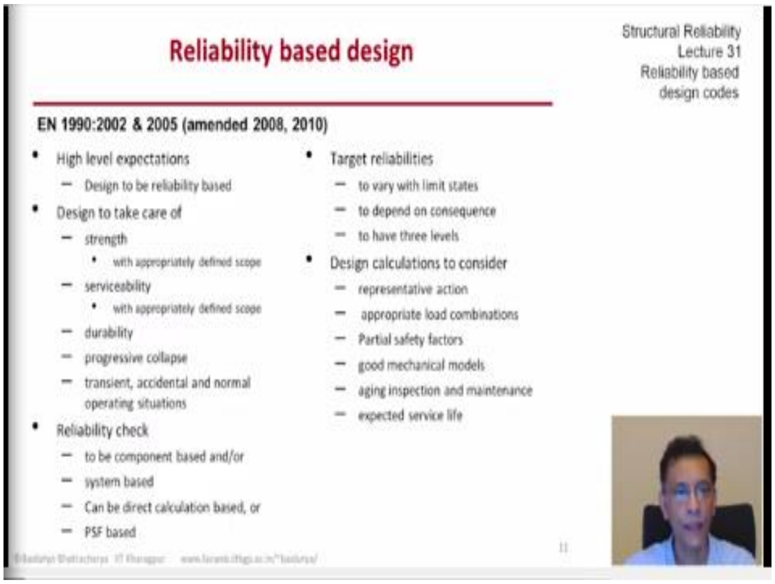
Structural Reliability
Prof. Baidurya Bhattacharya
Department of Civil Engineering
Indian Institute of Technology-Kharagpur

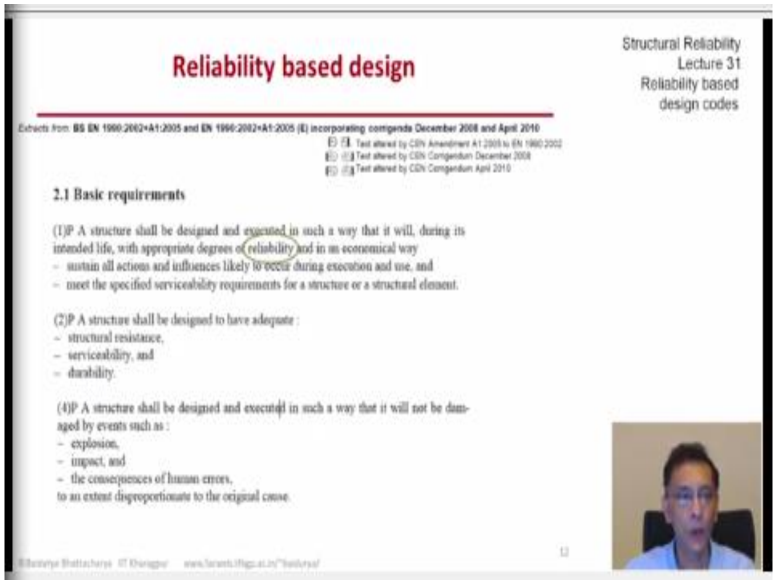
Lecture-230
Reliability Based Design Codes (Part-06)

(Refer Slide Time: 00:27)



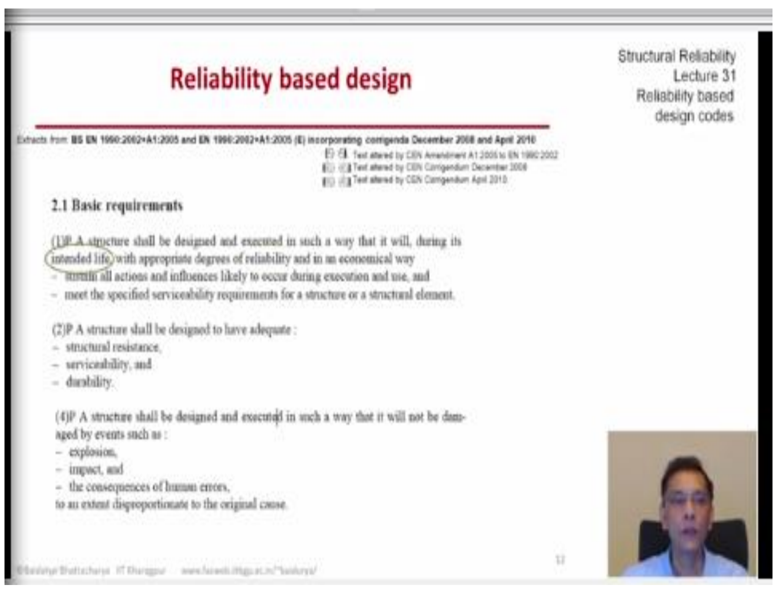
So, after presenting this summary storyline, describing the high level expectations behind the structural Euro codes EN 1990, let us see in the next few slides how the code makers have expressed these expectations through codal provisions. And we are going to look only at the first few pages of EN 1990.

(Refer Slide Time: 00:57)



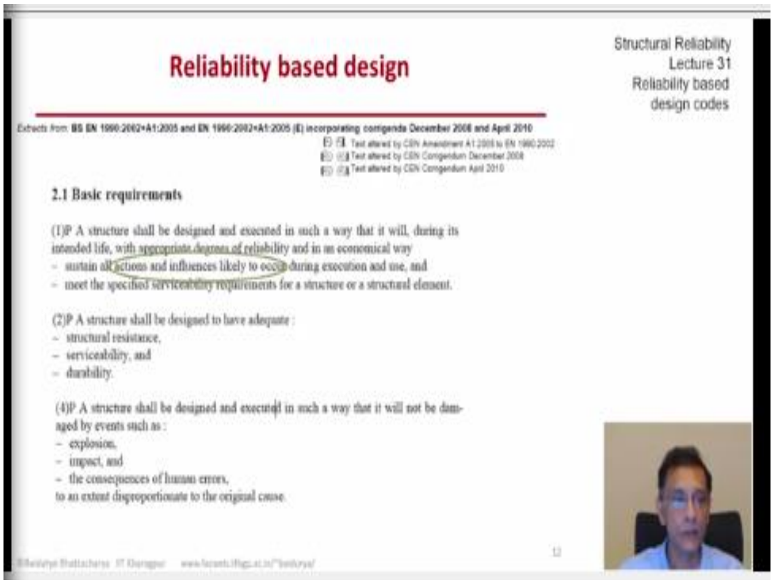
So, the very first set of requirements section 2.1 clearly lays down the context and the parameters behind the code. So, the code is reliability based we are very clear about that.

(Refer Slide Time: 01:19)



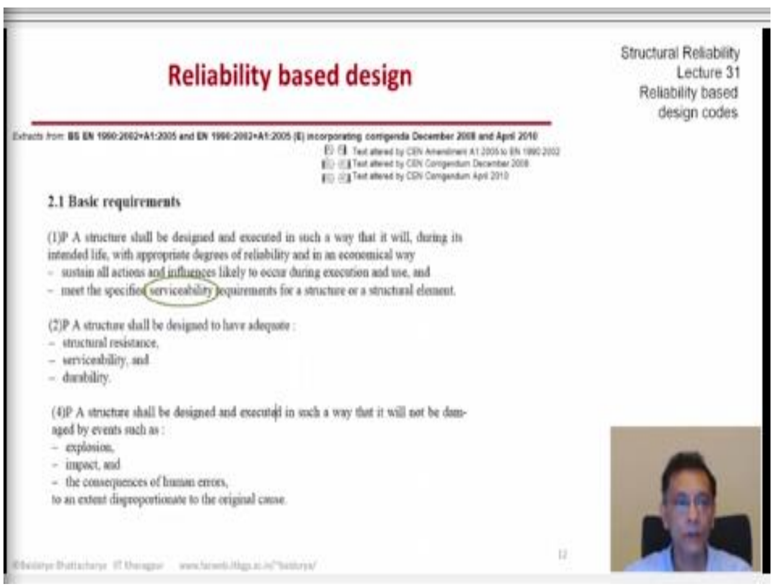
We also see the issues related to the definition of reliability that we discussed early on in this course. They are all contained in this sentence; there is an intended service life.

