Structural Health Monitoring (SHM)
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Lecture – 20
Part – 2: Data Evaluation and Assessment

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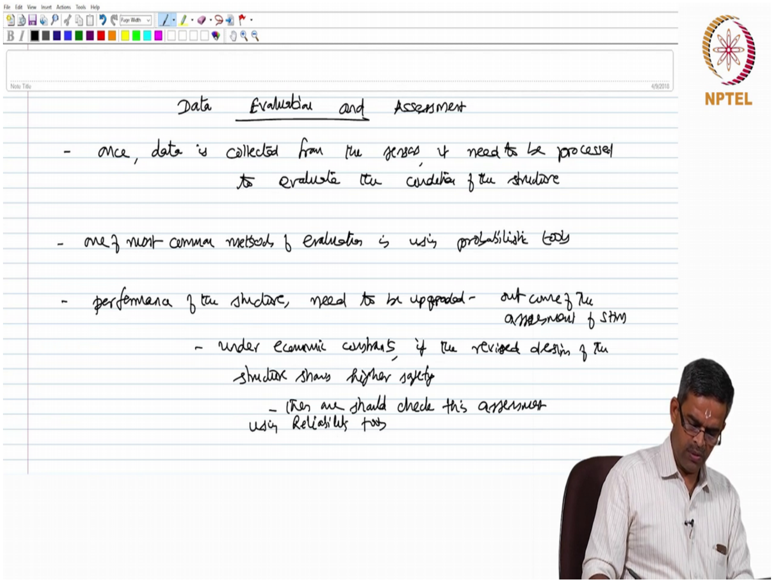

Having said this let us talk about the importance of Data evaluation and Assessment. Friends, once data is collected from the sensors this data need to be processed to evaluate the condition of the structure. One of the most common methods of evaluation is using probabilistic tools.

So, let us say the performance of the structure need to be upgraded which is one of the important outcome of assessment of the structure under health monitoring. So, later let us say under the economic conditions and economic constraints if the revised design of the structure shows higher safety then one should check this assessment using reliability tools.

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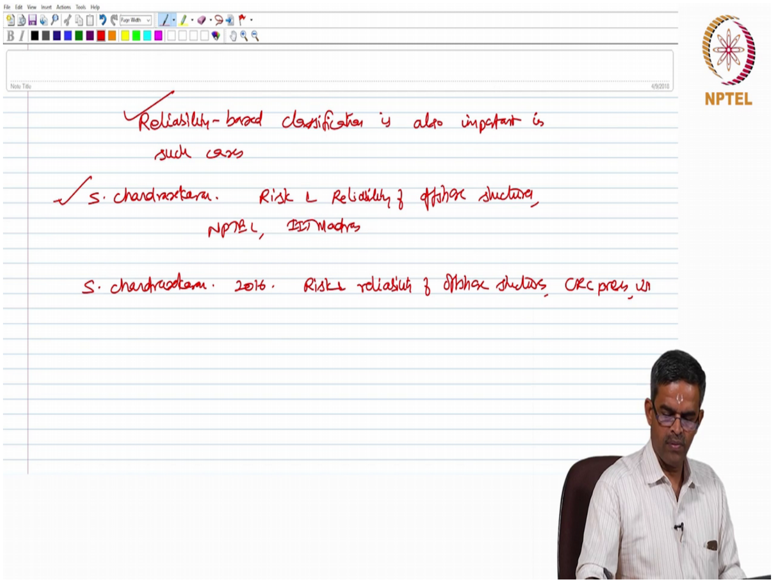

So, reliability based calculation and classification is also important in such cases. So, for your extra knowledge and reading there is a course in NPTEL risk and reliability of offshore structures which is done by me and NPTEL at IIT, Madras this can be useful additional reading for people to know more about reliability based calculations for estimating the risk on a given structure.

One can also refer to my textbook risk and reliability of offshore structures under CRC press. So, just for the interest of viewers let us cover some fundamental on this now.

