustain for longer period of time in comparison to the conventional buildings. The cost of these buildings may be high at the first place but on a long run they are much cheaper.

For designing any green building an architect must be aware of its scientific aspects. GRIHA or Green Building Rating System in India is an acronym for Green Rating for Integrated Habitat Assessment. Now this has come with the intention to give guidelines on how to design buildings which are energy efficient, sustainable and environment friendly. Throughout the life cycles, right from construction to operation and then demolition, Buildings consume resources in the form of energy, water, building materials and they give out a lot of waste either directly in the form of solid municipal solid waste or liquid waste or indirectly as emissions from electricity generation. Griha attempts to minimize a building's resource consumption waste generation and overall ecological impact to within certain acceptable limits or benchmarks.

So, in Griha what has to be done is first we need to measure what we are either consuming or we are generating in the form of waste and it believes that only what you can measure you can manage. So Griha attempts to quantify aspects such as energy consumption, waste generation, renewable energy and many other things so as to manage, control and reduce the same to the best possible extent. It's a rating tool which helps people assess the performance of their building against certain nationally acceptable benchmark. It evaluates the environmental performance of a building holistically over the entire life cycle and thus provides a definitive standard for what constitutes a green building. The rating system based on accepted energy and environmental principle will seek to strike a balance between the established practices and emerging concepts both nationally and internationally.

There are many benefits of following green building which we have already seen, which are already enlisted and we have already seen them. Now there are many criteria in GRIHA based on which the building is assessed and based on which the building is evaluated and marked. So the first criteria is a sustainable site planning. Under sustainable site planning, the criteria against which a building is evaluated is green infrastructure, green infrastructure, low impact design. How low impact and low key is your design? Design to mitigate urban heat island effect.

Having said that construction management under the section construction management there are various criteria and the criteria are air and soil pollution control, Soil preserve topsoil conservation, why is topsoil conservation important? Because topsoil is one of the most fertile soils. And it is very important that we do not use the topsoil for a landfill or it is not dumped anywhere because it is a fertile soil because of the organic compounds available leaf and decayed leaf and things like that. That topsoil must be reused. So, normally what they do is people who are aspiring for a green building certification will preserve the topsoil and reuse it for landscaping. Normally in other buildings what they do is they use the topsoil as a filler, they fill it which is not the correct way to do.

What are the construction management practices? Energy efficiency, if you see energy optimization gets maximum point, it gets 12 points. Then under energy efficiency you also have use of renewable energy utilization. So, both these put together is 17 points which is a large number. Then use of low ODP and GWP materials, materials which give out which are low in volatile products that is one.

Occupant comfort is very important. It gives important to visual, thermal and acoustic comfort, maintaining good indoor air quality and hence you can see under energy total marks is 18. which is a substantial percentage. Water comfort, water demand reduction, wastewater treatment and rainwater management along with water quality and self-sufficiency gains important. Solid waste management, waste management post occupancy, organic waste treatment on site so that you don't dump the waste of your building outside. Utilization of alternative materials in building, this comes under sustainable building materials.

So, if you see the sustainable building materials part, that comprises utilization of alternative materials in building. Alternative materials will be materials which are low carbon. Then you have reduction in GWP through life cycle assessment, global warming potential. Need to have materials which have low global warming potential. Alternate materials for external site development.

So, use of materials which are low on embodied energy. So, this comes to 12 points. So,

if you see by now, use of low low carbon energy low embodied carbon energy materials comes to 30 percent under griha the form of various criteria. Life cycle cost analysis must be done. Socio-economic strategies include safety and sanitation for construction workers, universal accessibility, dedicated facilities for service staff and a positive social impact workspace, construction workplace.

There are other things like performance metering and monitoring out of which operation and maintenance protocols, smart metering and monitoring, commissioning for final rating is available. If you see innovation again has 5 points. Sometimes you can use innovation to reduce the energy, embodied carbon and embodied energy. Even without that a total of 30 marks goes for innovation. It is given for anything to do with low embodied energy or low embodied carbon.

So, GRIHA which is an indigenous Indian rating, green building rating criteria gives a lot of importance to low embodied energy use. Now, despite low per capita annual emission of 1.8 tons of carbon dioxide equivalent as against that of US which is 14.7 and China which is 7.6 carbon dioxide equivalent, India is the third largest emitting country globally in terms of total national emissions.

Therefore, to avoid the worst effects of climate change, India will need to play an important role. India is currently one of the fastest growing economies in the world and it is home to almost one-sixth of the global population and its pace of economic growth is an integral part of global development. India's development agenda faces several challenges including climate change. India is committed to mitigating climate change by ensuring that economic growth and social developments follow pathways that reach net zero emissions by 2070 as announced in 2021 at COP26. India's long term low carbon development strategy is very very important to India and the world.

But India's real carbon saving potential lies in the assets that are yet to be built. There is a huge demand for buildings as a growing country, as a developing country, as a country of young people. There is a huge demand for buildings that are yet to be built. This is a great opportunity and challenge for us to establish low carbon buildings in the buildings that are to come. Estimates suggest that 70% of India's 2030 urban infrastructure consisting of drinking water facility or sanitation, sewage system, electricity, gas distribution, urban transport and primary health services is yet to be built.

This highlights the need to minimize the associated embodied carbon. Currently, Governments and private stakeholders are largely focused on reducing operational carbon emissions. While in comparison, embodied carbon remains more challenging to track, record and report. Across the life cycle of a project, typically 50-70% of the total

embodied carbon is emitted before completion. Of this, 85 to 90 percent of embodied upfront emissions are during the manufacturing stage.

7 to 10 percent during transportation and 3 to 5 percent during construction stage. In August 2022, India had updated the NDC to reach net zero emissions by 2070, committing to meeting 50% of India's cumulative electric power installed capacity from non-fossil fuel based sources by 2030 and reducing GDP carbon intensity by 45% below 2005 levels by the year 2030. Having said this, the commitment and the pressure that India has to reach net zero emissions is high and it is imperative that the building sector acts immediately to ensure that we meet the targets. Indian government on one side has already initiated a number of schemes and plans. We can see that India has planned for many voluntary schemes by which architects and designers have a choice to decide on low embodied building materials, low carbon emitting building materials.

The environment right now,- research environment, research ecology /environment everything is very conducive to research innovation, startups and hubs. And therefore, the stakeholders such as clients, architects, designers, building contractors, builders must be willing to accept and adopt new building materials and new construction techniques, which are low on embodied carbon and low on embodied energy. So, if we are able to do some of this then I am sure we will be able to achieve our targets. So, I rest my class now and we will continue with the same topic with an another dimension in the forthcoming class. Meanwhile, it will be good if you look up into the various non-mandatory voluntary building codes that many organizations are working across the country to ensure that architects use low embedded building materials and low carbon building materials. Thank you.