(Refer Slide Time: 01:35)



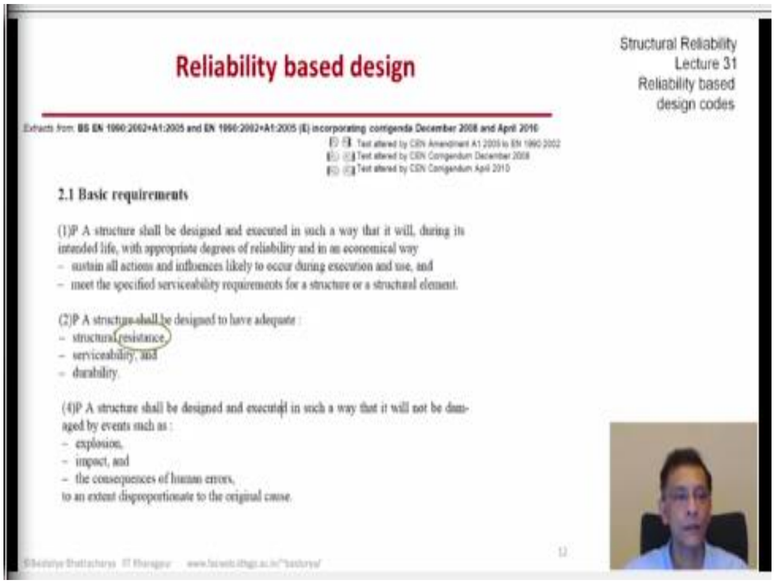
There are all service conditions and demands that are placed on the system. So, those are the loads and the structure should not fail under those loads.

(Refer Slide Time: 01:47)



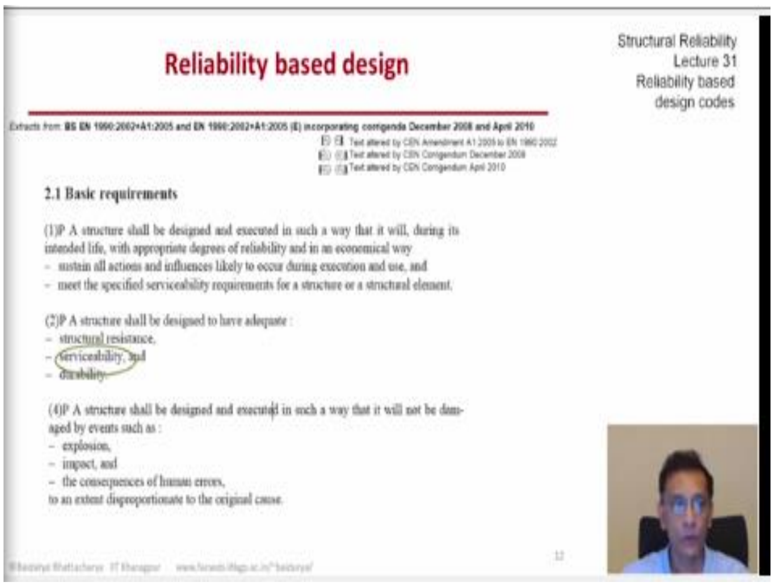
And the structure should also function. So, all the boxes are checked.

(Refer Slide Time: 01:56)



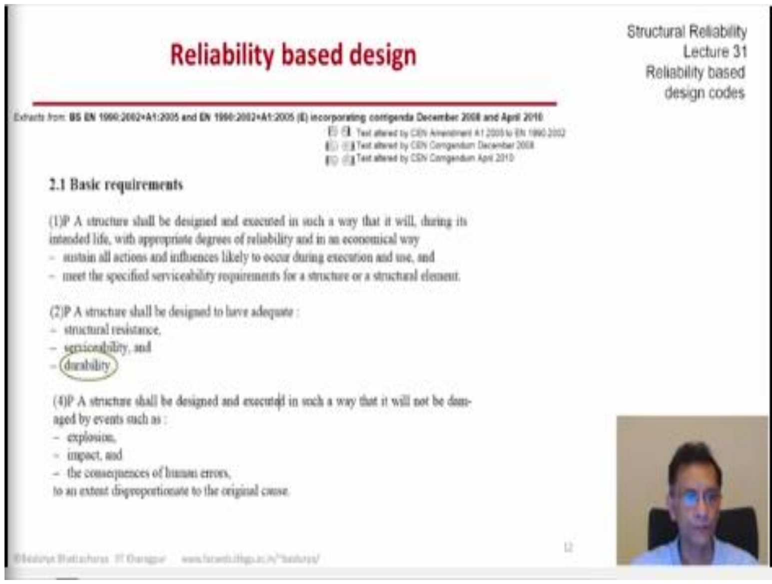
And more specifically, so that there is no ambiguity the strength issue.

(Refer Slide Time: 02:03)



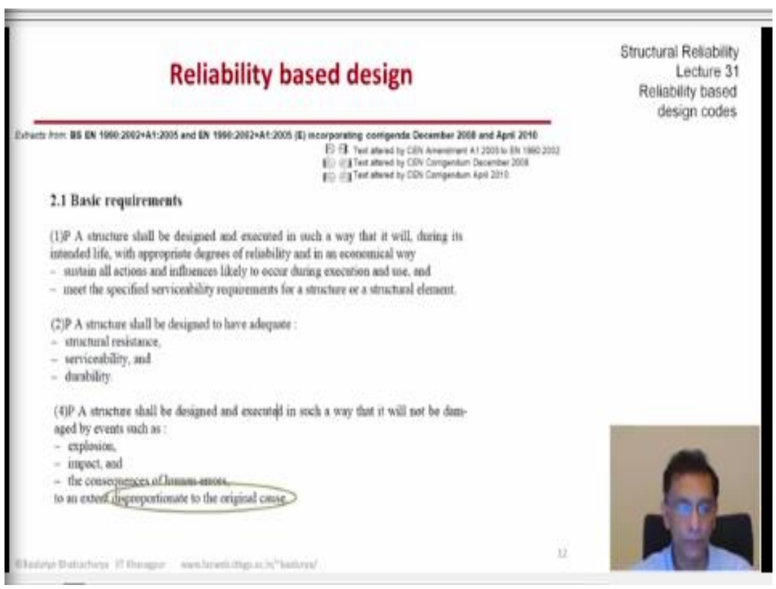
The functionalities issue.

(Refer Slide Time: 02:05)



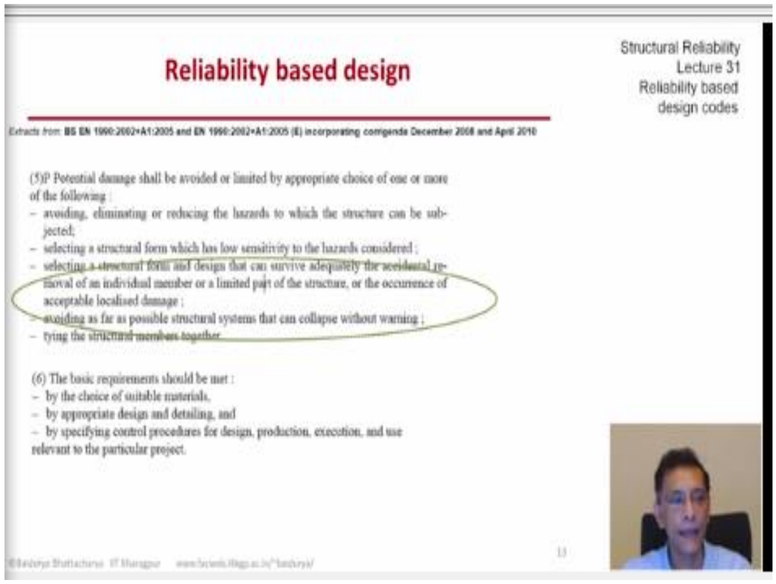
And the longevity issue, the time dependent issues they are clearly spent out.

(Refer Slide Time: 02:12)



Very early on it is interesting to see the code makers have been worried about and they have expressed the progressive collapse issue. So, this disproportionate collapse a progressive collapse has shown up quite early in the codal sentiments.