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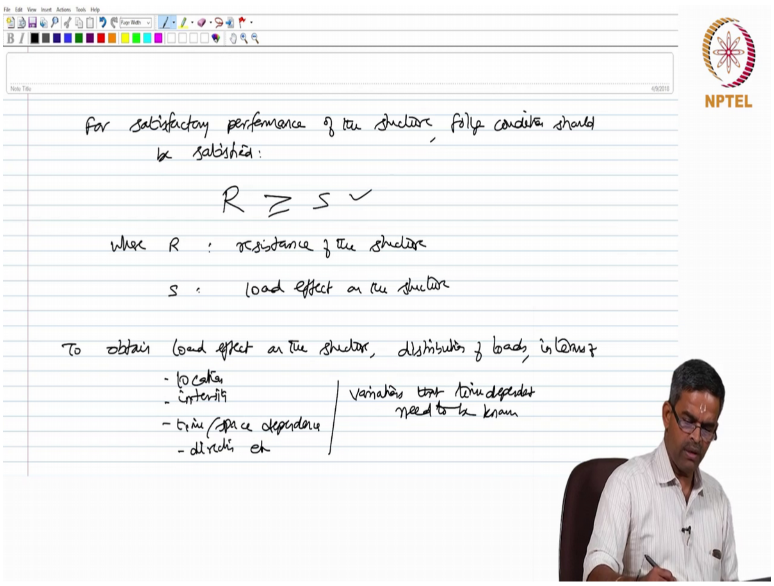

We do agree as the reliability that for a satisfactory performance of the structure following condition must be satisfied R should exceed S, where R is the resistance of the structure and S is the load effect on the structure.

Now, to obtain the load effect on the structure distribution of loads in terms of its location, intensity, time and space dependence, direction etcetera which are all variations that are time dependent need to be modeled I should say it need to be known to estimate this relationship.

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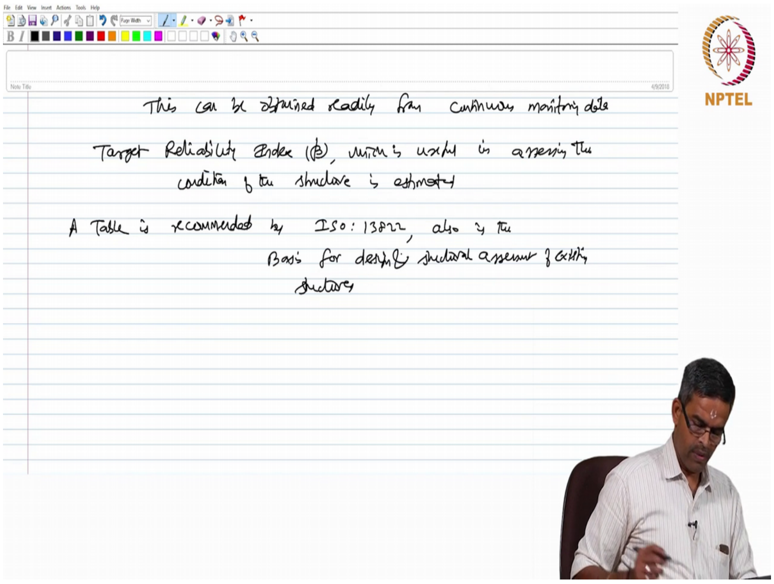

Now, the best solution is this variation can be obtained readily from a continuous monitoring data based on that target reliability index beta which is useful in assessing the condition of the structure is estimated.

So, a table is being recommended by ISO 13822 which also is the basis for design of structures or design of structural assessment of existing structures design and structural assessment. Let us see what is this table?

