Course Name: Architectural Approaches to Decarbonization of Buildings

Professor: Dr. Iyer Vijayalaxmi Kasinath

Department of Architecture,

School of Planning and Architecture, Vijayawada

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Lecture 03

Strategies to reduce Embodied Carbon through Design and Development

So, last class we had seen some of the strategies for low embodied carbon and we will continue with strategies for low embodied carbon even in this class. So, the next strategy is one for one material substitution. Now material replacement and specification- it naturally occurs later in the design process when the project is more defined. So, substituting and specifying low embodied carbon materials alone can have a very important impact. It is a very significant impact, it can have on the embodied carbon of a construction or even a renovation project. For insulation products, this includes their thermal properties like R value as well as their form factors like blown product or rigid board or bat and other performance qualities whether they also provide an air barrier or resist fire or repel pests.

Pest repellent is an important criteria. Another example - we can specify carpet tile rather than broad loom or sheet carpets to reduce installation and maintenance waste. Because broad loom carpet typically generates 10 to 20 percent installation waste and cannot be easily repaired if damaged in one particular section. So, if you have one large carpet, then if there is a damage, then you have to remove the entire carpet.

Whereas, if you have carpet tiles, then it can result in 1 to 5 percent installation waste as against 10 to 20 percent installation waste in the broad loom carpets. And the useful life of the floor can also be extended with selective tile by tile replacement for damaged sections. So, specify carpet tile to minimize waste and waste associated emissions such as landfill emissions and emissions associated with the production of a new or replacement material. So, these are all very important decisions and they have a direct impact on the embodied carbon because If in one particular place there is a damage then imagine the entire element to be replaced or only that section to be replaced. It's the same with even facade.

So if you have large panels on the facade and if there is a damage to even one part then you will have to replace a large section of that facade. So, you need to look at these from a designer's point of view. Again another example we can think of is, say when you choose cellulose as a insulating material instead of petroleum based insulation like for example expanded polystyrene. Now you achieve the same function- you satisfy the same functional need which is insulation. But dramatically you will reduce the embodied carbon of the overall project.

So, you should now remember that slide I had shown two or three classes before where I had shown you the embodied carbon versus sequestered carbon of so many of the insulating materials and how we had classified them as high carbon, mid carbon and low carbon materials. And some even being carbon negative. So, choose that, because that slide was for achieving the same U value. So, for achieving the same functional end, the choice of building material matters. So, substitute one material for another carbon negative or at least low carbon material to achieve the same impact that you want.

In some cases, insulation products can lead to even near zero or net negative carbon emissions because it has sequestered carbon. If you remember cork, it has sequestered carbon. And therefore, just the choice of using that material can not only give you near zero, but it can give you net negative carbon emissions. So, key considerations when considering two material, it is important to consider that first is functional performance, whether it satisfies and does the same function. If it is insulation, does it insulate to the same extent? Its thermal properties, so how is its thermal property? Its form factors, and its performance quality because what happens is you also need to look at its maintenance.

When I say performance qualities, it is not necessarily from thermal performance point of view, but point of view of maintenance. Sometimes it becomes very cumbersome and difficult for us to keep replacing that particular material. just because it's low embodied energy, you use it and then it becomes cumbersome. What will happen is, over a period of time, you will be so fed up that you will end up putting another conventional material which will be high embodied carbon. So make correct decisions when you have one for one material substitution.

For every material you choose, explore other options which are low embodied carbon, low embodied energy, to give the same thermal performance impact or to give the same functional effect. So, these changes can include lowering the ratio of say I am taking another example. Suppose you take cement then your choice to lower portland cement incorporating supplementary cementitious material or using aggregate that will result in lowering the total embodied carbon. So, the key considerations you should follow in this is, for a given material choice the design team can use open source tools like how we had seen- what are open source tools of life cycle analysis or any other databases. You can use any other databases also to identify the lower carbon cost comparable option for their project.

Some suppliers may not have environmental product declaration. So, the data that has to be displayed on the product, which shows how much it has renewable material in it for us to gauge its embodied carbon or embodied emissions. Not all products will have that kind of a environmental product declaration. Now, under such displaying the embodied carbon content of the material to prove it has low embodied carbon content then standard practices may not be available. A designer can specify a desired percentage reduction of global warming potential in a given concrete mix.

