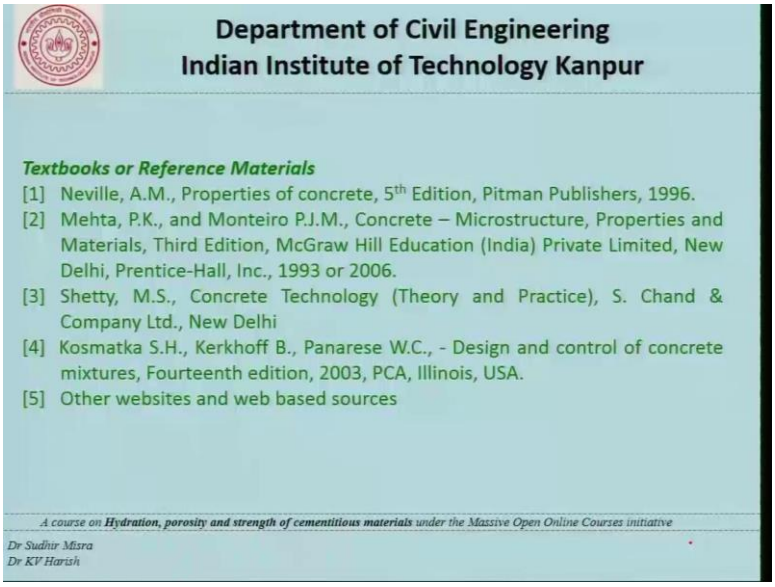
Hydration, Porosity and Strength of Cementitious Materials
Prof. Sudhir Mishra and Prof. K. V. Harish
Department of Civil Engineering
Indian Institute of Technology, Kanpur

Lecture - 01
Introduction to the Course

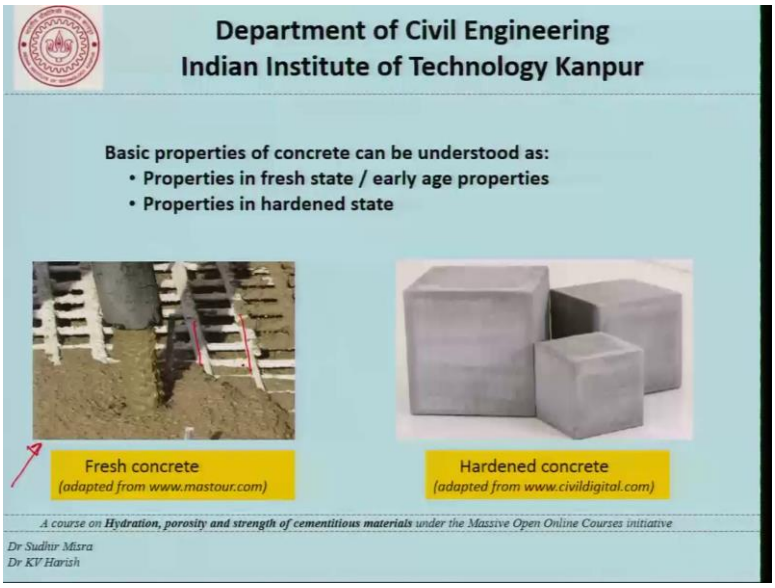
[FL] and welcome to this first lecture which is the Introduction to the Course on Hydration, Porosity and Strength of Cementitious Materials. My name is Sudhir Mishra and I will be giving some of the lectures and the other part will be handled by Professor K. V. Harish who is a colleague of ours in the Department of Civil Engineering at IIT, Kanpur.

(Refer Slide Time: 00:47)



These are some of the references and text books which you could use when you listen to the lectures and want to start a little bit on your own or try to get more information about things which are given is the assignments and so on.

