Structural Health Monitoring
Prof. Srinivasan Chandrasekaran.
Department of Ocean Engineering
Indian Institute of Technology, Madras

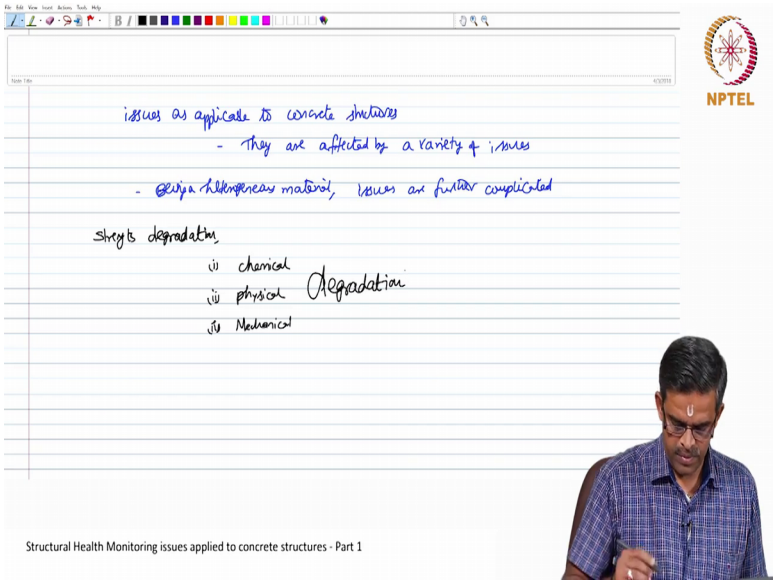
Lecture – 13
Structural Health Monitoring issues applied to concrete structures – Part 1

Friends, welcome to the 7th lecture in module 1, where we will discuss Structural Health Monitoring issues as applied to concrete structures.

Concrete is one of the favorable construction material for offshore structures and civil engineering structures. Nevertheless, concrete has shown great advantages of structural use, because of it is strength, because of it is application criteria, violability and different structural forms, which can be amendable as concrete as a construction material.

However, when we talk about health monitoring of concrete structures, there are some specific issues, which requires a fundamental understanding. And there are specific kinds of non destructive evaluation methods, which are very useful and particularly powerful when applied to concrete structures; we will see those details in this current lecture.

(Refer Slide Time: 01:49)

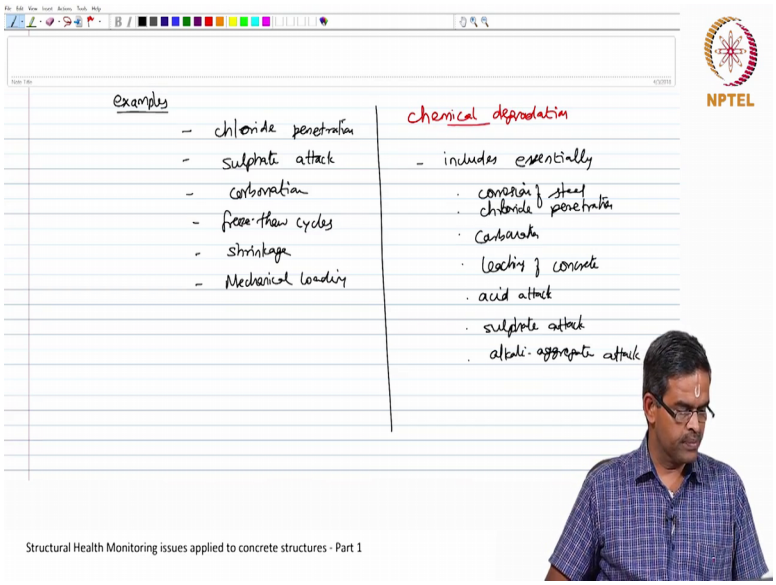


If you look at the issues in general as applicable to concrete structures, not necessarily health monitoring, but concrete structures have special kinds of problems. Generally,

they are affected by a variety of issues, fundamentally being heterogeneous material, issues are further complicated.

When we talk about strength degradation, concrete has several ways by which the strength is degraded, one is chemical degradation, next is physical degradation and third could be the mechanical degradation.

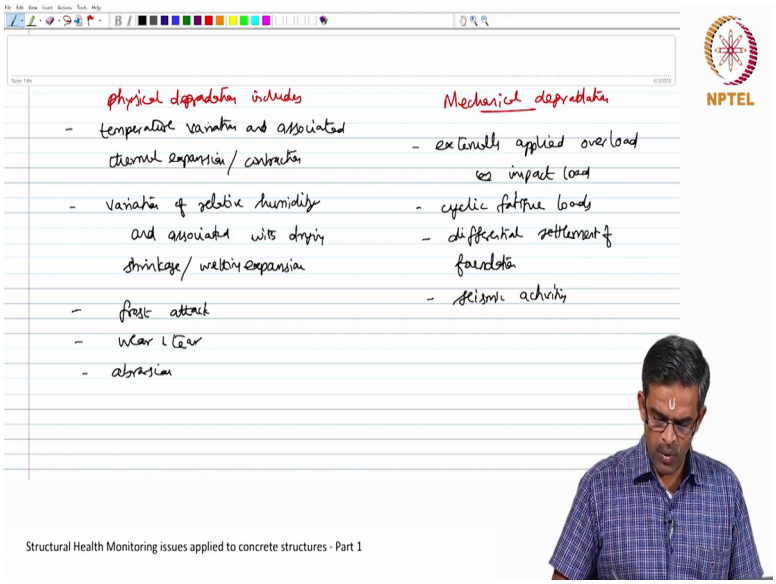
(Refer Slide Time: 03:36)