To meet this demand, the manufacturer will have to incorporate the changes. So, the manufacturer works backwards and then get a concrete mix design that reduces embodied carbon while meeting the necessary strength requirements. Now, let us look at another impact. Cement often drives the embodied carbon of a given concrete mix and lowering its content will reduce the carbon impact of the project. Under these conditions what consideration should you have? You must reduce portland cement content because this will lead to noticeable changes in process such as longer cure times for a given concrete mix.

Some suppliers may not have this environmental product declarations and these data limitations are expected to improve as you as an architect and the client start demanding this from the suppliers/the manufacturers because you have to prove that you have become aware of low embodied carbon materials. And given a choice, you would want to select those. So, you need those specifications on the material product. Next, this is very interesting. So, we now look at the comprehensive strategies to reduce embodied carbon throughout the design and development process.

So, first is look at the primary roles of people. You have the architect here, the contractor, the manufacturer, the owner, the structural engineer, the geotechnical engineer, the landscape architect and so on. In the pre-design and site selection stage, One needs to consider reusing an existing building before deciding to design a new building. Who has to do that? It is the owner and the architect. The owner and the architect has to decide that.

Then assess soil type and determine options for the building's foundation. Because some types of foundation use greater quantities of materials than others. Who has to do that? Geotechnical engineer, the structural engineer and the architect. Consider salvaging or reusing materials from a building that is to be deconstructed. Architect has to do that in consultation with the client.

So, client has to consent to it. Set an embodied carbon target for the project based on

LCA calculations for similar buildings or case studies. Who has to set the embodied carbon budget or target? That has to be the owner in consensus with the architect. This happens at a pre-design or site selection stage. When we look at the conceptual or schematic stage, one needs to ensure structural systems are compact, efficient and not oversized.

As I said, optimization is important. Optimization in terms of its function as well as its structural characteristics. That has to be done by the architect and the structural engineer. Design flexible and efficient spaces that allow for long-term changes to use. This I gave you an example of what happened during COVID times and we call these as adaptable spaces.

Now who does that? It is the role of an architect. Design for future disassembly and reuse. Again adaptable. This is done by architect to give adaptable spaces. Consider the embodied carbon trade-offs related to architectural design decision such as massing, envelope system, foundations and landscaping.

I call these as simple passive strategies. simple passive strategies. So who has to do that? It is the role of the architect along with the landscape architect and the structural engineer. Conduct an initial whole building LCA or perform an LCA for hot spot materials or assemblies with high carbon intensity- assemblies with high carbon intensities. What we mean to say is take the first step to understand.

So, you make the first move that has to be done by the architect to have a LCA and at least look at building components or domains which are high carbon intensity. Select building systems and assemblies that minimize embodied carbon. This has to be done by the architect. Assess the availability of local reused and locally sourced materials. Architect's role but in this very important client's consent.

Client has to consent and he should be happily able to embrace using a recycled product. And almost until here is called as whole building design which is what we have been seeing so far. Little of this is specify material characteristics that results in low embodied carbon. So, building specification, again building specification has to be done by the architect, but again here we need to take the owner into confidence. Substitute materials that offer lower global warming potential.

We just discussed one to one substitution. So, this also has to be done by the architect. Consider the embodied carbon trade-offs related to architectural and structural refinements and changes and be aware of the repercussions of your decisions. All these comes in the design development and construction document where you clearly say, by virtue of substituting A material with B. We had already seen the example of a high carbon building, a low carbon building and a net zero carbon building, a cement based building, a timber based building and a bamboo based building respectively.

Document each of this so that you have quantitative information. Update WB life cycle assessment as needed. Whole building life cycle assessment must be updated as needed so that you understand the repercussions of your design decisions and your material selection decisions. Then when it comes to bidding and procurement or construction data, construction stage, we won't go much into that stage because till here whatever decisions are taken at the pre-design and site selections. Then second is conceptual and schematic design.