(Refer Slide Time: 01:08)

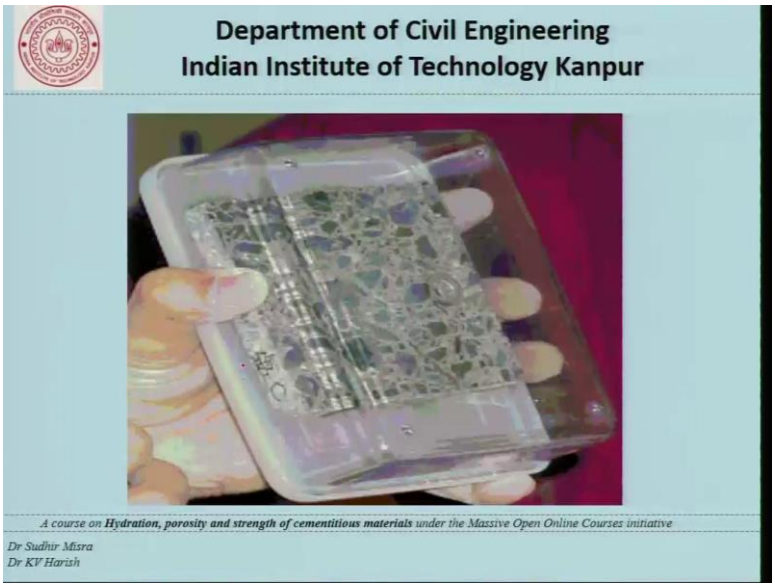


Now, before we get started with cement paste and cementitious materials we must understand some of the basic properties of concrete because at end of it cement paste and cementitious materials are an integral part of concrete and very widely used in that from. It is now in fresh state we except concrete to blast behave like a fluid as I shown in this picture. We except concrete to go through the reinforcement that is shown here, and fill up all the gaps, that can be done with some amount of help through consolidation.

Otherwise we now have self compacting concretes which do not require any compaction. And take whatever shape the form work has. Other than fresh concrete we expect concrete after it has hardened to take the shape of the form work it could be cubes it could be teels it could be ice we have seen. So, many shapes of concrete structures and at that point we expect concrete to behave more or less like rock.

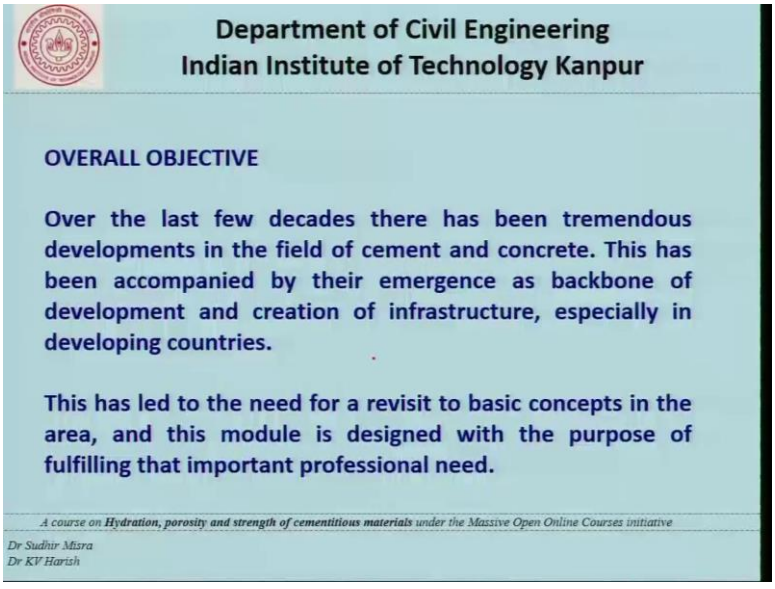
So, when we are taking of cements cementitious materials course aggregate water mineral and mixtures and any constant of concrete. We must keep these 2 states of concrete in mind we except different properties in the fresh state and different properties in the hardened state.

