**Advanced Topics in Science and Technology of Concrete**
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**Lecture - 20**

Now, let us spend a few minutes talking about construction and demolition waste. Construction and demolition waste also has its own supply chain, right? So, as you can see here, there is a building, okay, that building is coming down it is being demolished and so yeah, so you can see it being demolished here. All of this and you have all of this rubble, so you have the rubble is brought to a collection point, right. So, the rubble from various construction sites, etcetera, and then it is taken to a recycling plant, okay. From the recycling plant these things are crushed and processed, dried, you know whatever and finally, you know, become some kind of building material, right, could be stone, aggregate, whatever it is.

These building materials are then taken back to a construction site to build, right. So, this is also a supply chain, right, but it is a, it is an interesting supply chain because it is a circular supply chain. You started from the building and you ended up at the building, so it is a bit of a circular supply chain, but it is a supply chain nonetheless. All the issues that I talked about are important here, right. How will you manage the bullwhip effect in C&D supply chains, important question. How will you manage vendors, how will you ensure that this recycling plant is functioning at optimal capacity. What will your transportation and distribution strategy be and what will happen once the building reaches the end of its life, right. So, all of these are very important questions that you will have to answer, okay. For construction these are problems that we have to solve, okay.

Now, what happens if the supply chain is being, is not robust. Now, this is very important because construction demolition waste is a new concept. So, the construction and demolition waste supply chain is really very mature today, right. In many cases the demolished, the parts of the demolished building do not even make it to collection point, they go straight to landfill, okay. The recycling plants today are not necessarily very efficient.

There is not much demand for C&D waste and so your logistics are also very inefficient. Yes, you have a factory that produces a plant that produces some building material what do I do with it, right, how do I get it. So, it is not a very efficient supply chain. So, what happens

because of that is today it takes a long time to receive C&D waste based building materials and it probably costs a little bit more. In many places people have told us it is cheaper for me to buy new aggregate, right, rather than buy, you know, recycled aggregate.

Why is that so? Because the supply chain is new and immature, okay. So, you know at IIT Madras we recently built something called, you know used a technology called glass fibre reinforced buildings GFRG, right. And we use GFRG to build, you know, a building on campus. GFRG is this glass fibre reinforced gypsum comes in the form of panels. So, you get a bunch of prefabricated panels that come and of course the foundation is a regular foundation. But then you use the, you put the, you erect the panels of course you put some reinforcement and grouting in between the panels.

But then you connect them and you get your building, right. So, we actually built G plus 1 building in 27 days or 28 days or something like that, right, very quickly because it was prefabricated, okay. Now, when we look around and see okay you guys have demonstrated that you built a building in 27 days why is not everyone using it, right. Why do not we have so much low income housing to build Pradhan Mantri Awash Yojana you look at the data the data tells you that we should have built we are very well we are well behind in terms of what we need to build. So, why do not we use this kind of technology and build faster, right.

The reason that did not happen is because of the immaturity of the supply chain, okay. First of all there were very very few supplies in fact at one point there was only one supplier, right. Now when you have one supplier it is always a problem because if that person is not supplying properly you have nobody else to go to, right. So, they become what we call a monopoly, okay. They raise the prices they lower the efficiency, right.

So, this was a supplier and his factory also was not going at 100 percent you know efficiency as a result of which the supply of materials was very slow, okay. You also need for many of these you need trained manpower, right. In this case you need people who understood this technology to be able to erect it on site a general mason or a general labourer who is used to pouring concrete would not necessarily be able to do this. Similarly in a C&D waste recycling facility you need some specialized labour, right. In in in immature supply chains those labour are not available or they are available in small numbers and they therefore charge much higher rates, right.

So, it is difficult to get them and the overall product tends to be far more expense, okay. Third stage nobody likes to adopt innovation, okay people like tried and tested things. So, when we went and told a lot of people hey you will get a house in 27 days they looked at us and said oh no this seems to be some panel it is not very strong, right. We want reinforced concrete we want brick we want to be able to knock on it and get that comfort that this is a solid structure. Now nothing structurally wrong with GFRG just like we know that there is nothing structurally wrong with a C&D based building material whether it is an aggregate or whatever.

But there is a shortage of demand, right and because of the shortage of demand there is a shortage of supply, right and you can see this bullwhip effect you know picking up. So, there are no what we call economies of scale, right people are producing in low amounts. So, cost tend to be high because this is still a low volume business there is not enough trained manpower and because there is not enough of these examples people are reluctant to adopt this, okay. So, because of these reasons you see that this glass fibre reinforced gypsum technology although it is robust and although it has been tried out successfully in multiple areas has still not caught on. Construction and demolition waste is in the same boat, right it is in the same boat because we still do not have enough demand we also do not have enough supply and because of this the sector is not quite taking off it is a vicious cycle, right if I do not have more demand why will I have more supply, right if I do not have more supply cost will go up and there will be lesser demand, right.

