# Admixtures And Special Concretes

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**Lecture - 19**

**Chemical Admixtures: Air entrainers - Part 2**

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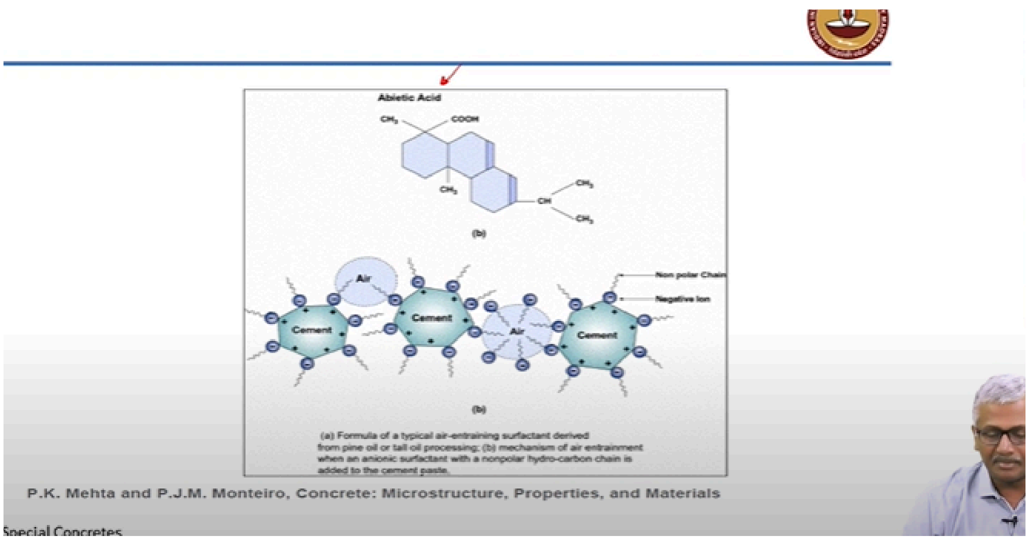


Okay, good morning all. So yesterday we were talking about the various methodologies with which we can utilize an air entering agent in concrete and looking at some potential compounds that act as air entering agents as we discussed the molecule is fairly similar to the water reducer except that it does not have a main hydrophilic chain, it only has a polar end attached to a hydrophobic chain right and the polar end basically helps in reducing surface tension of the water and the hydrophobic chain stabilizes the bubbles once they are formed. So in a structure of the cement or sorry in the structure of the concrete the air bubbles need to be generated with a uniform spacing or at least ensuring that you have somewhat of a uniform spacing to ensure that there is not much distance between successive bubbles.

**Mode of action:**

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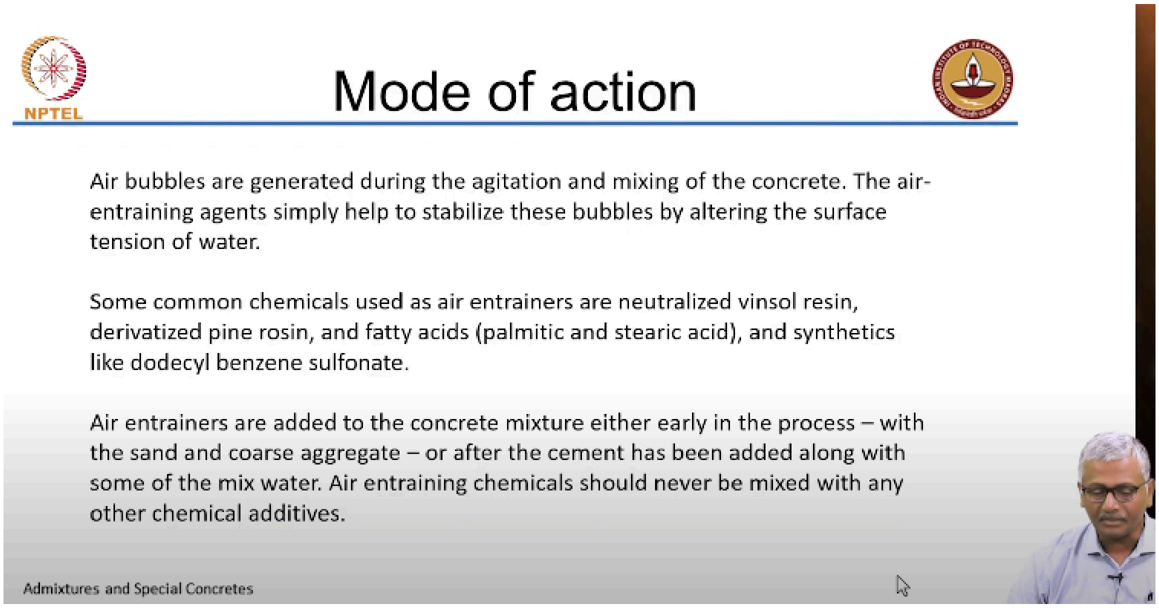