(Refer Slide Time: 02:48)



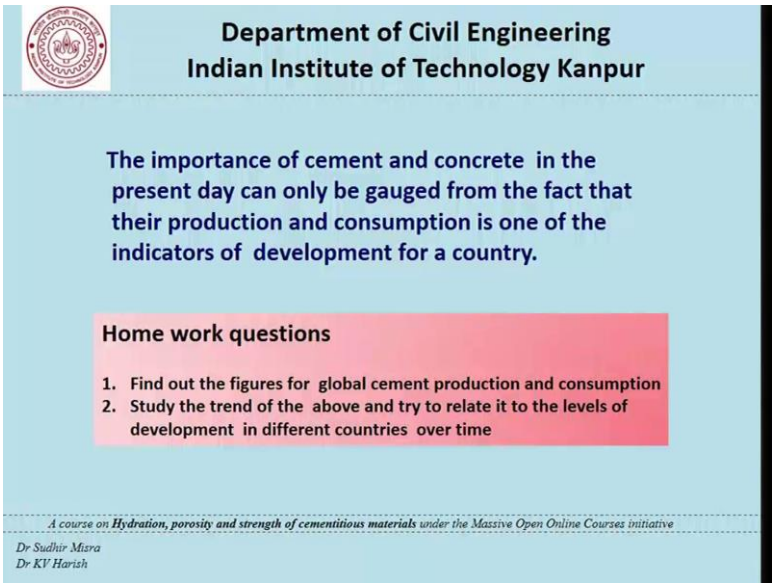
This is a cross section of concrete. You can see that these are course aggregate particles which are more or less suspended in the motor face. And motor itself if you look closely enough we can see some finer particles here with the naked eye we cannot see anything finer that. And finer than that we have cement and then there is of course, water except that water does not exist most of the time and hardened state and that is this state in which this picture is taken water exist as part of the hydrated cement paste which is the binder in the concrete.

(Refer Slide Time: 03:37)



So, the overall objective of this course is coming from the fact that over the last few decades, there have been tremendous developments in the field cement and concrete. This has been accompanied by their emergence as the backbone of development and creation of infrastructure especially in the developing countries. This has led to the need for a revisit to basic concepts in the area and this module is designed with the purpose of fulfilling that important professional need the importance of cement.

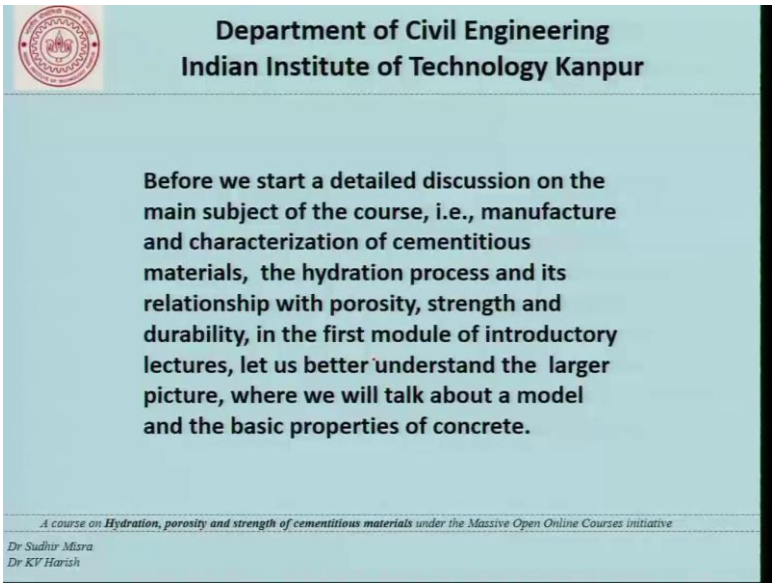
(Refer Slide Time: 04:16)



And concrete in the present day can only be gauged from the fact that their production and consumption is one of the parameters which is used to evaluate the development in a country. Now, since it is a course we are talking about examinations will talk about quizzes this is the home work question for you. Find out the figures for global cement production and consumption and study the trend of these figures try to relate that to the levels of development in different countries over time.

What you will find or what I expect you to find is how the cement production in the world as changed let us say in the last 30, 40, 50 years, and how it is changed as for as the global distribution is concerned different countries the developed west the developing countries now countries like Japan, China and how the cement consumption the concrete consumption and these areas has changed you will find that there is a very strong correlation between this consumption and the development that has taken place in these countries.

