Admixtures And Special Concretes

Prof. Manu Santhanam

Indian Institute of Technology Madras

Department of Civil Engineering

Lecture -50

Mineral Admixtures : CASH analysis in blended system and Life cycle assessment of concrete - Part 1

Influence of Temperature:

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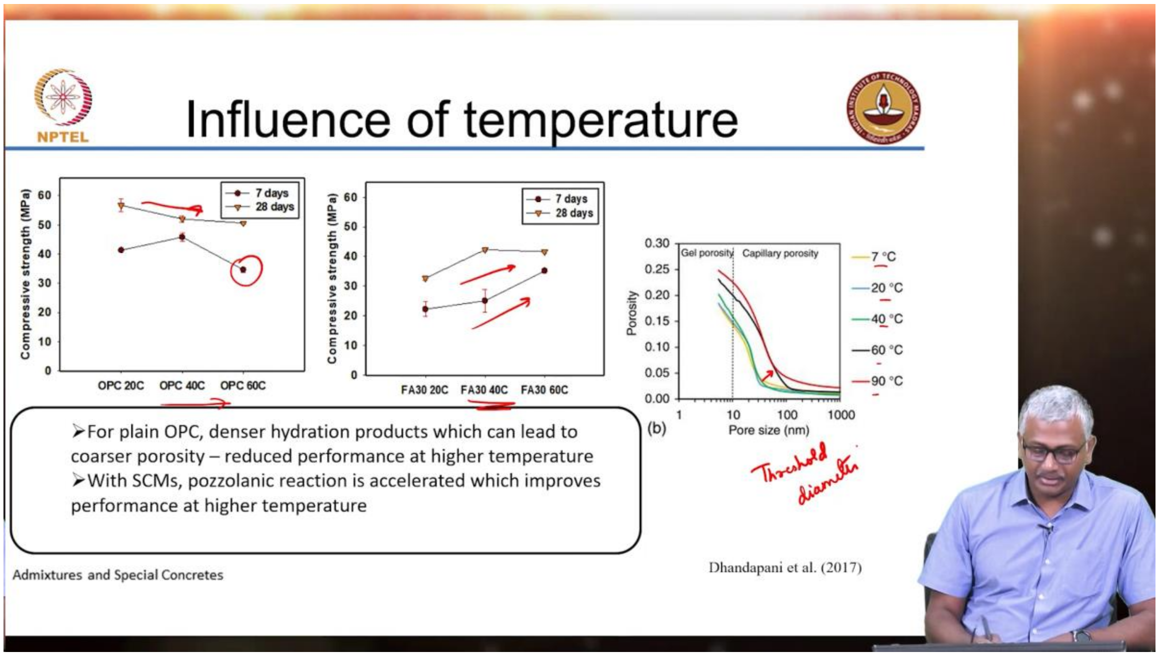

Right, and there is also going to be an influence of temperature. So here in this chapter, we are basically talking about lot of different things which are connected with the overall performance of the concrete. Now we talked earlier about chemical admixtures and their performance when temperature of the system changes. Right, we saw that increase in adsorption of chemical admixture happened when temperature increased, loss of slump was faster and temperature increased and so on. In the case of mineral additives, it is important for us to understand what is temperature doing to the rate of hydration that happens with mineral admixtures. Now in ordinary Portland cement with increase in temperature what we end up doing is accelerating the reaction, the reaction happens faster but it happens fast enough to cause the pore structure to be coarse that means the pores do not get a chance to get completely filled up when cement hydrates at high temperature.