So generally as we discussed earlier some things like soaps and detergents basically generate bubbles because they are lowering surface tension of water that happens upon agitation. Similarly when you mix the air entrainer in the concrete mixture that is when it starts generating these bubbles and these bubbles remain stable because of the action of the molecule. So as I was saying earlier most of the air entertaining chemicals are usually tree derivatives or plant derivatives. Vinsol resin is one of the most commonly known air entertainers and then you have pine rosin and fatty acids and sometimes even synthetic chemicals like dodecyl benzene sulfonate. If you look at your shampoo formulations at the back amongst the ingredients you will always find this ingredient available in your shampoo.

Now what we want to do is maximize the chance of the bubbles forming and ensuring that these bubbles remain stable. So when you add early in the process right with the sand and coarse aggregate along with  some of the water these bubbles can start forming very early in the process. Now I talked earlier about this example where in ready mix concrete plants where people store chemicals in drums, the mixing of air entering agents with other chemicals may lead to solidification of the resin and that kind of blocks the pipes right and that is something you need to be careful about that air entertainers should not be mixed directly with any other chemical. You can dissolve all chemicals into water and then use them but intermixing of chemicals is not a good thing.

**Air entrainment:**

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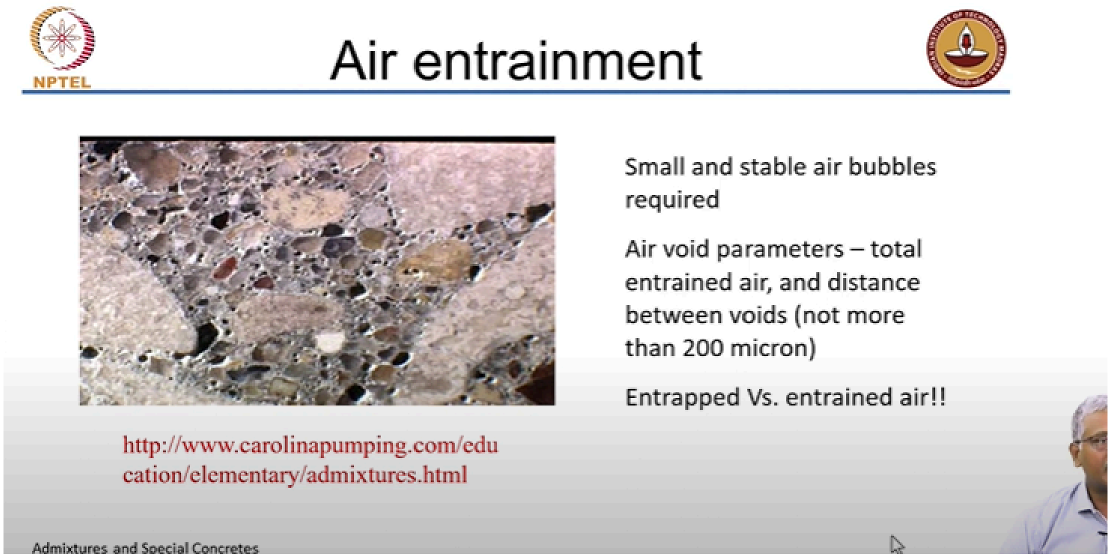