(Refer Slide Time: 02:37)

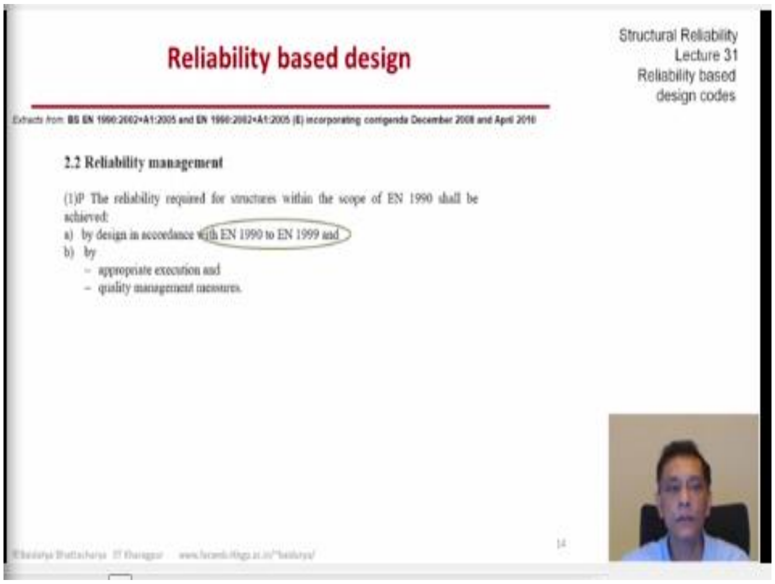


And in the next few provisions also we see more details on how this sort of progressive collapse can be prevented.

(Refer Slide Time: 02:53)

And then the code says that all of this should be done by appropriate design. So, the importance of design has been not left to any ambiguity.

(Refer Slide Time: 03:08)

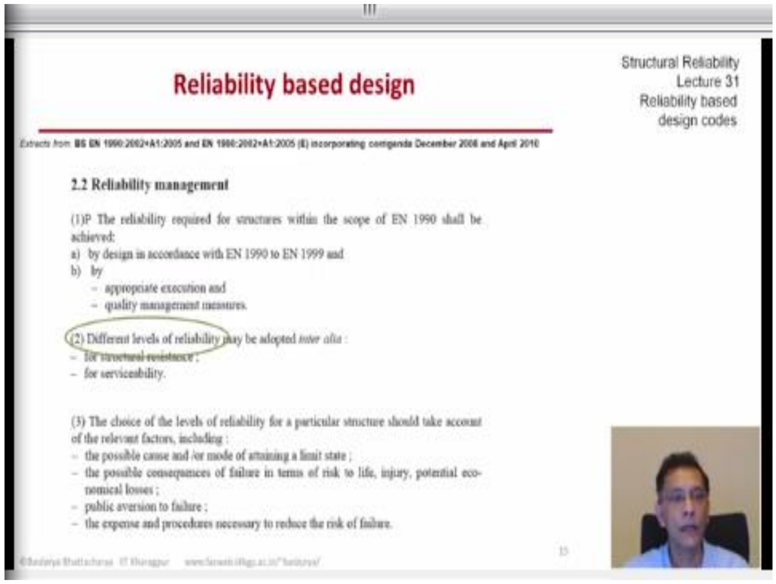


Now here we see the introduction of all the companion documents. So, EN 1990 shall be read with 91 through 99.

(Refer Slide Time: 03:23)

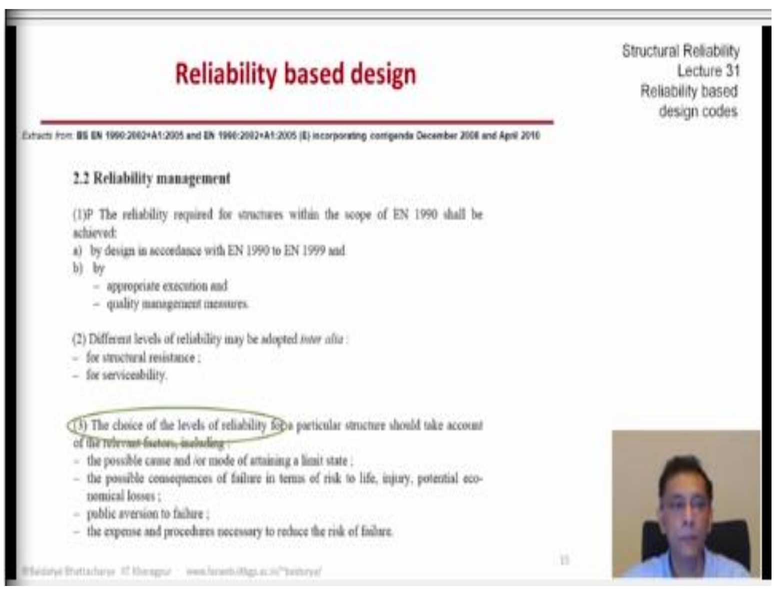
And they are listed here that covers various materials, various loads and so on.

(Refer Slide Time: 03:33)



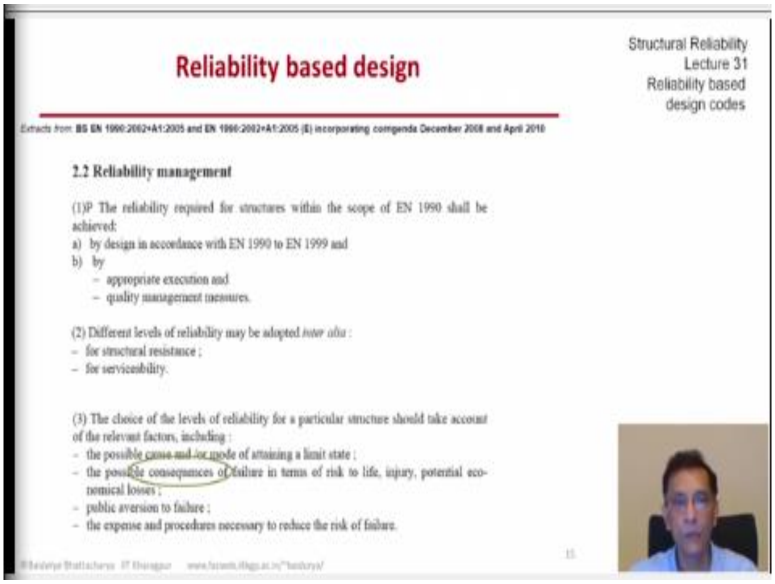
Now we come to the point that different limit states, different types of expectations should have different levels of probability of exceedance or acceptable reliability.

(Refer Slide Time: 04:00)



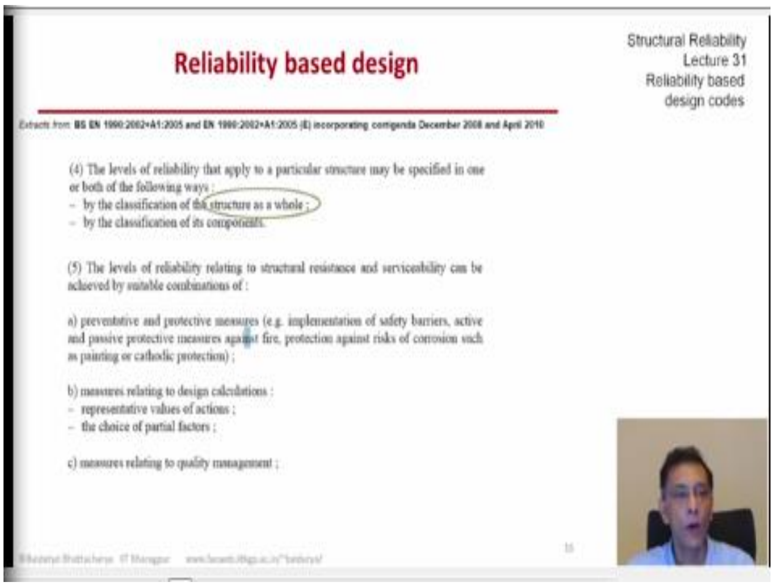
So, depending on the consequence these target liabilities should change or should be made different.

(Refer Slide Time: 04:11)



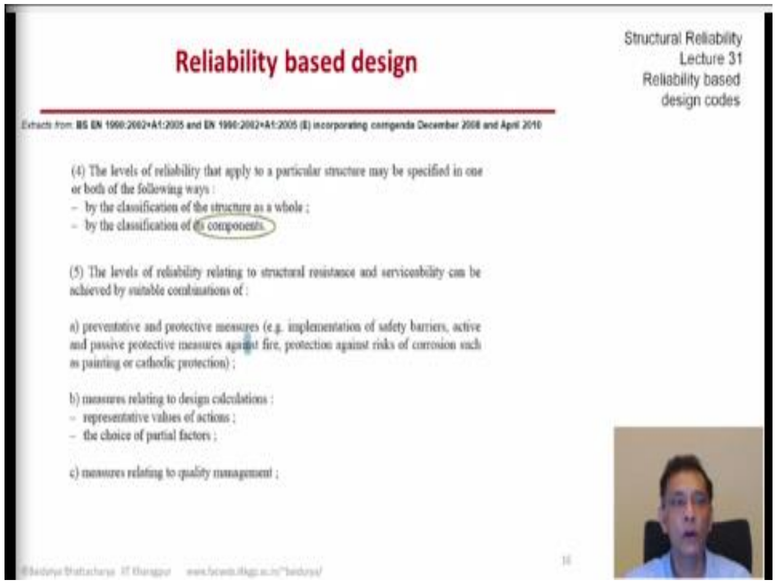
So, that is also spelt out very clearly. So, far we have understood that the design has to be reliability based different consequences must have their respective acceptable reliabilities.