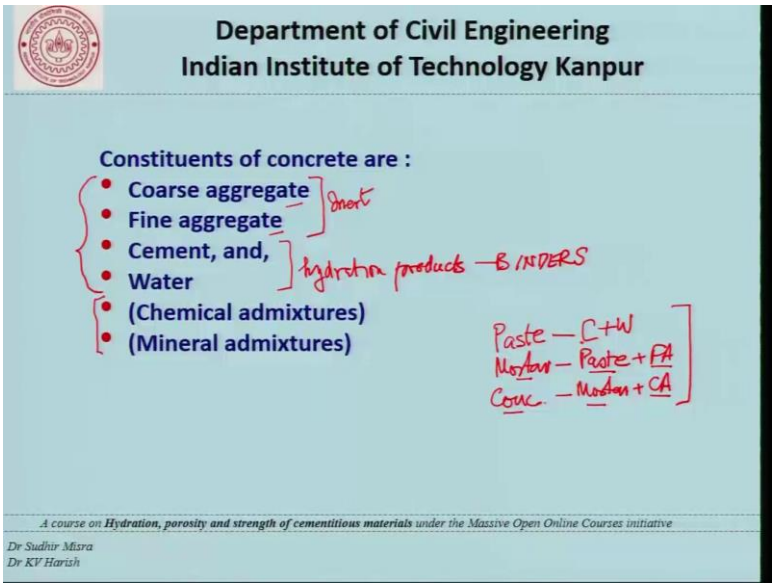
(Refer Slide Time: 05:43)



Moving on before we start a detailed discussion on the main subject of the course, which could be the manufacture and characterization of cementitious materials the hydration process, and it is relationship with porosity strength and durability. In the first module in these few lectures to begin the course let us better understand the larger picture where we will talk about a model that we use for the concrete from the structural point of view from the material point of view and also the basic properties of concrete.

We must remember that only if we understand the requirements of concrete, in different areas we will be able to understand what kind of cement to use what are the especial properties that we need from the cement or the hydration products, how do we control porosity how do we control strength how do we control durability and so on.

(Refer Slide Time: 06:53)



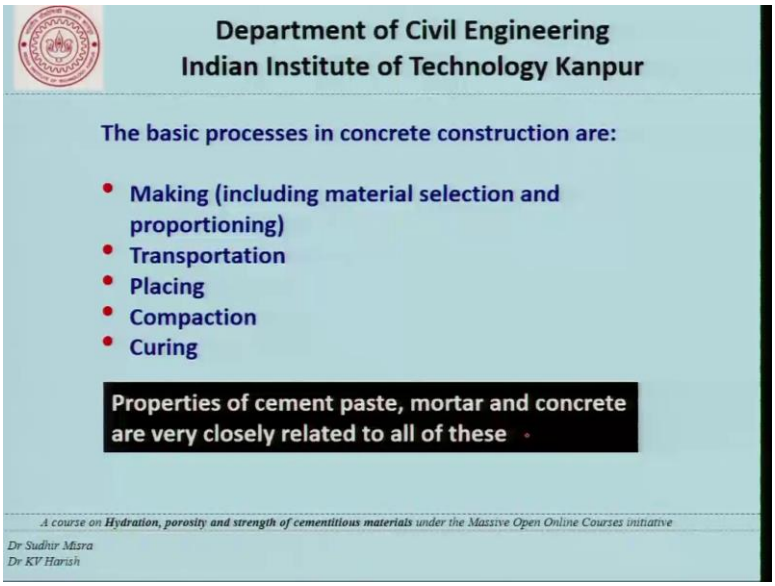
So, these few lectures initially are devoted to understanding concrete. Now the constituents of concrete are coarse aggregate, fine aggregate, cement and water. And then we have chemical admixtures mineral admixtures the chemical admixtures and mineral admixtures have been added in brackets because these 4 constituents are part of the 4 traditional concrete which we knew. These 2 admixtures chemical and mineral are being added to concrete routinely and as part of our regular job now. In the last say thirty forty years when we have better understood how concrete behaves how cement hydrates and what kind of concrete we need in different environment and so on.