Now if you look under the microscope as I was saying earlier you need to do a proper air void analysis under the microscope for this we take a concrete segment that has been properly polished. Then we need to do the point count analysis. I hope you will be able to go through the ASTM spec which talks about this test method. So if you look under the microscope the distribution of air voids looks something like this so here you have different types of air voids and air bubbles that are inside.

You notice these larger void spaces right which are close to the surface of the aggregate that essentially is your entrapped air, air that remains in the system despite your consolidation. Consolidation is done in order to remove any unnecessary air that is inside the system but how much ever you consolidate there will always be some level of entrapped air in the system it is not possible to completely remove all the air. So this entrapped air is generally of the size range of a few millimeters. So these are fairly large voids. Entrapped air could also be formed because of bleed channels. Let us say you have a large aggregate and the bleed water that is trying to rise to the surface gets trapped between the or right under the aggregate. So that becomes a void now it is almost similar to an entrapped air void except that in this case it may be water filled if the water is still there but the water can also distribute itself into the paste and leave behind a void right under the aggregate. So that is a bleed channel related void. So this could be a bleed channel related void also right. So these are voids that cannot be removed even by proper consolidation.

On the other hand entrained air are what you see as the miniature air bubbles which are looking almost circular because air bubbles are expected to be spherical in shape and because of that you see them dispersed widely in the paste. Of course from this picture because there is no scale you cannot really tell the distance between successive air bubbles but it has to be ensured that whenever a microscopic image is presented there should be some scale involved to try and understand what the sizes that you are looking at are. That is why if you look at pictures of exploration they put a pen alongside the object that is being captured because you know the size of a pen you can associate the size of the object related to the size of the pen. So in this case the bubbles that are distributed all across the paste the small minute dots that you see them are the entrained air bubbles. Entrained air what was the size of entrained air? We saw this in the first chapter. Maybe tens of microns to maybe about 0.1 mm or maybe 10-20 microns all the way up to 100 microns.Could be somewhat more than that sometimes also sometimes these bubbles may coalesce and form a larger bubble but in most cases the sizes will be between tens of microns to 0.1 mm. So they have to be embedded uniformly in the paste to ensure that the distance of travel of water is restricted to less than 200 microns.

**Air measurement:**

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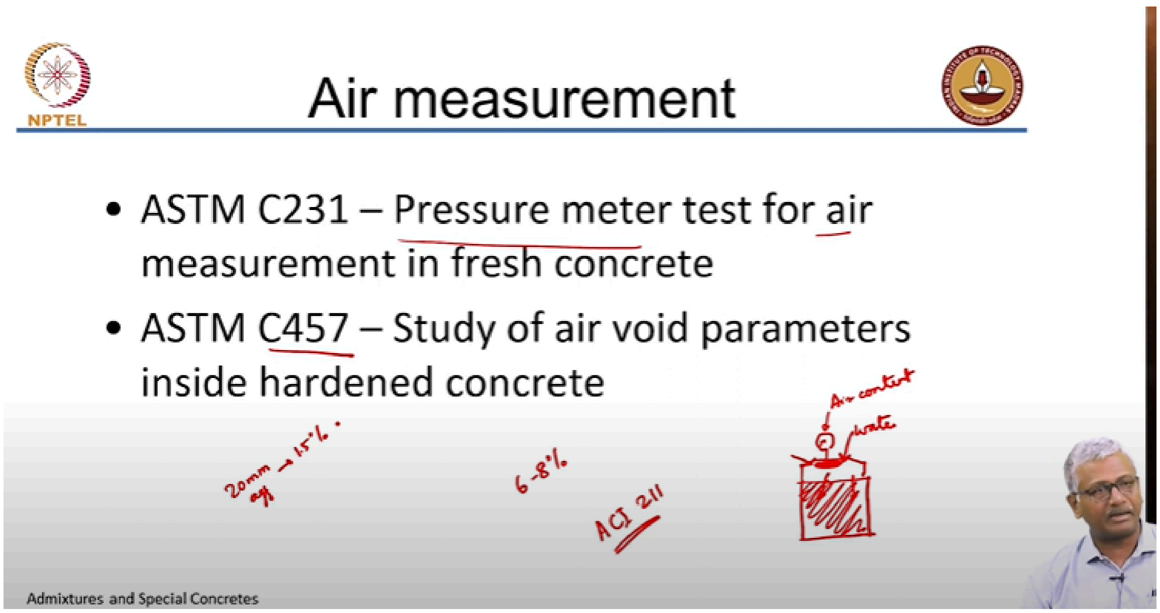