(Refer Slide Time: 04:26)



And then we come to the point of how to do this safety check whether it should be done as the structure as a whole or on a component basis?

(Refer Slide Time: 04:42)

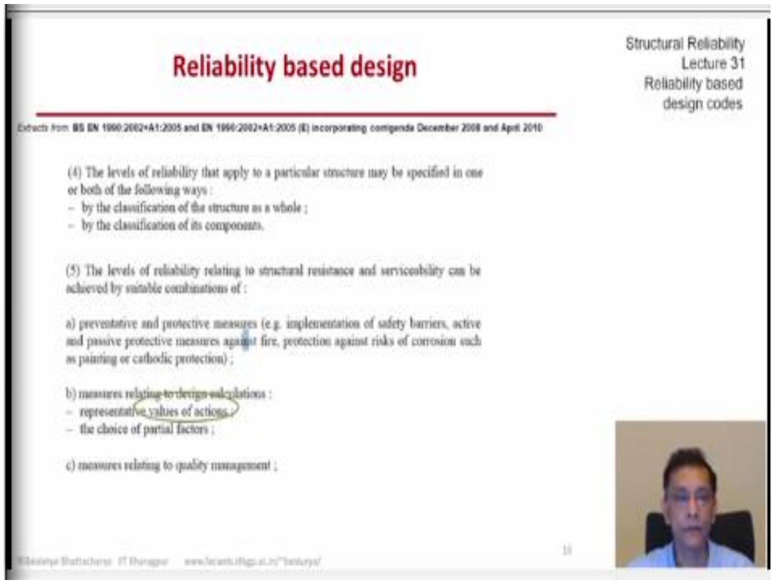


Both options have been given and it so happens that we are still more tuned towards a component based design approach than whole systems based design approach.

(Refer Slide Time: 04:57)

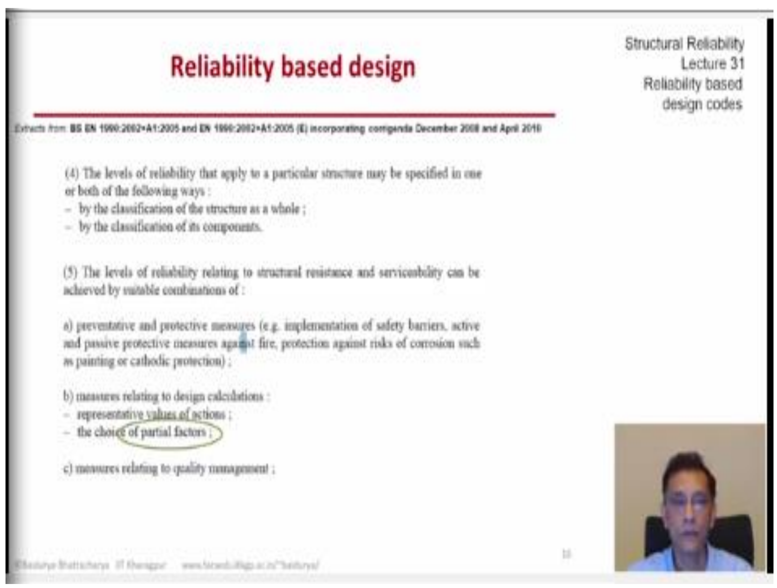
Then these design calculations becoming more specific have to be based on representative actions.

(Refer Slide Time: 05:06)



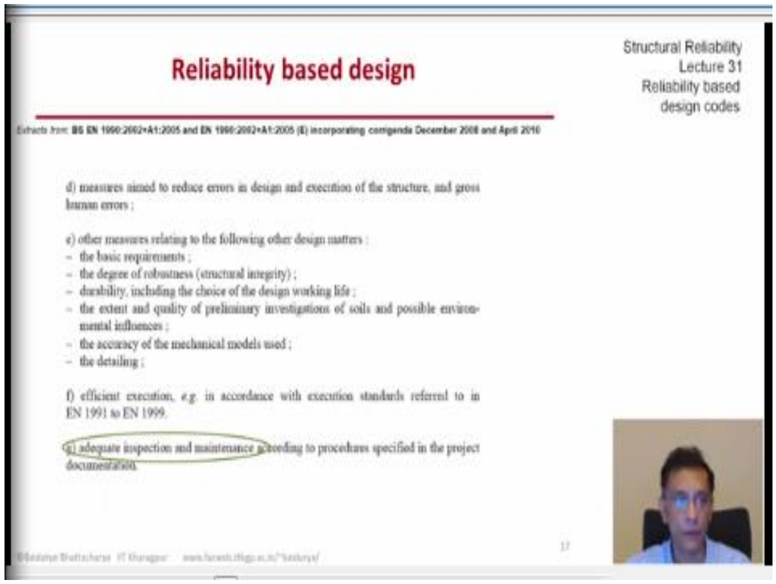
The sort of quantities that we saw in those partial safety factor based equations.

(Refer Slide Time: 05:12)



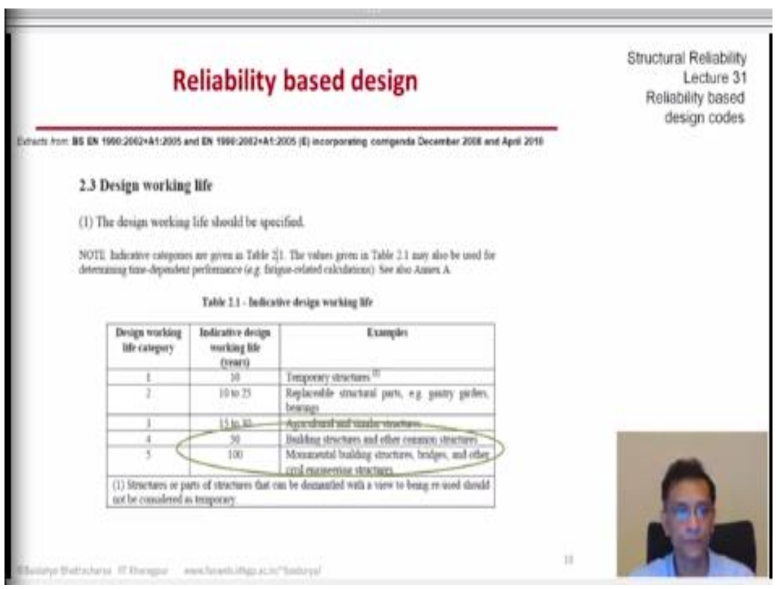
And more specifically the choice of partial safety factors. So, the partial safety factors are also introduced very early on in the design document.

(Refer Slide Time: 05:27)



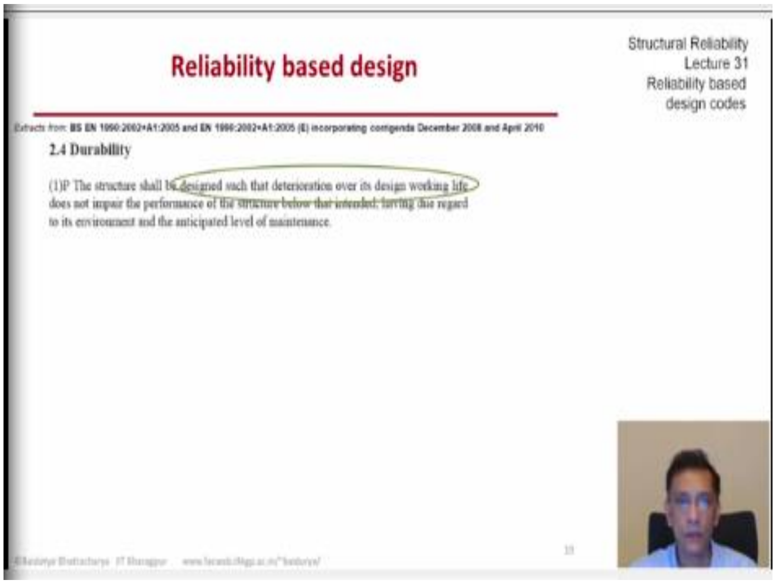
Next we are reminded of the importance of inspection and maintenance because of all the time dependent issues related to aging and accumulating damage.