I can give several examples, then we will classify them into different categories. Chloride penetration, sulphate attack, carbonation, behavior of concrete in free thaw cycles, shrinkage of concrete and issues related to mechanical loading on concrete structures.

When we talk about chemical degradation in particular, this includes essentially corrosion of reinforcement, chloride penetration, carbonation, leaching of concrete, concrete in an acid attack, concrete under sulphate attack, concrete under alkali aggregate attack.

(Refer Slide Time: 05:49)



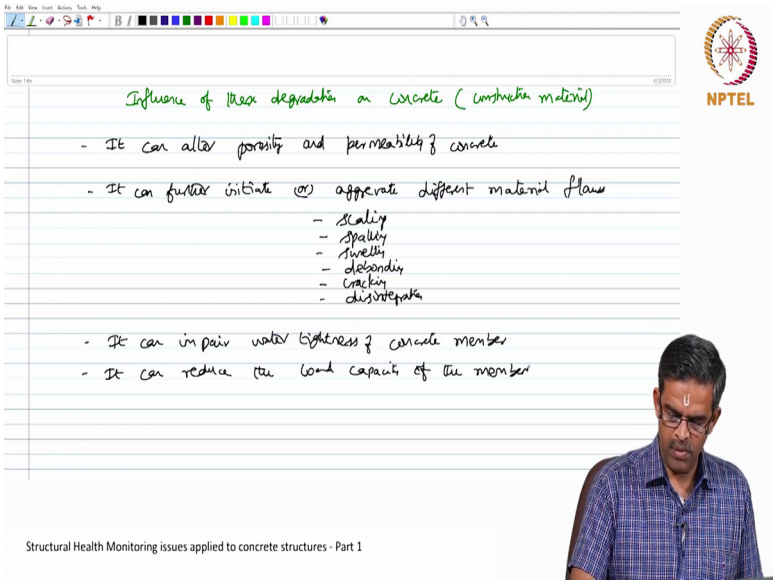
When we talk about physical degradation, these includes temperature variation and associated thermal expansion, or let us say thermal contraction. There can be issues which can cause physical degradation arising from variation of relative humidity. This is very important for coastal structures and issues associated with drying shrinkage and wetting expansion.

There can be issues related to frost attack which can cause a physical degradation. There can be wear and tear and abrasion on concrete surface, which can result in physical degradation. We can also have issues related to mechanical degradation of concrete, this can arise essentially from externally applied loads, which can sometimes cause overload or impact loads.

There can be issues related to cyclic fatigue loads, which can cause degradation; there can be a differential settlement of foundation of concrete structures. And of course, interestingly seismic activity can also cause mechanical degradation.

Now, the question comes under such chemical mechanical and physical degradation, what is the influence of these on concrete.

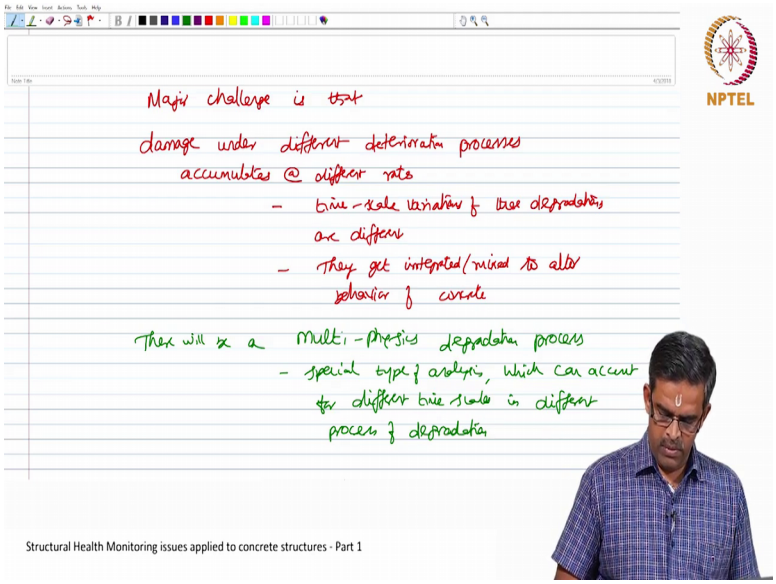
(Refer Slide Time: 08:43)



So, influence of these degradation on concrete as a construction material are as follows. These degradations can alter porosity and permeability of concrete. It can further initiate or aggravate different material flaws such as scaling, spalling, swelling, debonding, cracking, disintegration of concrete, etcetera.