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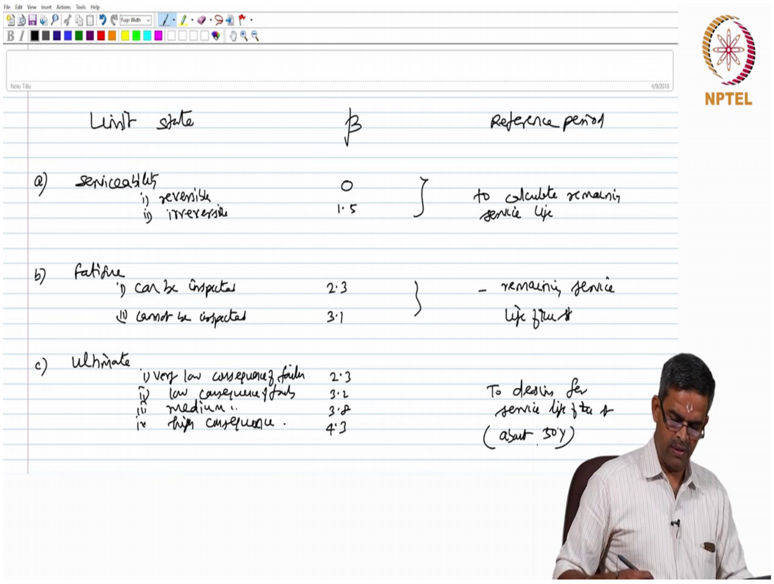

It is varying for different limit states. So, let us say a column like limit state target reliability index and what is the reference period? As recommended by ISO 13822. There are three states of limit states as we indicate here; serviceability fatigue limit state and ultimate limit state.

Under serviceability if I have reversible or irreversible the reliability index is 0 and 1.5 which is useful to calculate the remaining service life of the structure. For fatigue reliability the condition saw if the structure can be inspected or it cannot be inspected the structure can be inspected then target reliability index is 2.3 if not is 3.1 which will also help you to calculate the remaining service life of the structure.

For ultimate limit state there are four categories; very low consequence of failure, low consequence of failure, medium consequence of failure and high consequence of failure. So, it is classified based on the consequence of failure and the reliability indexes are 2.3, 3.2, 3.8 and 4.3. They are actually used to design for service life of the structure, usually the service life design is about 50 years.

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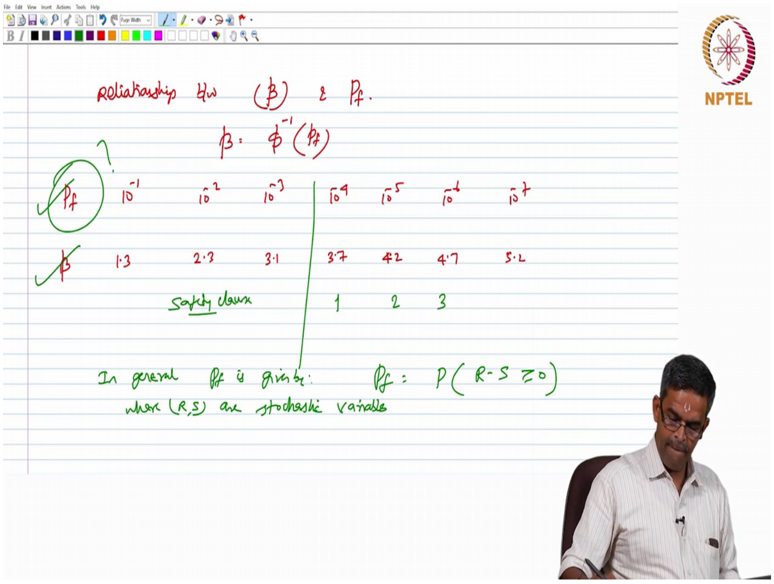

Now, let us see the relationship between the target reliability index beta and the probability of failure. Beta is actually given by the phi function inverse of probability of failure, where the table says probability of failure and beta are connected by a simple figure for different values of failure 10 power minus 2, minus 3, 4, 5, 6 and 7; 1.3, 2.3, 3.1, 3.7, 4.2, 4.7 and 5.2.