So, you see this vicious cycle. So, how do you break out of this cycle one important measure is policy, okay and we have seen this being successful in several sectors, right at the top a policy is enacted which for instance says that you know so much of recycled C&D material must be used in a building or there is a policy that says if you use so much C&D waste in a building then you get this incentive, right you get this tax incentive or whatever it is. There is an incentive there is a policy that incentivizes the use of

C&D naturally demand will pick up if demand picks up there will be a business opportunity and therefore supply will pick up more entrepreneurs will come up who may set up construction and demolition waste plants might start improving the efficiency of the distribution and lowering the prices at which they supply materials and also if there is

competition, right that is also a wonderful way in which you lower prices. So, if there is a lot of demand and you have two or three of these suppliers then each of them are competing with each other and lowering prices, right. For instance we saw this in the telecom sector, right number of firms providing telecommunication services Airtel, Jio, Vodafone whatever and because there is competition prices have come down.

So, you and I it is very easy for us to get a phone plan, right whatever plan you want is very cheap, right because competition has brought down the prices okay. So, policy is going to be an important lever in terms of mainstreaming C&D supply chains today you do not see as much C&D being used on construction sites because of the supply chain, right and if through policy we can incentivize the use of C&D the supply chain will become far more robust and it will be far easier to use construction and demolition waste, right. So, this is one of the learnings hopefully that you take out of this session okay. So, in order to use you know C&D waste it is also important that you understand the economics, right because the economics are what drive costs and ultimately, right ultimately even though most of us tend to be engineers cost is what drives decision making, right. So, if you look at a C&D supply chain, right or a C&D you know the person who manufactures those building blocks, building materials, aggregates whatever what are their costs, right on the one hand they have capital costs, right they need to buy some land they need to set up a factory that manufactures, right you take raw materials and you manufacture.

So, there are some capital costs, right which to set up that factory and that land then they have to buy the raw material, okay. So, the raw material needs to be supplied and there are some costs associated with that, okay then they have to actually manufacture which they need electricity, they need water, they need manpower etcetera, right. So, those are operating expenses, right then I will just stop scale for a second then they have to actually then send it to somebody else then they will have to send it to somebody else. So, they have logistical costs, okay. So, these are all the costs that go in okay capital costs, raw material supply cost, operating cost, logistic cost.

Capital costs could be reduced perhaps through favourable policy that says if you are going to you know develop a C&D system then maybe I will supply you know you have to pay less tax on the land because you are actually doing something that you know promotes the environment. Raw material supply costs will come down if more and more people start you

know demanding this more and more people you know more and more buildings are demolished and the demolition supply chain starts becoming far more efficient. So, the moment we start scaling we get more and more people we start finding that we reduce the raw material supply cost. As you start building expertise your operations become more and more lean as there is more demand the your operations become more and more lean. So, in some sense the demand will help reduce operating expenses okay and if there is also high demand your logistic cost might also come up because there will be a lot of sites in the vicinity that will require this you need not necessarily transport large distances okay.

So, the economics of supply chains are critical to their being adopted if supply chains can organize themselves so that they produce something at low cost people will readily buy. Today the C&D waste supply chain is for reasons I have just mentioned not that optimal right there is you know manufacturing capability is low logistical costs are high demand is low and so the overall costs are high and people are not necessarily buying it. But as these chains develop as they become more and more mature like for instance the cement supply chain right cost will come down and people will buy it readily and in some sense policy which is enacted by government or policy that can be enacted by large developers saying I will only use C&D waste can catalyse this shift in supply chains right and that is going to be very critical okay. So, a big moral of today's session is that supply chains are critical to the functioning of any business construction and demolition waste supply chains exists but are not efficient and if this these can become more efficient there will be further adoption of construction and demolition waste in order for them to become more you know efficient they need to tackle the bullwhip effect manage their vendors better improve the efficiency of their manufacturing processes improve the efficiency of their logistics and work on the circularity of the supply chain right. And by doing all of these you know it is definitely you know very very possible that through policy intervention through improvements that organizations make that in the years to come we will see a very well functional supply chain.