That is why when we do steam curing and then leave the concrete without curing after the end of steam curing the long term you may actually see a strength drop or you may see a durability drop is definite you may also see a strength drop. So like you see here when you cure concrete at higher and higher temperatures you are seeing a strength drop when you go for very high temperature of curing and this is because the pore structure that you produce when you cure at high temperatures is generally much coarser. In the case of fly ash-based systems when you replace cement with fly ash and cure at high temperatures you do not see the negative effects of this long-term strength regression when cement is replaced by fly ash and that is because the pozzolanic reaction is benefited by the increase in temperature and you are able to see a significant enhancement in the compressive strength because of the pozzolanic reaction. This can be shown also in terms of the mercury intrusion porosimetry studies at different temperatures 7, 20, 40, 60 and 90 degree Celsius what is clearly happened is as you have gone from 40 to 60 there is a shift in this diameter which we had earlier termed as threshold diameter of pores.

Threshold diameter of the pores has been shifted to the right indicating that system has become much coarser as compared to a system that is cured at normal temperature. So there is always a price to pay when you want to accelerate the strength development of your concrete you cannot get everything you cannot get early strength, late strength, high durability everything is not possible in one go. You can't, you may need to compromise on one or the other of the issues, but when you start using mineral additives you can overcome that deficit to some extent.

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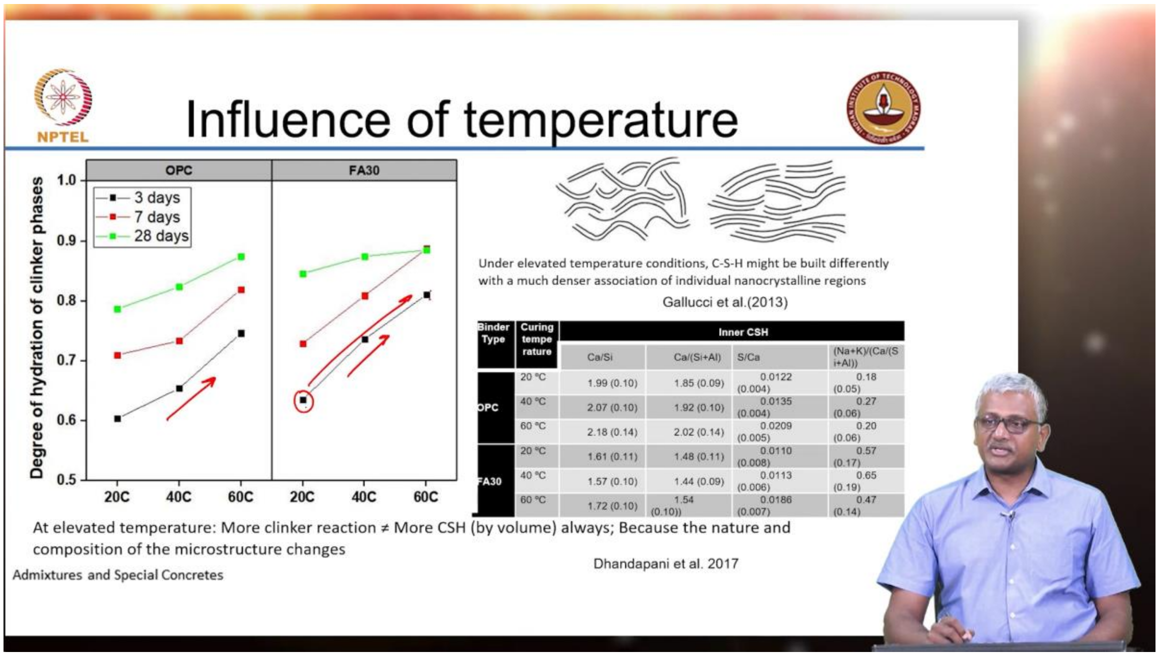

Again this is an example of the degree of hydration that happens at higher temperatures. So again you see that as you increase the temperature the degree of hydration of clinker phases increases and with fly ash again you see that the degree of hydration of clinker phases C_3S, C_2S etc is quite high and increases significantly as you increase the temperature.