We must remember that the coarse aggregate and the fine aggregate they essentially work as inert materials in the concrete. And it is only the cement and water that actually hydrates and gives hydration products and these hydration products act as binders. So, in a manner of speaking concrete can be looked upon as a suspension of fine and coarse aggregate in a binder of cement and water. Please recall that we use the word paste which is basically cement and water we use the word mortar which is nothing, but paste and fine aggregate and we use concrete which is mortar and coarse aggregate.

So, one way of looking at concrete is concrete is a suspension of coarse aggregate in mortar, mortar is a suspension of fine aggregate in paste, and paste itself is a suspension of cement particles in water. We must remember that the fluid component or the liquid component of concrete is only water cement fine aggregate and coarse aggregate are also

solids. We must remember that this course is not really about concrete, but about cementitious materials and their hydration and the resulting porosity strength and durability, but as I have pointed out we cannot talk about it meaningfully unless we understand the bigger picture of concrete apart from the materials.

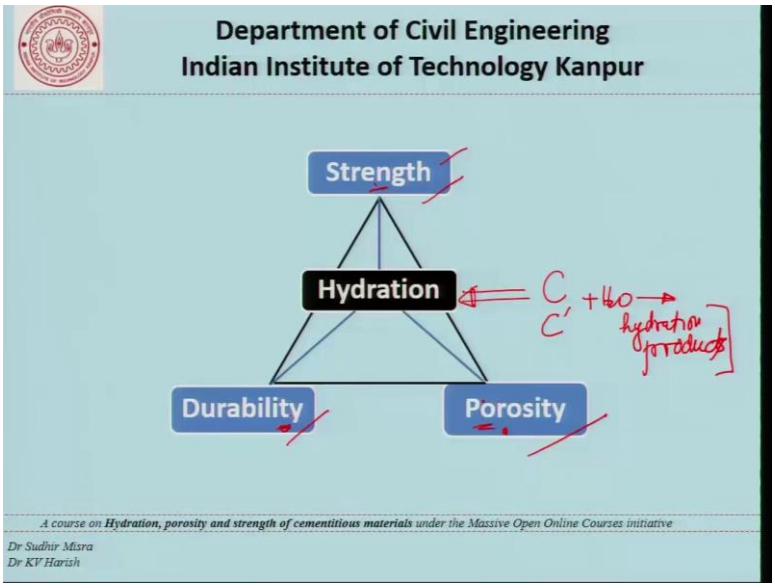
(Refer Slide Time: 09:56)



We must remember at the basic processes in concrete constructions or making the concrete which includes materials selection and proportioning transportation of that concrete form the RMC plant to the site of placement the placing of concrete itself which involves the movement of concrete from the trucks to the actual side of placement which could be the beam or the column or the slag whatever the wall that we want to cast the compaction to the concrete if it is required in that place and finally the curing.

So now, the properties of hardened concrete are those which the property which evolve after the concrete has been placed and as it exists in this structure that is the incentive properties, but those are very much affected and very closely related to the entire set of all the other processes and making of concrete transportation placing and all that. So, we must have the larger picture, first before we get involved with the details of the hydration of cement and cementitious materials in the presence of chemical or mineral admixtures and the resulting porosity strength and durability issues.

(Refer Slide Time: 11:20)