However, friends, interestingly there is a safety class which is also introduced depending upon the reliability index. So, this safety factor or safety class is 1 and 2 and 3. So, in general if I know the probability of failure I can find the index or if I know the reliability index. I can always check what is my probability of failure of a given system which, tells me the assessment of the structure, which is actually accumulated and collected from the continuous monitoring data.

So, in general probability of failure is given by the following expression which is probability of R minus S exceeds 0, where R and S stochastic variables.

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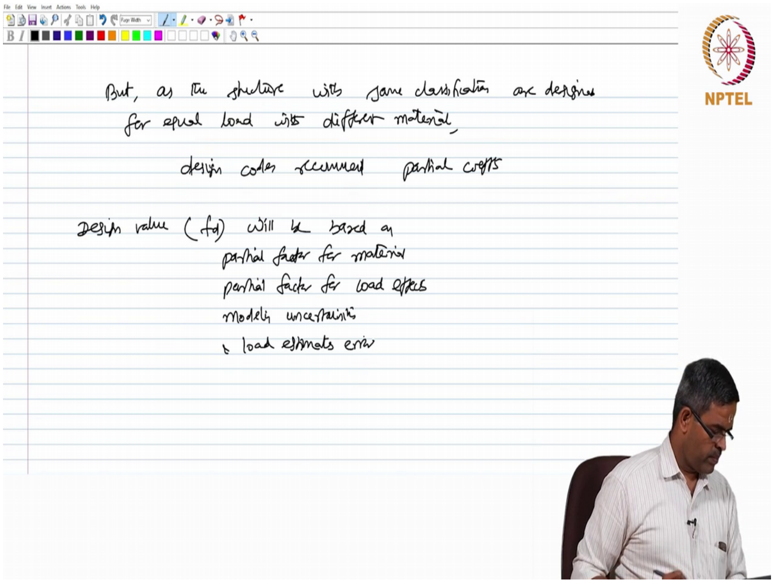

But, as the structures within same classifications are designed for equal loads with different material there are need to be a modification to the estimate of probability of failure as we discussed in the previous slide.

So, therefore, design codes recommend partial coefficients. The design value which is f d will be based on the partial factor for material, partial factor for load effects to cover the modeling uncertainties and error in load estimates.

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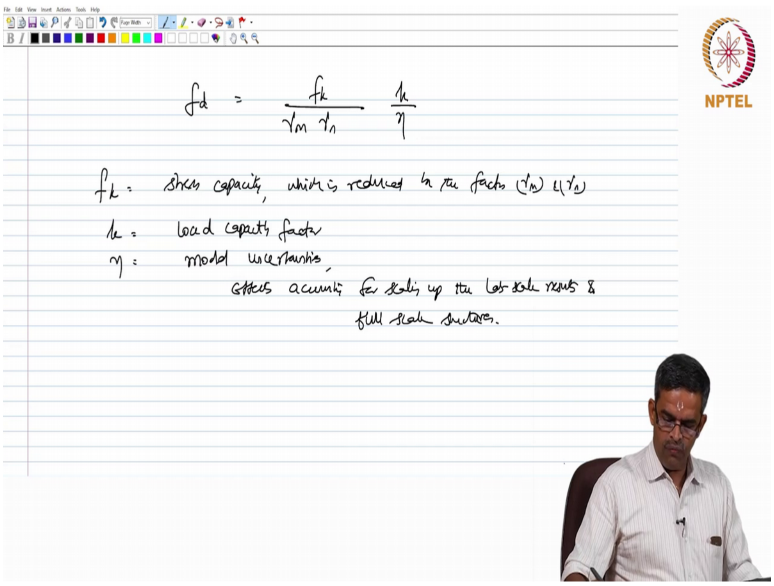

So, f d is given by f k by gamma m and gamma n, k by eta; where f k is the stress capacity which is actually reduced by the factors gamma m and gamma n; k refers to load capacity failure, sorry load capacity factor and eta refers to the value accounting for model uncertainties and effect accounting for scaling up the lab scale results to full-scale structure.