So, at 3 days you are causing an increase in degree of hydration from about 0.65 to nearly 0.8 or 65% to 80%. This goes to show that when you are starting to do heat curing of concrete systems with fly ash, fly ash will respond quite well to heat curing. So, not only does pozzolanic reaction get benefited you are also causing an increase in the extent of hydration of cementitious phases that happens at higher temperatures.

So very often if you go to construction projects they will not allow fly ash in precast systems which are heat cured which have the need for high early strength development to increase the productivity of the precast system. Now, in such instances what people are not realizing that you can actually design concrete well enough with fly ash to achieve the benefits of high-strength development in the early ages because of steam curing. You can get very good performance with slag or fly ash-based systems. Very often randomly somebody has written in some report that you cannot use fly ash or slag in steam-cured precast products but there is nothing against it. All of these are myths which have to be broken by practice.

References:

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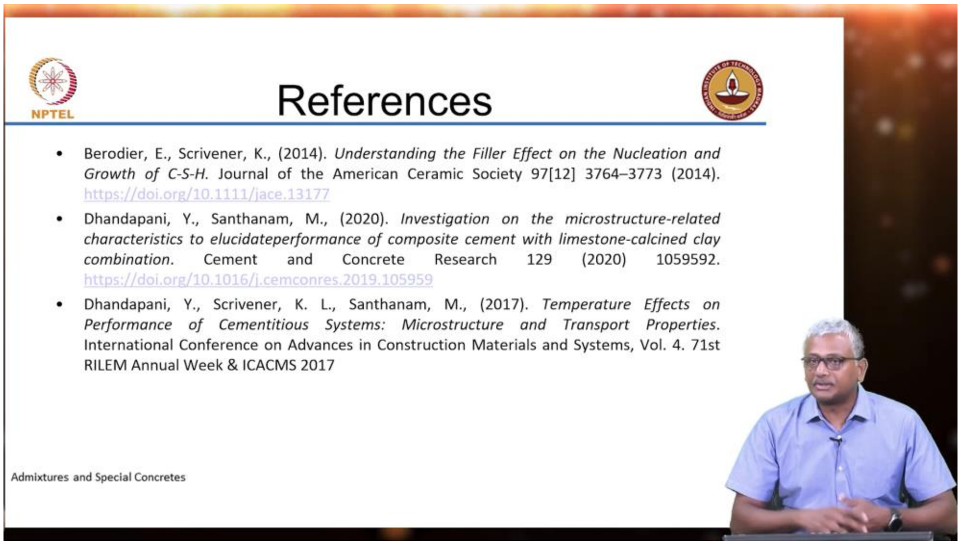

So we will finish our discussion on this aspect here.

About next chapter:

I just had one more aspect to cover with mineral admixtures and that is something which relates to assessment of sustainability impact. We have been talking about the fact that you can make concrete sustainable by using mineral admixtures but can we actually measure this impact is the question that I am going to try and answer in the next chapter.

Summary of Part 5

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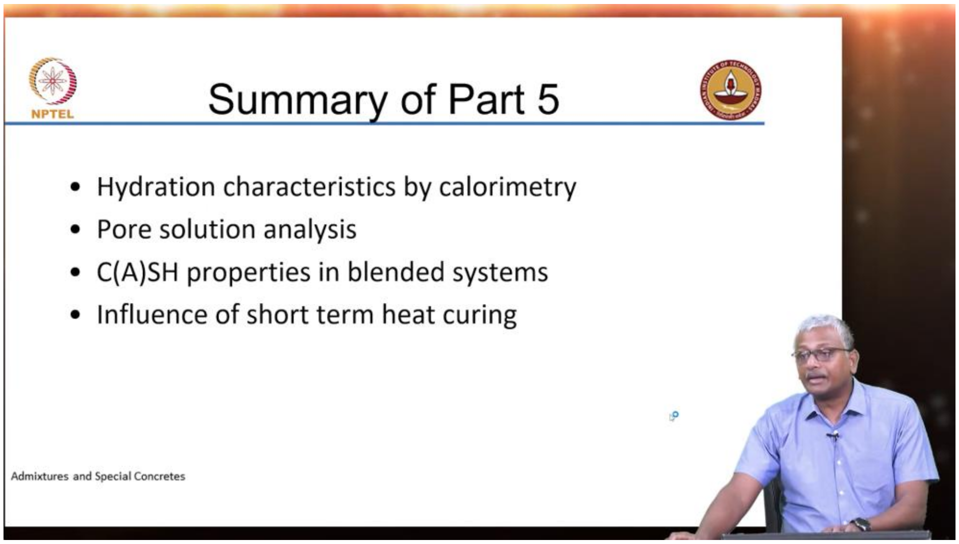