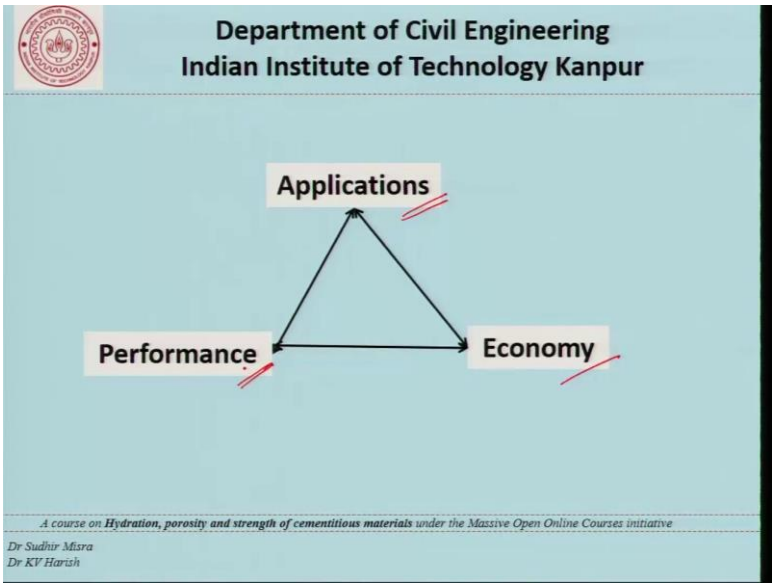


Now, this is a very important diagram for us to understand. At the root of the entire discussion is the hydration of cement and cementitious materials with water, which gives us hydration products. Now this phenomenal of formation of hydration products is closely related to porosity durability and strength. And these key parameters to strength porosity and durability are closely related among themselves. If we want high strength we would like to have low porosity.

Similarly if the porosity is low the durability would be high because it is this porosity in the hydration products that facilitates the movement of detrimental material whether it is chloride ions or it is sulphates or it is even carbon dioxide into the concrete. So, it is impossible to talk of durability strength and porosity independent of each other, but we must remember that at the root of all these 3 properties of concrete is the process of hydration. And this hydration is that of cement and water.

Where I say cement I include other cementitious material is well and to that extent in deed the coarse aggregate and the fine aggregate are only inert materials.

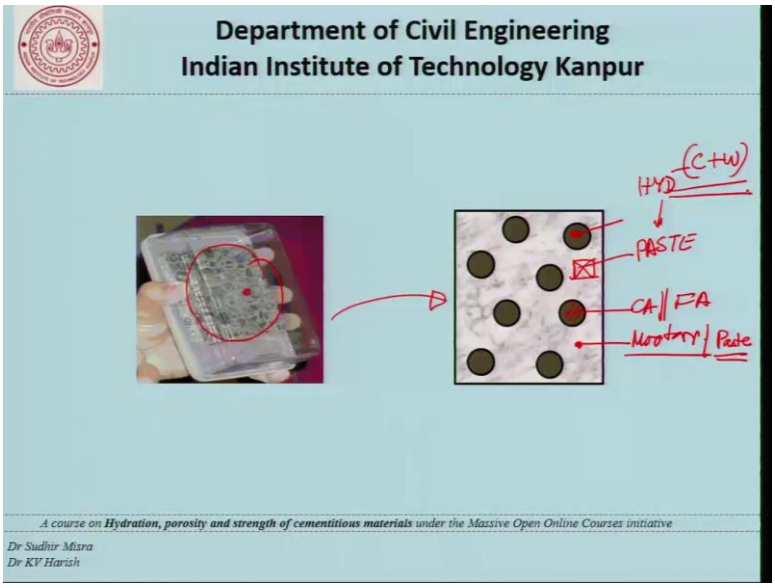
(Refer Slide Time: 13:12)



Let me also throw at you another relationship with 3 key words applications performance and economy. We have countless applications of concrete we just have to look at around and see the concrete is used in roads in buildings, industrial structure, bridges, and precast products. It could be manhole covers it could be (Refer Time: 13:44). It could be r c pipes and all those applications have different performance parameters. We must understand our application before we can decide what the performance parameters will be or what will be the parameters on the basis of which we will evaluate a particular concrete product and finally, economy.

Engineering without consideration of economy it pretty much meaningless excise we must understand what is economic are we willing to pay the additional cost for the additional performance that is likely to come by for a particular application those questions have to be decided at the policy.