And third is design development and construction document. These three stages are very very crucial for you to take design decisions that will aid in lowering the embodied energy. Stages after that like bidding and procurement or construction is more about seeing how whatever your design decisions are, how they are carried forward and how they are implemented and so on. These three stages the architect's role is very crucial in even trying to convince the client. In bidding and procurement it is more about conveying your clear goals related to embodied carbon and getting the data of say EPDs.

from the bidders to ensure that during the construction phase what happens is actually low carbon only. And construction again you need to be very clear that you document the as built embodied carbon of the building and you need to publish the data and make it public. Occupancy, maintenance, renovation, tenant fit outs all these are for the future after the building is constructed and is more on documenting so that we know what we can measure we can handle it better. So, these are the important strategies to reduce embodied carbon throughout the design and development process of the building.

Just a quick look at the current tools. as I had told you. So, a number of open source and subscription based tools are available to support low embodied carbon design and construction strategies. The Athena Sustainable Materials Institute is a non-profit research collaborative bringing life cycle assessment to the construction sector. Life cycle assessment is the science behind environmental footprinting. Athena Institute works with sustainability leaders in product manufacturing, building design, construction and green labelling programs to enable smaller footprints in the production and consumption of construction materials.

Another one is called as the embodied carbon in another tool for life cycle assessment is called as the embodied carbon in construction calculator EC3. It is an open source database that houses thousands of digitized third party verified environmental product declarations. And this tool is most useful in providing transparency of information and comparing the carbon impact of different product options across similar material types. One click LCA is another tool.

This subscription based product. And it integrates the building information modeling and an extensive database of material EPDs, environmental product declaration to produce a life cycle assessment in any design stage of a project. There is something called Tally also, which is another software. And in India, there is something called Edge. Edge is another one which is coming up. So, material selection strategies for low embodied carbon, they are crucial for achieving sustainability goals in the construction industry.

By considering the entire life cycle of materials and prioritizing those with low carbon footprints, construction projects can contribute to global effects to mitigate climate change. The conclusions drawn from such strategies often include environmental impact reduction, implementing material selection strategies for low embodied carbon. This can lead to substantial reduction in the environmental impact of construction projects contributing to overall sustainability goals. When it comes to cost saving, while some sustainable materials may initially be more expensive, The long-term benefits including energy efficiency and reduced operational costs often outweigh the upfront expenses. Reducing embodied carbon is an urgent and critical issue because the trajectory of embodied carbon emissions is not currently aligned with global climate targets.

Since 2010 as a global emission from building operations have decreased slightly constructions and emissions have actually increased by one and a half percent. So it is very important for us to do whatever it takes to ensure that our buildings are low carbon and zero carbon probably negative carbon negative buildings also. That is the only way for decarbonization and achieving net zero or regenerative buildings. So, industry innovations is very important Embracing sustainable practices encourages innovation in the construction industry, driving the development of new materials and technologies with even lower embodied carbon because you are only as good as the second best. So when there is heavy demand from designers, clients, contractors for low carbon material, only then will manufacturers get creative in offering such products.

So, the work done by architects and designers must push the construction industry to give us more carbon negative products. Reductions can go well beyond 50% by considering whole building design strategies. What are the whole building design strategies? The entire chart. These, these are the whole building design strategies. So if you do enough work in this domain, You can save up to 50% embodied carbon.

That is the power where you have to work meticulously with whole building design strategies incurring a higher cost premium or leveraging some of the advanced materials that are coming down due in the R&D pipeline. The technologies that enable low embodied carbon construction will continue to evolve and regional nuances will continue to influence the efficacy of individual products or solutions. But the design methods and considerations can be applied to any project today offering lasting solutions to eliminate and sequester carbon emissions in our buildings. In conclusion, material selection is a critical aspect of sustainable construction and strategies for low embodied carbon contribute to creating environmentally friendly and resilient built environments. Hence, it is our responsibility as architects to ensure that we work in tandem with the client and all other stakeholders during the whole building design phase which will result in low embodied carbon construction.

So, with this thought I will conclude this chapter, this class and we will meet in the next class with yet another section. Thank you.