So in the previous chapter we were talking about hydration characteristics with calorimetric analysis we talked about how the pore solution composition can be determined and how it is different in the case of systems with mineral additives. Then we talked about calcium alumina silicate hydrate and its composition and blended systems and influence of short-term heat curing and how the systems with mineral admixtures respond to short-term heat curing.

Outline of Part 6:

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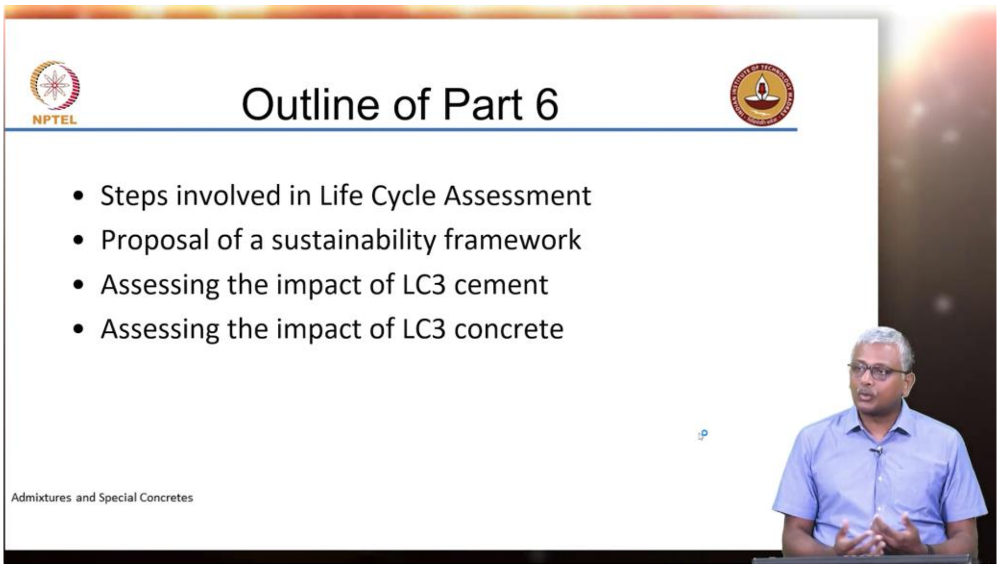

Now in this part, we will talk primarily about life cycle assessment. How do we actually do an impact analysis and how do we establish a sustainability framework to do this impact analysis? Then we will take an example of LC3 or limestone, calcium and clay cement and assess how the CO_2 and energy from the cement could be quite different as compared to auto-report in cement and how can we apply that cement study to assessment of concretes in terms of life cycle impact. Very often at least in the past when people did not have a clear idea about how to calculate this impact they were just saying okay I have replaced 20% cement by fly ash so my concrete is green. So, and then they used to get these lead points based on the use of fly ash, the use of slag and so on and so forth.

But there was no quantification done as to the effect of these materials as to how they are truly bringing down the CO_2 potential other than just saying that okay cement is reduced. So the extent of CO_2 that gets released from that much of cement is now brought down. But then there is other issues also you are transporting fly ash, you are transporting slag from distances and that transportation involves the spending of fuel and that fuel also releases CO_2. So again all of these aspects need to be then included in calculations. There are software available internationally which can be actually used but the data and the software, the database that is available in the software is probably not going to be relevant for many of the geographical regions.