(Refer Slide Time: 05:43)



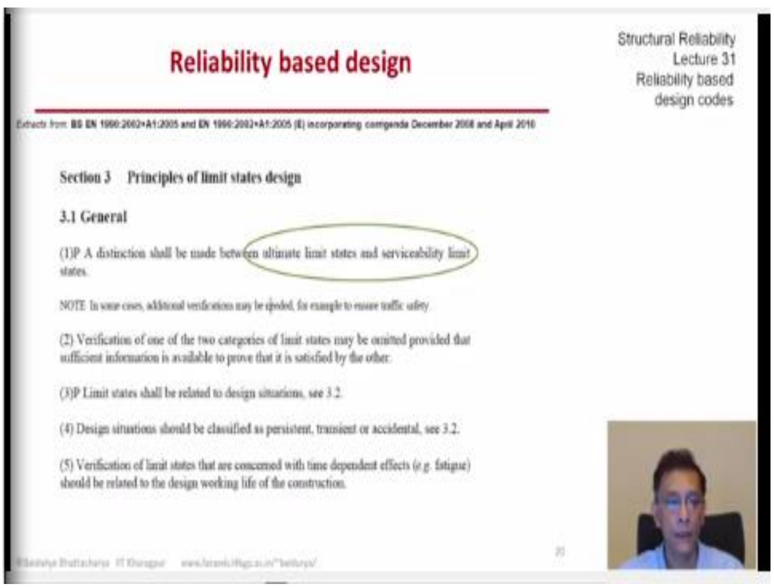
More specific things now, so the design working life depending on the type of structure that is Ranna needs to choose the service life, the intended life. And that is typically for the kind of structures that we undertake formal designs are of the order of 50 to 100 years.

(Refer Slide Time: 06:09)



And then the issue of durability once again comes up and the designer is cautioned that all issues related to aging and environmental degradation have to be anticipated and considered.

(Refer Slide Time: 06:31)

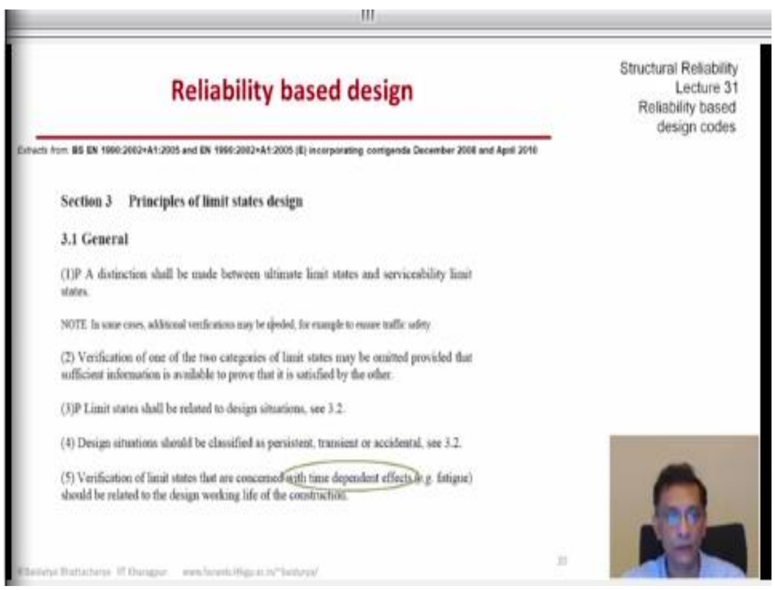


Finally more details on the type of limit states to be considered are spelt out. So, we see specifically that ultimate limit states and serviceability limit states have to be considered.

(Refer Slide Time: 06:53)

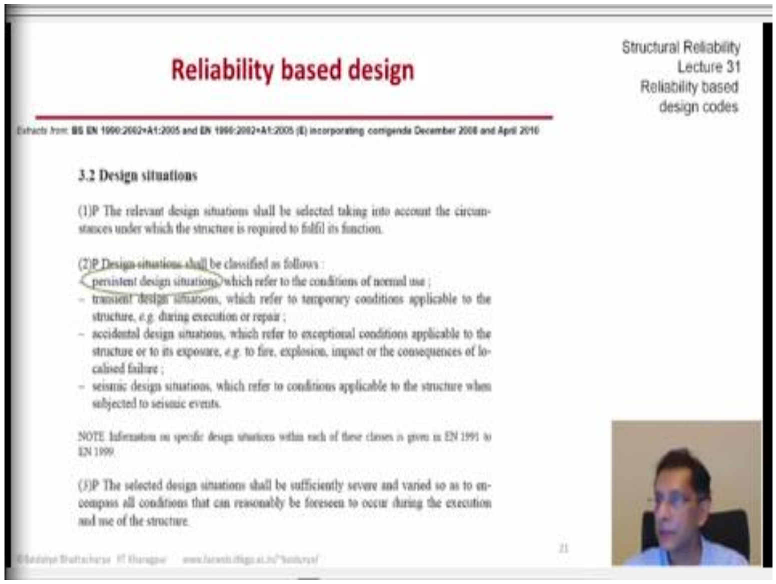
Not only that, the designer also needs to worry about not only the operating condition but transient situations and accidental situations as well. So, that presumably includes the construction phase as well.

(Refer Slide Time: 07:11)



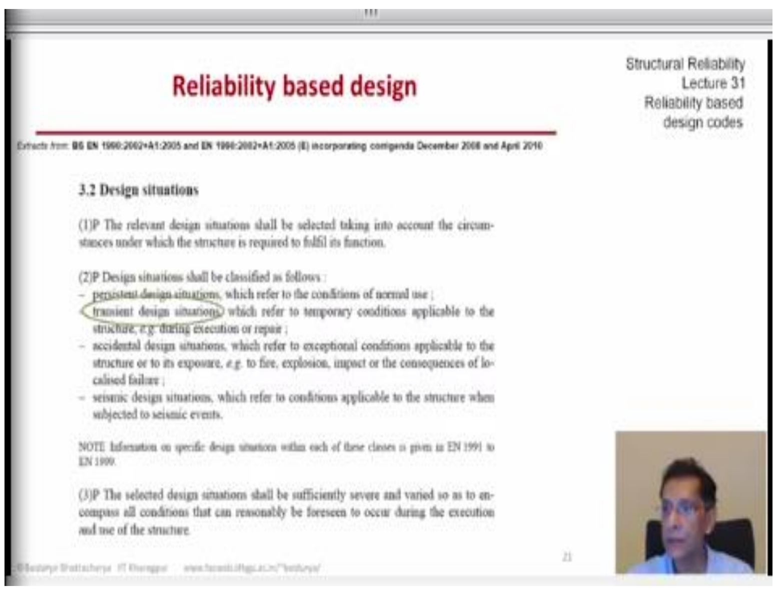
Once more time dependent issues are again brought out and the designer is reminded of that.

(Refer Slide Time: 07:20)



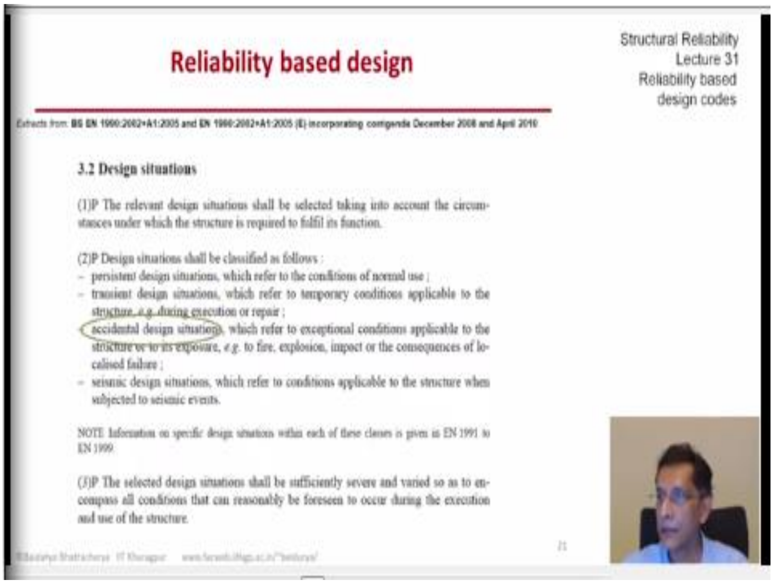
Now the design situations, the normal and abnormal and the transient etcetera, so more details are given now. So, the persistent design situation.