But the point is that what happen automatically there needs to be some kind of a policy push for this to happen and then you will see a lot more use of C&D waste in at the actual construction sector today the actual use is miniscule. So, although there is a lot of discussion a lot of science and technology development that has been done the actual utilization is miniscule and hopefully through some of these ideas this will pick up okay. So, this is just a you know a map that I took from a thesis that a student of ours had recently published his

name is Ram where he looks at you know look at the number of waste collection points in a city like Chennai right. The logistics of going to each side collecting the waste bringing it I mean it is extremely challenging right and so this is one of the reasons why this has not yet picked up but over a period of time people will figure out you know hubs and spokes and how to actually collect and transfer waste okay. So, again you have things that are dumped you have to segregate it right.

So, you got to make sure that the reusable construction demolition waste actually comes whereas all the other debris you know maybe other kinds of waste are put away. So, segregation again is a challenge. So, if there is enough volume of people demanding this then it makes sense to invest in all of these processes logistics segregation etcetera right. But unless we can spur demand the supply chain will stay immature and we can spur demand and it is chicken and egg right. Today the costs are high so there is no demand and because there is no demand the cost remain high and that is where policy I think becomes a very very critical tool right.

If policy can mandate or incentivize greater use of C&D waste increase the demand for C&D waste the supply chain will become more efficient and costs will tend to come down okay. Yeah, so this is just a picture of a C&D waste recycling plant okay. And maybe one last thought before we conclude because we are now at the end of this session is that the construction supply chains unlike other supply chains are very fragmented. There are several people who come together right to build a construction supply chain. You know everywhere there is a fragmented supply chain but the construction industry tends to have more linkages than elsewhere.

And therefore these kinds of supply chains are often innovation retarders right. So, innovation does not happen you know very quickly. So, for instance this is work that a former colleague of mine John Taylor did for his PhD where you know a firm in Finland came up with a software technology right to improve the construction supply chain right. This software was something this building modeler was something that helped with design and detail okay. In Finland design and detailing was done by a single function whereas in the US design was done by someone detailing and fabrication was done elsewhere and I think this is the case in India as well.

So, because of the different kinds of supply chains and the different kinds of fragmentation this technology diffused in Finland because it matched the supply chain but did not diffuse in the United States where it did not match the supply chain right. So, the US supply chain in this case did not adopt that innovation and we see this in several parts of the world where because of the fragmentation of construction supply chains and innovation comes in but the innovation does not cleanly fit the supply chain right or people start questioning saying okay in the next project I will work with a different group of people right. What is the point of adopting this innovation in this project where in the next project I will go back to business as usual. So, construction supply chains tend to retard innovation a little bit and one of the ways of solving that is to start looking at more integrated supply chains where you do not have so many pieces you have for instance we talk about design and build contracts where designers and contractors come together as an integrated system. So, we will have to look at also integrating our construction supply chains to promote the adoption of things like construction and demolition waste okay.

So, yeah so integration so in order to so the mantra for supply chain management is I want to have more integrated supply chains right. So, it is easier to pass information materials and finance back and forth and more coordinated supply chains maybe through the use of IT and so on where instantly if there is a change in demand or whatever every part of the supply chain understands it right and they are able to respond to it respond to it very quickly through better logistics through better handling of the bullwhip effect and so on right process orientation advanced planning etcetera okay. So, integration and coordination need to be very critical. So, again if you want to make construction and demolition waste use a reality we have to fix the supply chain right partly you fix that through policy that creates demand but also you need to ensure that the supply chain is better integrated and well-coordinated through the use of digital solutions all kinds of people can play a role here. There will be people who will manage the supply chain like cement manufacturers you will actually have C&D waste manufacturers you have large clients who can push changes in the supply chain you have governments that can enact policy you have technologists that can bring and academics that can highlight these ideas so that practitioners can play a role.

So, all of us have a role to play but fundamentally if you do not have a functional supply chain the use of construction and demolition waste will continue to be small scale and largely academic and we really need to solve the cons the supply chain problem in this area okay. So,

with that we have come to the end of this talk I hope it was interesting probably something a little bit new or a topic that many of you may not automatically be familiar with but please take away the notion that construction demolition waste reuse is extremely important for the environment we are running out of material we need to reuse as much as possible but despite all of us knowing that it does not happen because the costs are too high the trust is too low and essentially all of that is because the supply chain is not yet mature right and so we have to work towards a much more mature supply chain like I said all of us have a role to play and in this lecture I have tried to cover what are some of the challenges that supply chains face what are some of the problems you have when you have an immature supply chain and what could you possibly do to leapfrog to a more mature supply chain okay. So, thank you very much and all the very best to all of you.