These are mainly there for European countries and for North America and we have to start generating our own data to really get a true estimate of what sustainability impact analysis can be done with our materials.

LC^3 expected to emit less CO_2

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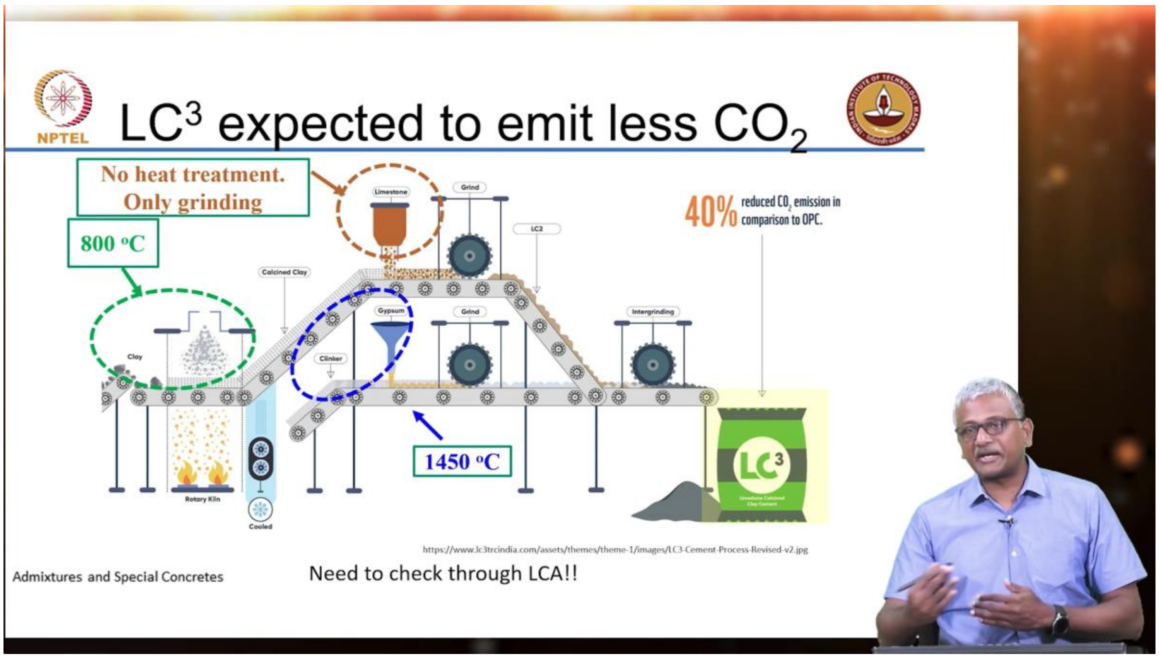

So I mean just to put things in perspective we talked about the fact that LC3 has a clinker content of only about 55%, 45% is your calcined clay limestone combination and you of course have gypsum to optimize the system with respect to sulphate. Now overall what you have in the system is that instead of burning at 1450 degree Celsius the clinker is burnt at 1450, you are calcining the clay at 800 degree Celsius. Calcined clay is produced with lower temperature burning 800 degree Celsius. There is no heat treatment of the limestone that you add in the system later, it is only ground together with the calcined clay and cement and you produce LC3 effectively by combining these systems and you can expect that there is up to 40% reduced CO_2 emission as compared to OPC because you are reducing the temperature of burning that means less usage of fuel and then you are not burning a material which will release more CO_2.

Much of the CO_2 load that comes from cement manufacture is because of the burning of limestone. Now here you are not burning as much limestone anymore, you are reducing the extent of clinker in your system. So you can expect that up to 40% reduction in CO_2

may happen but then how do you establish this? So you have to check this through life cycle assessment.