(Refer Slide Time: 07:34)



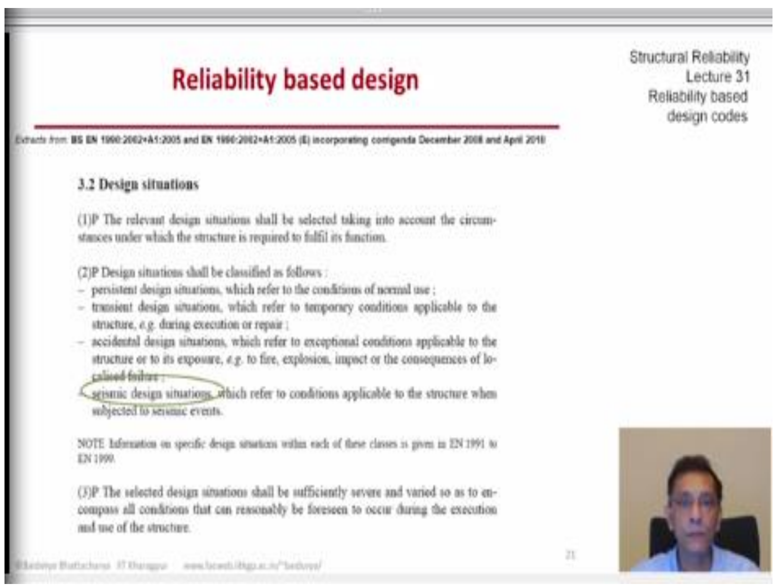
The transient design situation.

(Refer Slide Time: 07:36)



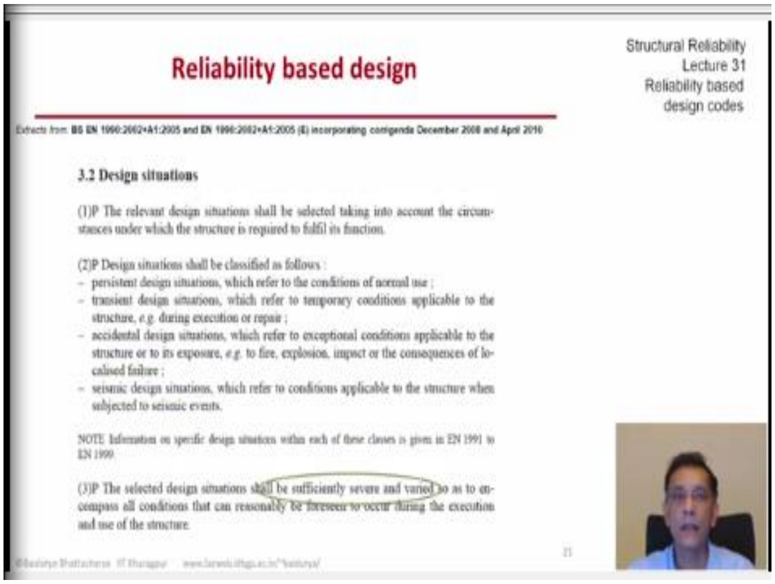
The accidental design situation.

(Refer Slide Time: 07:39)



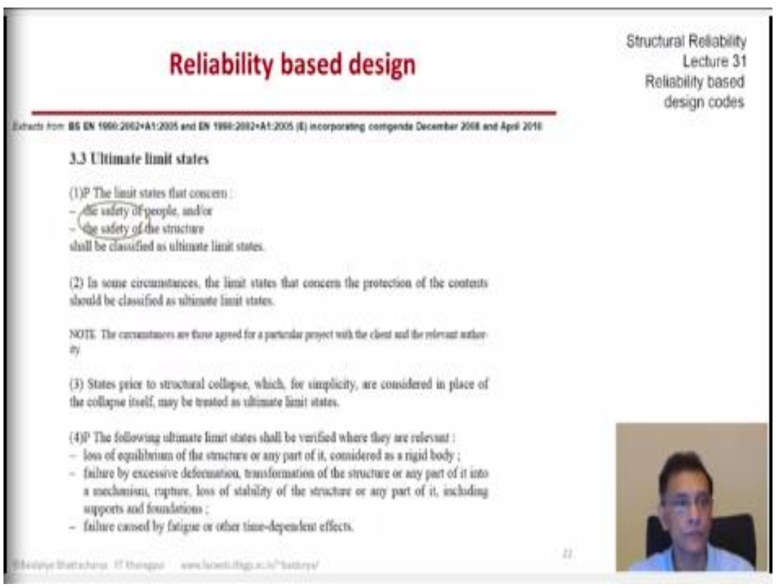
And the seismic design situation. So, special place of mention has been there for the seismic loads.

(Refer Slide Time: 07:51)



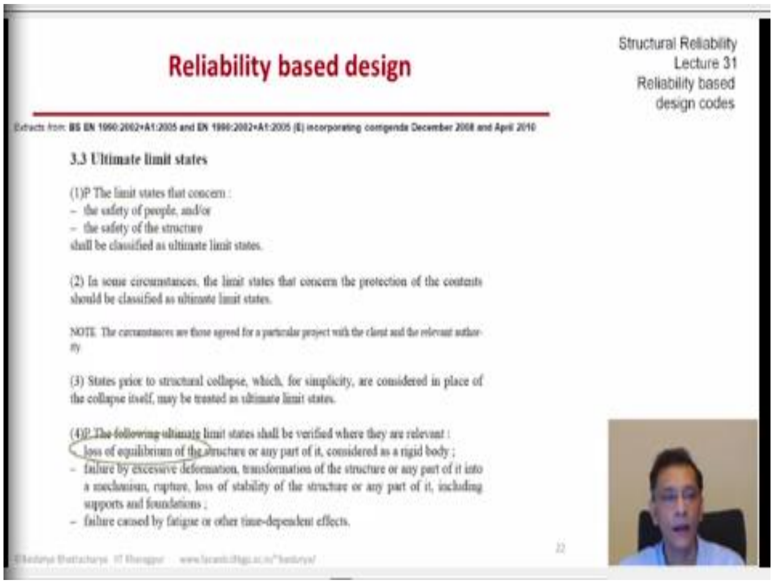
And then the designer is again reminded that he or she has to take care of all likely scenarios, so nothing should be left out of consideration at the design stage.

(Refer Slide Time: 08:10)



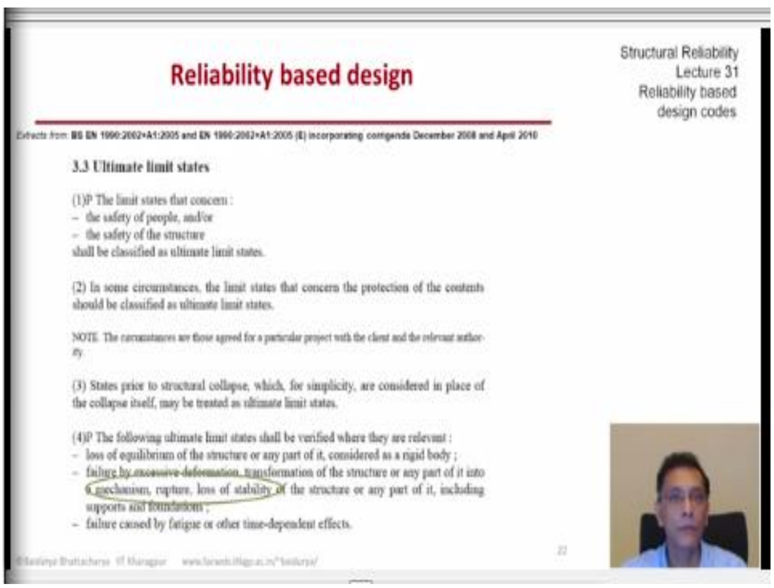
Now more details about the ultimate limit state and now we are getting more specifics that this limit state has to do with life safety or safety of very important assets.