When we add the air into the agent into concrete we need to measure how much air has been actually into concrete we need to measure how much air has been actually entrained in the concrete there are several methods in which you can study this. Of course the petrographic method that I talked about which looks at polishing concrete specimens and looking at the microscope to do an air void count analysis is ASTM C457 study of air void parameters inside hardened concrete. So this is something that petrographers use to determine whether the air void system is efficient enough to protect against freezing and thawing.

But if you want to measure the air content right after mixing the concrete apart from the slump one of the common tests that is done wherever air entrainment is used is the measurement of air in fresh concrete which is done with the help of what is called a pressure meter. You can definitely look at the standard it is a simple enough test you have a container which you fill up with concrete with some standard compaction typically you fill it up in 3 layers each layer being rodded 25 times with the tamping rod and then you finish up the top surface right then you put an upper chamber to this which has a dial gauge you put an upper chamber and then you flood the upper chamber with water. And then you pressurize the water, after it completely fills up the upper chamber you pressurize the water. What will happen is as you pressurize the water it will start entering the concrete into the air voids. When you pressurize the system the water will enter into the air voids and then there is a pressure release valve on top which when you release all the extra air that is left behind because of the water entering the voids that will get released and that will be indicated in your dial as the air content. Simple enough test requires a bit of practice to actually get this right but it can be done quite easily with just some understanding of how this system actually works. This is called the pressure meter test.

There is also another test called volumetric test in which you do not apply pressure but you agitate the concrete by rolling the apparatus with your hand that causes the water to settle into the air voids in the concrete and then whatever is left behind is the air content in the concrete. So this has to be done along with the slump test whenever fresh concrete is tested for concrete that is subjected to freezing and thawing cycles. You have to ensure the air content is properly met. For most cases if you want a very good resistance against freezing and thawing the air content should be at least 6 to 8%. When you need excellent resistance to freezing and thawing air content should be 6 to 8%. So when you design this concrete with 6 to 8% air you obviously have to take into account the fact that this is going to reduce your strength significantly. Even if you assume 5% reduction in strength means we are talking about 30 to 40% reduction compared to a reference concrete. So you have to up your design by lowering the water to cement ratio that you use for air-entrained concrete.

And this is very clearly captured if you look at the mix design method prescribed in ACI 211 document that talks about mix design of concrete. There they clearly mention what should be the approach when you use air-entrained concrete, how much should you bring the water to cement ratio down to ensure that you have a proper strength attainment at 28 days.

How do we, this pressure meter test, measure the total air entrapped and entrained air correctly? How do we distinguish, well we cannot truly distinguish that but what happens is if you do a concrete without the air entrainer you can get an estimate of the air entrained air. Typically if you look at our mix design guidelines they suggest that when you use a certain size of aggregate let us say when you use a 20 mm aggregate we assume that about 1.5% entrapped air will be there in the system. It is an assumption based on data that has been collected from multiple concretes without any air entrainment you will get about 1.5% air. So when you use 20 mm aggregate you assume that about 1.5% of the total air is entrapped. You can do this test also for non-air entrained concrete you will find that air content is  typically between 1 and 2%.