Methodology for sustainability assessment:

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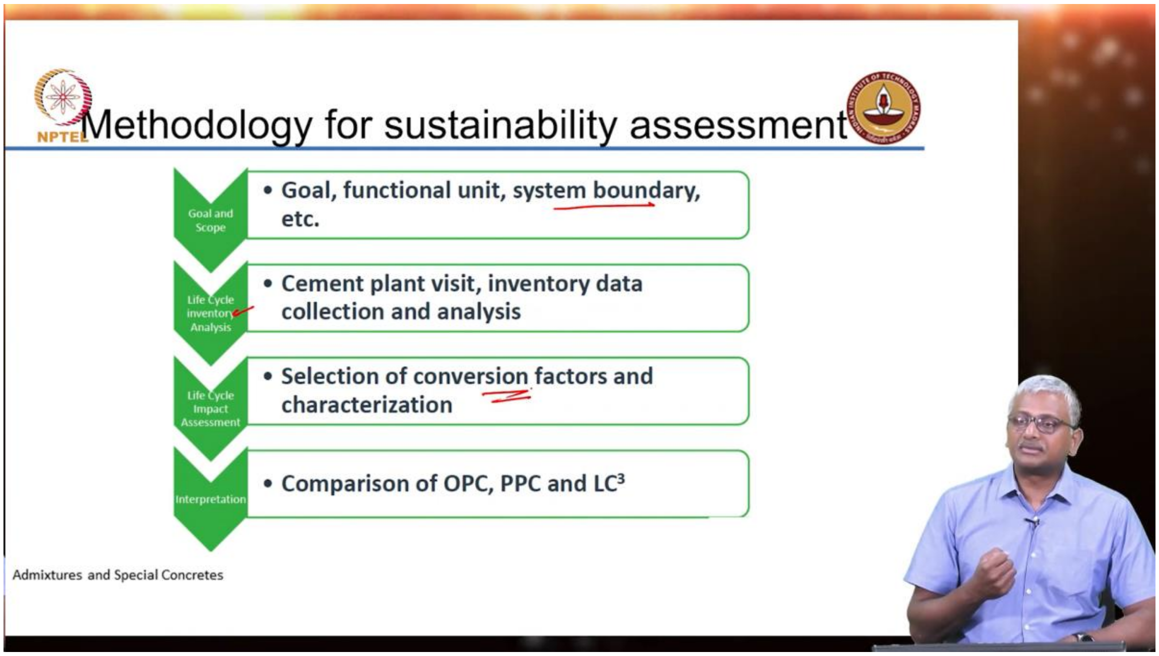

So the steps involved in life cycle assessment are as follows. First is of course you need to have a clear definition of the goal of your process.

What is your end goal and how do you calculate this goal in terms of what type of functional units? So for instance I can say that I am calculating this in terms of CO_2 emission per cubic meter of concrete if I am doing a concrete analysis or I can say CO_2 emission per kilogram of cement produced. But then I also need to define my system boundary. Now cement can be produced at the cement plant but the cement also then has to be transported to the job site where it is getting put in silos. Do I also include that part in my system boundary? For cement, I need to extract raw materials. Should I also include extraction of raw materials or should I only start from the process where raw materials are processed and kiln reaction actually happens? So the system boundary can be quite different based on what you describe.

The other second part is inventory analysis, life cycle inventory analysis. So here you need to actually visit cement plants, look at their data and collect the specific data related to energy, related to CO_2 and so on. Then the next part is selection of conversion factors and characterization. You also need to see the conversion factors in terms of what is the net emission applicable to a particular system. If you are using a fuel you need to characterize that fuel, what is the energy impact of the fuel, what is the CO_2 impact of the fuel and so on and so forth.

So all of those need to be done and finally, you need to do an interpretation. For instance here in this lecture, you will see a comparison of OPC, PPC, and LC3.