These degradations can also cause impairment in water tightness, of concrete members, especially reservoir structures and dams in fact, over tanks can also be affected very severely by this condition. It can ultimately reduce the load carrying capacity of the member.

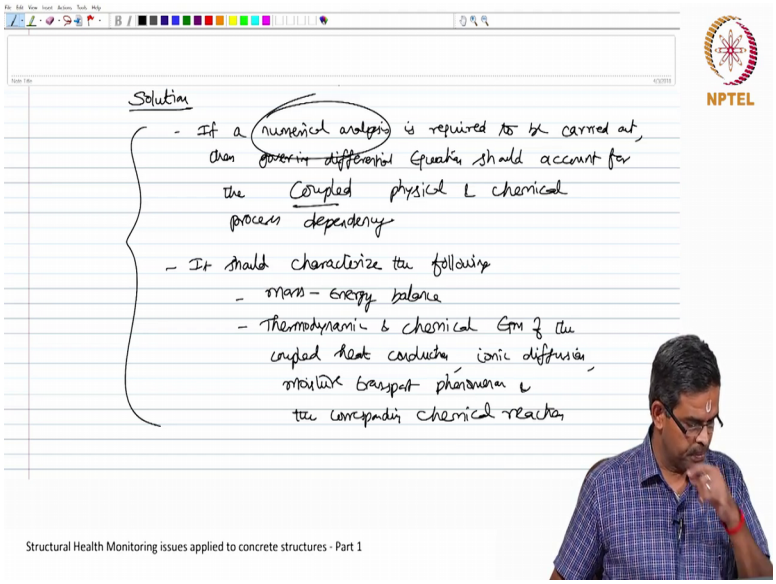
(Refer Slide Time: 11:06)



Let us quickly say what would be the major challenge then if you really wanted to monitor it is health. The major challenge is that damage under different deterioration process accumulates at different rates; that is the time scale variation of these degradations are different.

So, the confusion is they get integrated and mixed to alter behavior of concrete. Therefore, there will be a multi-physics degradation process, which needs a special type of analysis, which can account for different time scales in different process of degradation. So, that is the main challenge.

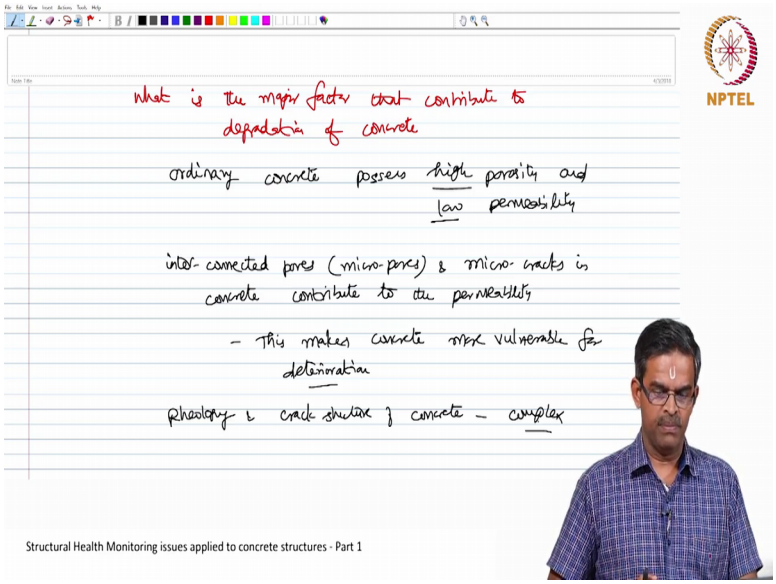
(Refer Slide Time: 13:29)



The question comes what is the solution for this problem, if a numerical analysis required to be carried out, then the governing differential equation, why differential? Because it is time variant as well as space variant. So, governing differential equation should account for the coupled physical and chemical process dependency. It should characterize the following.

One mass energy balance, thermodynamic and chemical equilibrium of the coupled heat conduction, ionic diffusion, moisture transport equation, or let us say moisture transport phenomena, and the corresponding chemical reaction. So, it is very complex to analyze this numerically.

(Refer Slide Time: 16:03)



Let us ask a question, then what is the major factor, that contribute to degradation of concrete because that is actually the health monitoring of concrete. Interestingly ordinary concrete possess a high porosity and low permeability.

Now, the interconnected pores which I should say micro pores and micro cracks in concrete contribute to the permeability. Therefore, this makes concrete more vulnerable for deterioration. So, it is actually the rheology and crack structure of concrete, which makes it complex.

So, health monitoring of concrete is actually not a physical process. It is also not an electronic process where you can simply measure the strain values and displacements and deformations. It is actually not purely a chemical process, because it also contributes from other source of physical and mechanical. So, all put together health monitoring of concrete essentially becomes a multi-physics dimensional problem.