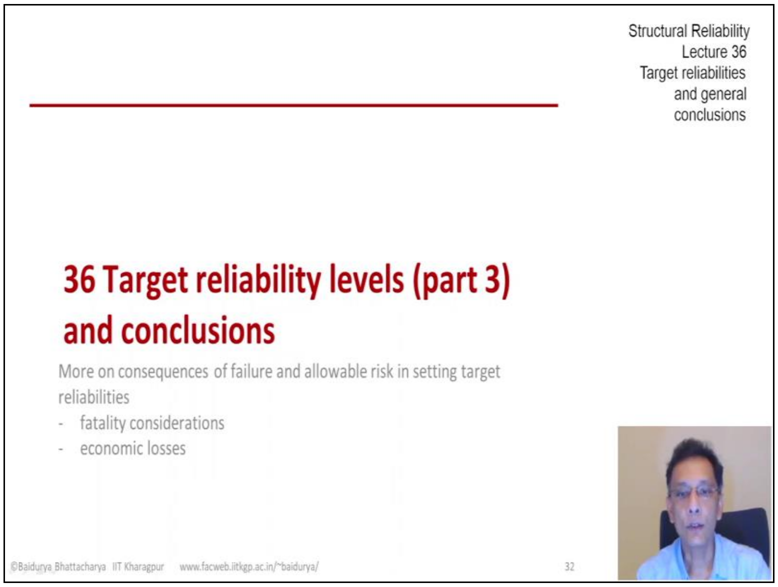
Structural Reliability
Prof. Baidurya Bhattacharya
Department of Civil Engineering
Indian Institute of Technology, Kharagpur

Lecture –248
Target Reliabilities and General Conclusions (Part - 01)

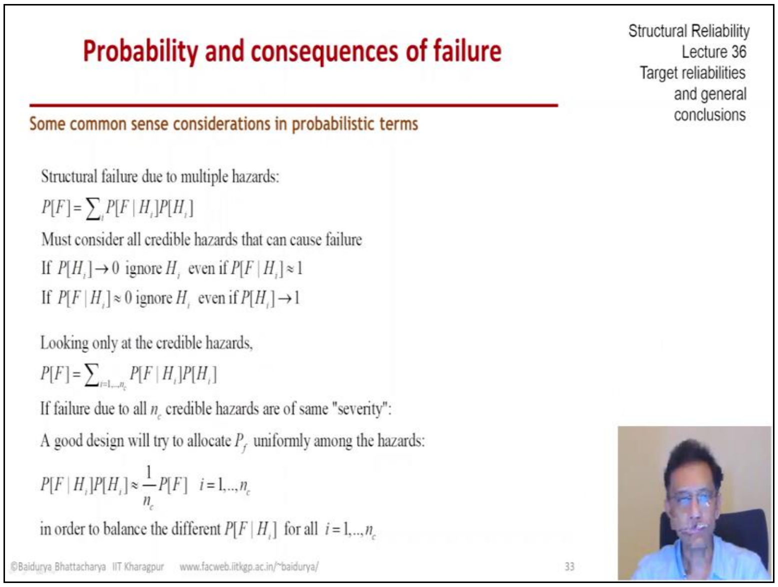
(Refer Slide Time: 00:27)



We have arrived at the last lecture of our course on structural reliability we have learned how to model uncertainties how to define limit states and frame reliability problems how to compute failure probabilities and how to derive factors of safety in a reliability based design. In this final week we have been discussing how to set target reliabilities. So, that we can decide whether the failure probability we compute is acceptable or at what reliability should peg the factors of safety when we develop a design equation earlier this week we studied how the reliability based design codes around the world have evolved.

And we concluded that there is a near universal consensus that the target reliability in any limit state should be tied to the consequence of that limit states violation. So, higher the consequence higher the target reliability we have also seen that the failure consequences we should worry about range from loss of functionality to economic loss environmental damage to large-scale societal disruption and loss of human life or of many lives with such a wide range of possible consequences let us try to put them on a common framework.

(Refer Slide Time: 02:27)



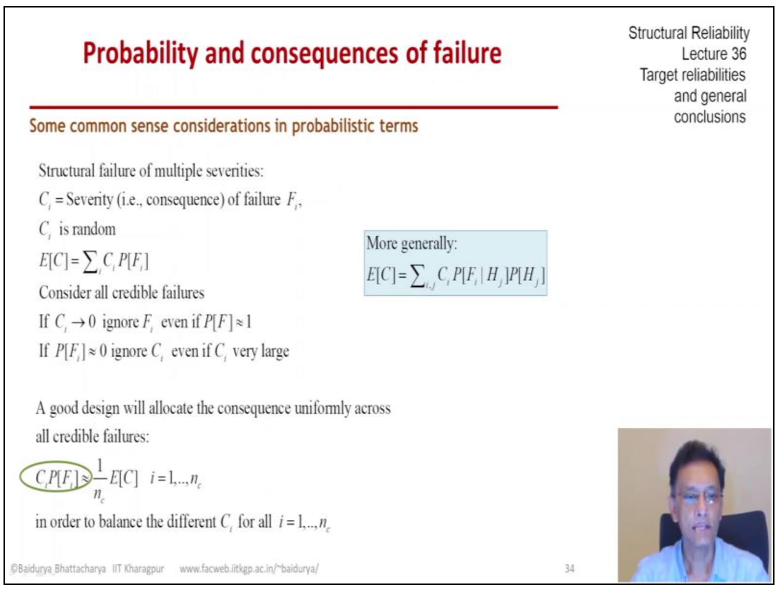
Let us go back to our old friend the theorem of total probability and let us describe the probability of structural failure when there are multiple hazards and we have been talking about these a lot. So, if all the ages if all the hazards constitute a partition of the sample space then we can definitely write this. So, P of F the probability of structure failure is the sum of the conditional probability of failure given a particular hazard times the probability of that hazard now one of the important practical considerations in design is that all credible hazards that can cause failure must be included.