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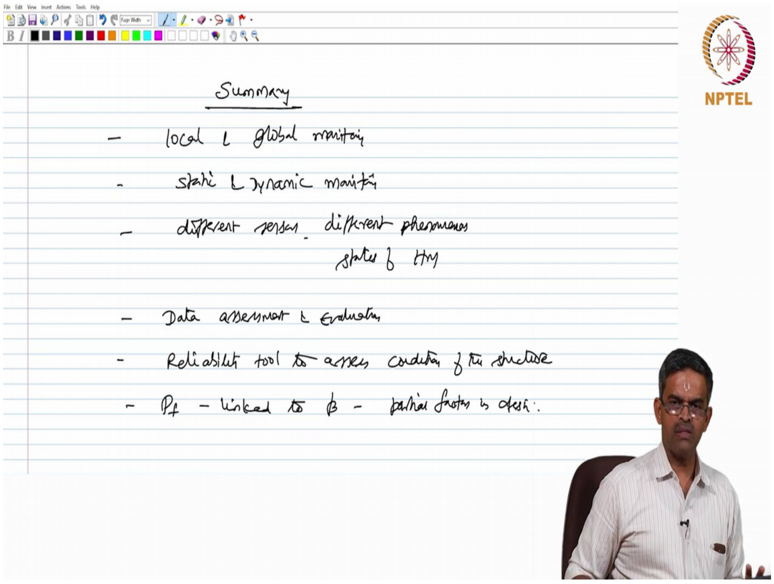

So, friends, in this lecture we learnt about local and global monitoring. We understood what conditions static and dynamic monitoring are carried out. We also learned use of different sensors for different monitoring phenomena and different states of health monitoring like local, continuous, periodic and triggered monitoring.

We also learned the importance of data assessment and evaluation. We learnt the use of reliability as a tool to assess condition of the structure whose data is actually supplied from the continuous monitoring system and we also learned how the probability of failure is linked to the reliability index and why we use partial factors in design.

We will continue with the discussion in the next lecture and explain different methods of monitoring further in detail where we talk about damage identification and how to actually plan for a structural health monitoring scheme.

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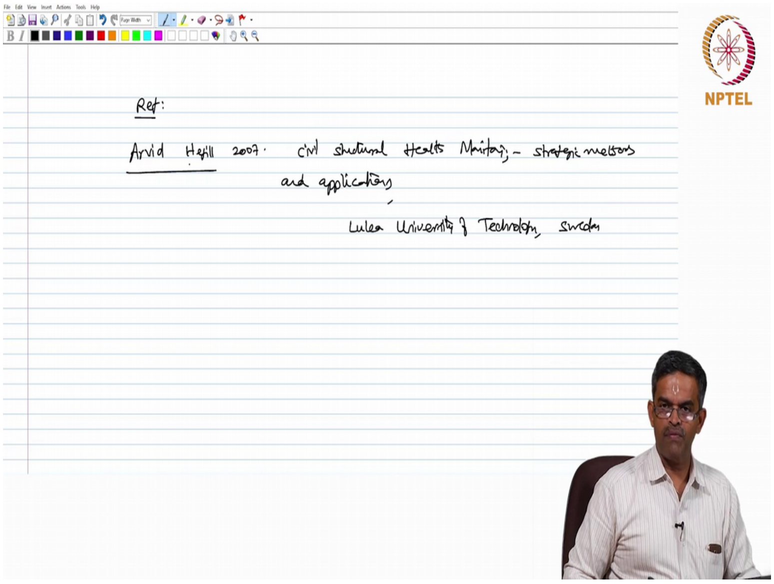

So, that is a good reference which you should read to learn more about this the good reference is Arvid Hejill, 2007, Civil Structural Health Monitoring - strategic methods and applications, Lulea University of Technology, Sweden. We give credits to this author for highlighting important methods of health monitoring in civil infrastructure.

Thank you very much.