(Refer Slide Time: 08:24)



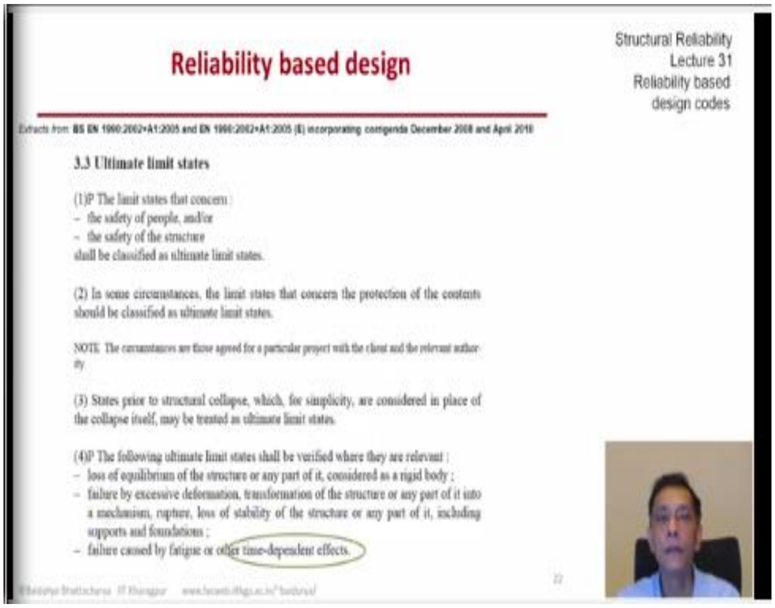
And more details about what sort of definition of this sort of failure? This ultimate limit state collapse should be considered.

(Refer Slide Time: 08:40)



So, loss of equilibrium, creation of a mechanism, loss of stability, rupture etcetera, would all come under this sort of ultimate or collapse limit state.

(Refer Slide Time: 08:56)

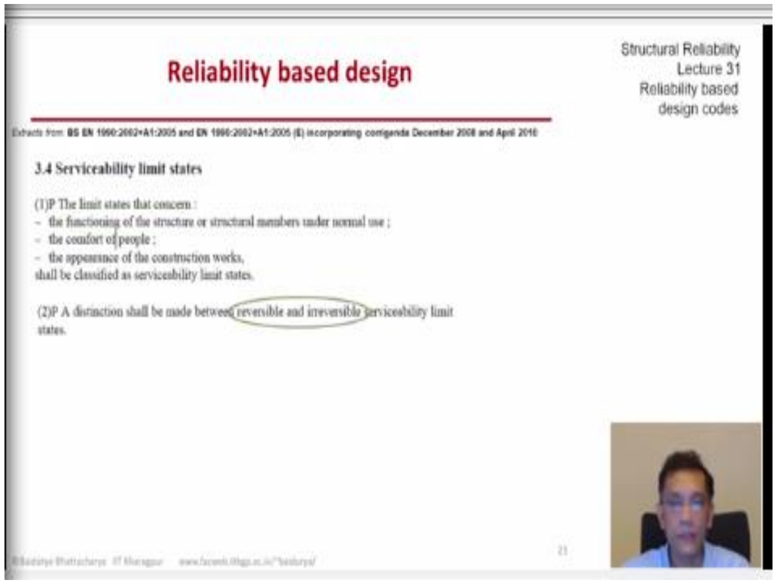


Time dependent effects should also not be forgotten. So, we are seeing again and again that the code makers want to remind the designer that time dependent effects have to be kept in mind. And then serviceability limit state is next.

(Refer Slide Time: 09:15)

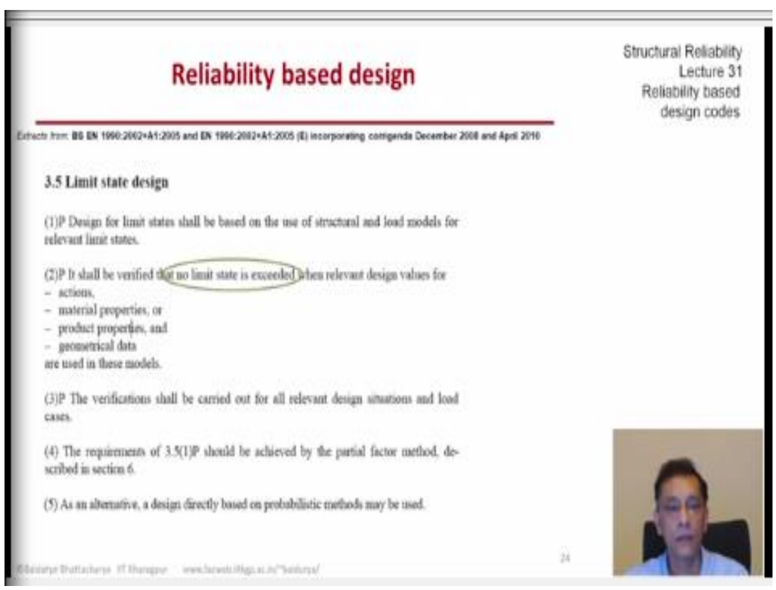
So, there the designer is reminded that everything to do with the proper functioning even though it does not interfere with safety, life safety, asset safety or any loss of stability but still the structure has to function. So, the designer is reminded of that and we see that the details.

(Refer Slide Time: 09:45)



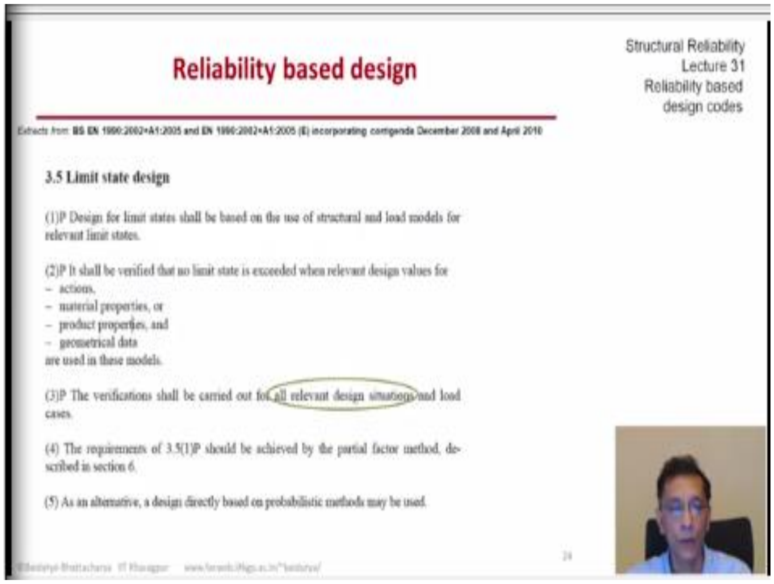
And 1 interesting distinction is drawn here between the reversible and irreversible service within limit states. And if you remember this would somewhat come under the consideration of whether we are talking about reliability or availability. So, if something is reversible then you remember that we said the term availability is more appropriate. So, here we see a broadening of the definition of reliability in certain situations.

(Refer Slide Time: 10:20)



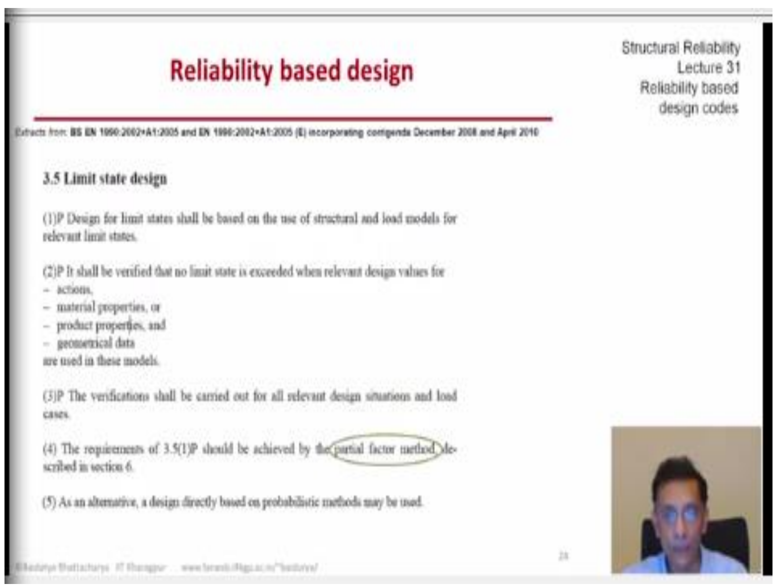
Then we go a little deeper into this concept of limit state design. So, the limit states are more firmly defined and again the designer is reminded.