So, the operative word here is credible which basically means is that if even if a hazard is very severe or is definitely going to cause damage or complete failure if it is unlikely if it is if P of H i is approaching zero then we should ignore it and on the other extreme even if some event is very likely even if some h is very likely if it does not cause any damage then we should ignore that as well. So, this basically is the practical consideration behind load combinations that need to be considered in design.

So, now looking only at those credible hazards and let us say we have NC of them. So, we should we should reduce the number of H's that we consider and P of F would be the sum over only the NC of them. Now if we are talking about failure of the same kind of the same severity then a good design will try to allocate the failure probability uniformly across all the hazards which basically mean that the product of P of F given H and P of H should all be of the same order.

So, roughly one over NC times P of F, P of being the total probability of failure and it is something like if I have say at a location I have the wind hazard and the snow has it and both can cause my structure to collapse. So, we are talking about failure of the same severity but wind is twice as likely as the snow. So, then I should make my structure twice as strong against wind compared to snow. So, that is that is what the engineer intuitively would like to do and design would like to accomplish that we can take this thought to consequence.

(Refer Slide Time: 06:08)

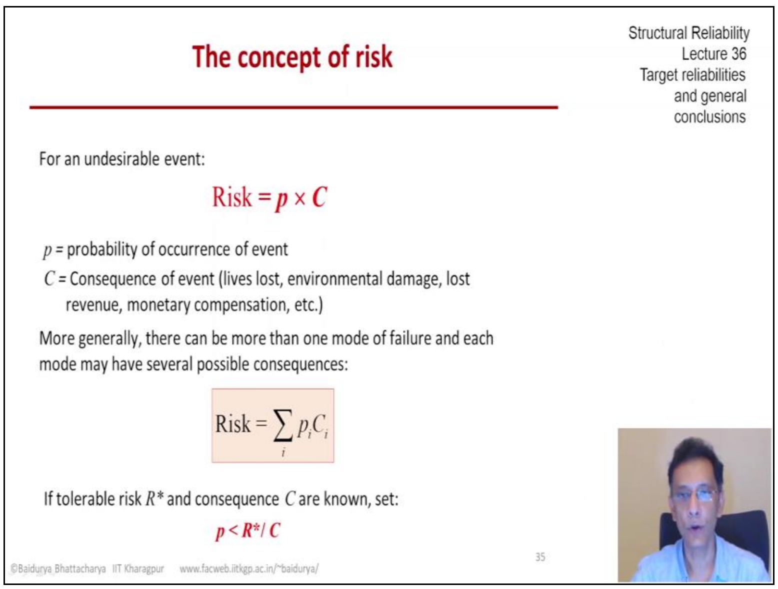


So, now suppose we have failure of multiple severities or consequences and let C be the consequence of failure i. So, f i gives rise to C i now C i is likely to be random in that case we would like to compute the expected value of this random quantity EC and by definition it is C i P of F i over all the different failures that we would like to consider. Now just like as we did previous slide we considered all the credible hazards here we should consider only the credible failures. So, which basically means if the consequence is negligible then we ignore that failure even if that p of f is very close to 1.

On the other extreme if something is extremely unlikely then we should also ignore that even if the consequence is very large. So, a good design just like we saw in the previous slide would like to allocate all the consequence or the total consequence uniformly across all credible failures. So, in other words the product C times P or C i P of i would be of the same order for each i and we would have that roughly the total expected consequence over the number of such different failures that we would like to consider.

More generally if we have to bring in different hazards also. So, that sum will now be over both i and j j being the j hazard. So, instead of P of F i we have P of F i given a j and times P of H but in principle it is the same. Now this particular quantity of C P or C i P F i has a certain name it is a very well known quantity and we call that risk.

(Refer Slide Time: 08:31)



And so for an undesirable event risk is P times C the probability of occurrence of the event times the consequence of that event and now we go back to what we discussed in the title slide that there is a range of possibilities or range of consequences possible starting from lives lost being the most severe environmental damage and then monetary losses. Now this risk is a technical term we must understand that although it is also used colloquially.

And in that case it is used interchangeably with the concept of probability and unless there is any scope of confusion one would one could use either one in some disciplines risk means probability especially when the consequence is constant and well defined like one individual fatality like in the medical literature. So, the word risk is commonly used there to mean probability of that event happening of a life being lost for example.

Otherwise if consequences can vary which is what we see here then the risk should include that consequence as well and hence this definition. In a more general sense as we saw in the previous slide if there are more than one failure events and correspondence a corresponding consequence. So, then the risk would be the expected consequence which is P times C summed over all i's. And now here is how we can use risk in setting target reliabilities.

If we have knowledge about the tolerable risk and call it r star and we know the consequence then we can derive the allowable probability the allowable PF the target reliability from the ratio of R star the allowable risk over the consequence. So, that gives us the idea. And now let us see if we can use this idea to also set target reliabilities.