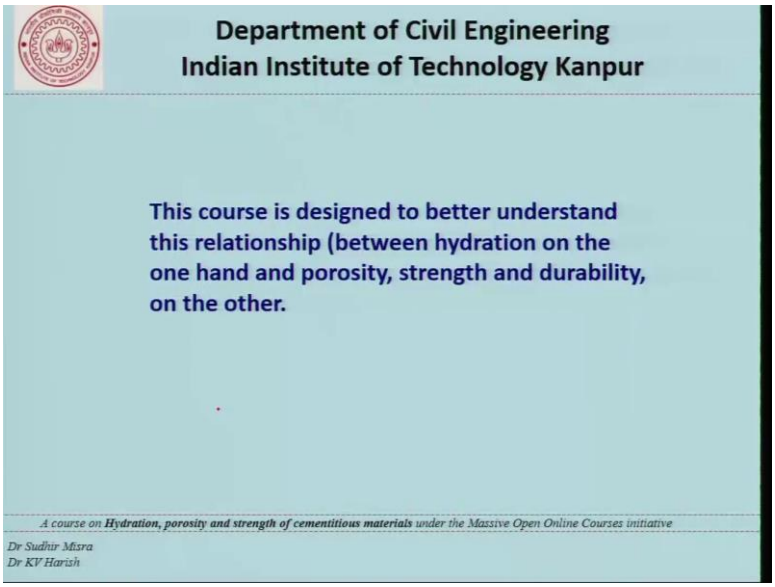
(Refer Slide Time: 14:38)



Now, let us look at this picture once again. Where we have coarse aggregate particles suspended in mortar and then we cannot see the suspension of fine aggregate and paste, but what we can do is we model this, in this form and we say that well concrete is or suspension of these coarse aggregate particles in mortar. And in the mortar level we say that this is basically fine aggregate particles in paste.

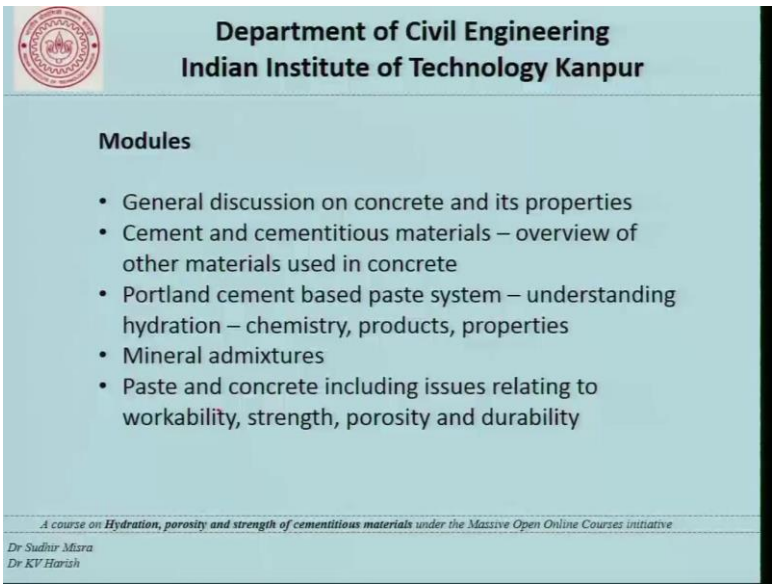
It is obvious from this picture now that in order to control or study the properties of concrete here, the fact that these particles are largely inert. It is absolutely imperative that we understand whatever goes on in this face. And this is the paste face and this paste is nothing, but the hydration products of cement and water. So, this course basically focuses on the hydration processes and the evolution of hydration products come back to this course.

(Refer Slide Time: 15:58)



This course is designed to better understand the relationship between hydration on the one hand porosity strength and durability on the other. That is the slide that I should your pervious time.

(Refer Slide Time: 16:15)



And the modules that we are using to go through this excise are a very general discussion on concrete and it is properties that is this lecture and then may be the next 2. Then we will move on to cement and cementitious materials which would include an overview of all the material used in concrete including aggregates they manufacturing processes the

quality control criteria the specifications involved. And finally, we come back upon detailed discussion of Portland based of Portland cement paste systems, which would mean we would pay emphasis to understanding hydration from the point of view of chemistry hydration products and their properties.

Have you understood the process of hydration and it is chemistry and all that for ordinary Portland cement we will move on to using mineral admixtures in the system? And then we will graduate to the relationship between the paste and the concrete which would include discussions like workability strength, porosity and durability of concrete.

With this I would like to thank you for joining in and I look forward to seeing you in the next lecture when we talk about concrete initially and then we want to talking about hydration porosity and strength of cementitious materials.

Thank you.