(Refer Slide Time: 10:34)



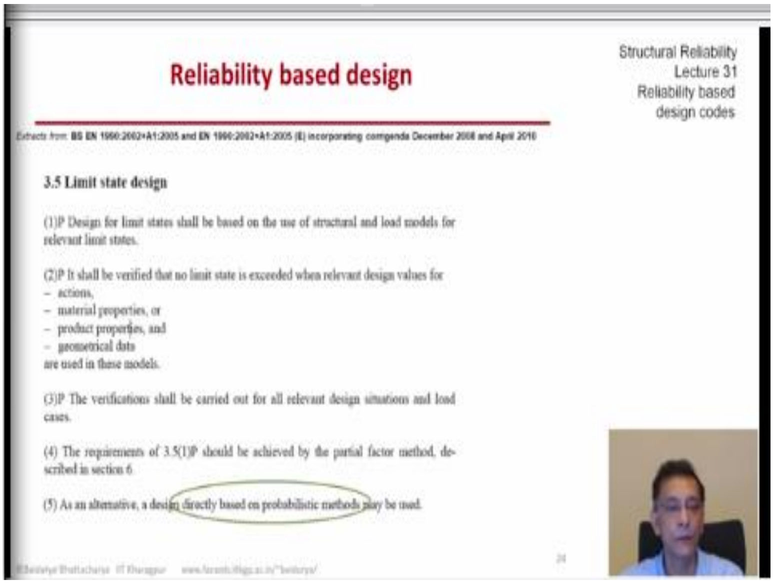
That all relevant design situations must be considered.

(Refer Slide Time: 10:40)



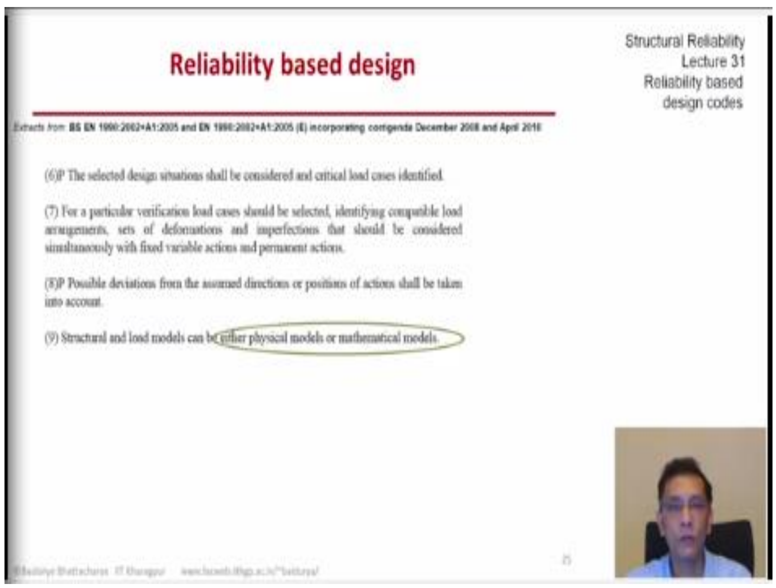
And the preference for partial safety factors is clearly stated.

(Refer Slide Time: 10:49)



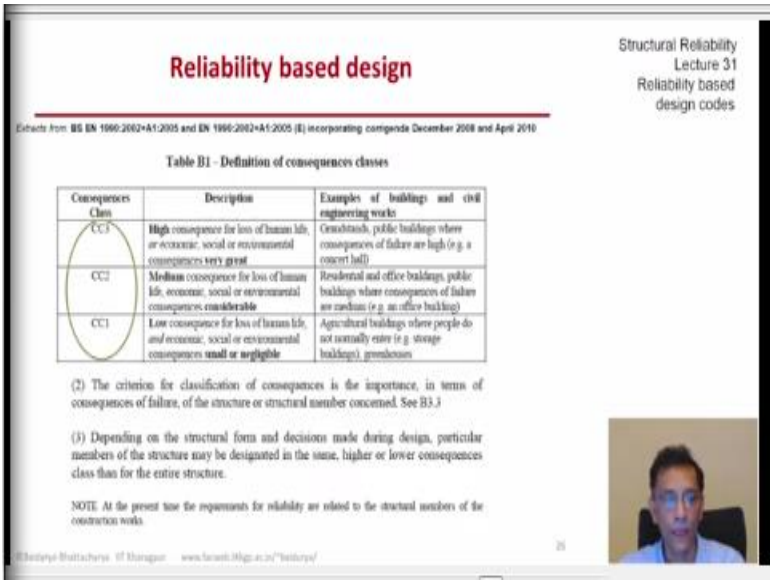
But the designer is also given the option of doing a direct reliability based analysis.

(Refer Slide Time: 10:59)



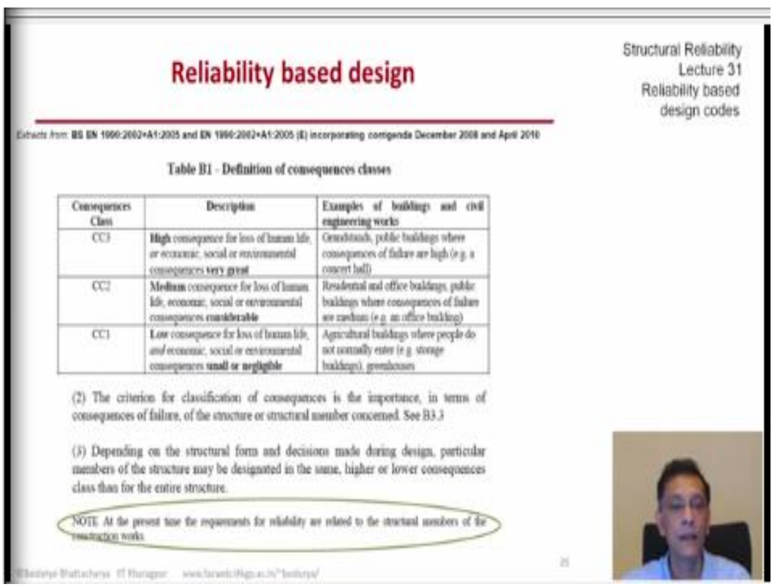
We have talked about models. So, here the code makers emphasize the importance of good modeling and this could be a combination of physical and mathematical models.

(Refer Slide Time: 11:17)



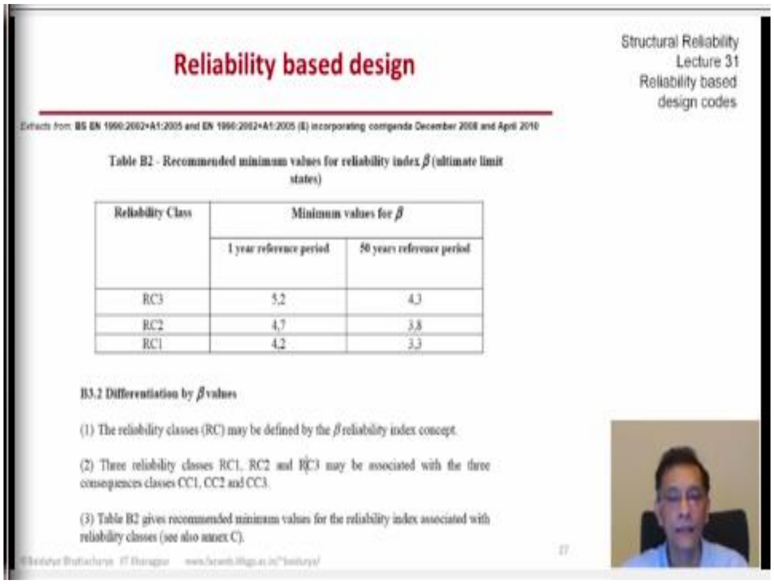
Then details about the consequences. So, we have been told about limit states, we have been told about target reliabilities and now these target reliabilities have to be tied to consequence classes. So, 3 consequence classes have been defined early on and the designer has to decide which class their structure comes under.

(Refer Slide Time: 11:46)



And again this note is actually very important, this tells the designer that so far all these requirements in terms of acceptable failure probability are to be applied to structural members or they are component based. So, these targets that we are going to see next, they are going to pertain to structural elements, components and not the entire structure. And that is actually consistent with the fact that I said that still most design verification is done at a component level.

(Refer Slide Time: 12:25)



Next comes the corresponding reliability classes. So, each consequence class gives rise to it is corresponding reliability class. And here we see finally the explicit stating of the target beta values, the target reliability indexes. And it is given for 1 year reference period and 50 year reference period for each of the 3 consequence classes or reliability classes. So, this brings an end to our high level discussion and investigation of the philosophy behind the structural Euro codes. And now we will take up more details about reliability based design and what this partial safety factors are? How they come and how they are derived?