Structural Reliability
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Lecture –251
Target Reliabilities and General Conclusions (Part - 04)

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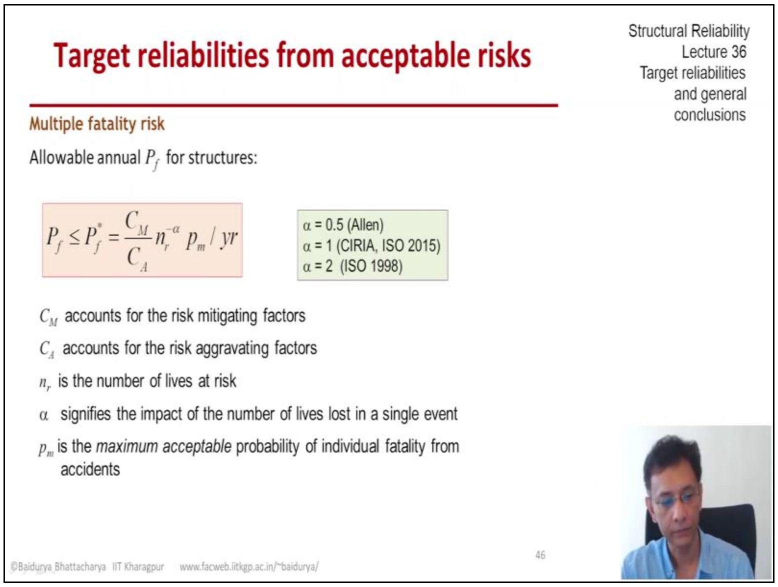

Thus we see in all these surveys that we presented in this lecture and the earlier one is that the target reliability should be based on the consequence of limited violation and the most severe of all consequences is the loss of human life and larger the consequence more should be the target reliability. And we have also seen a general hesitancy of obtaining these target reliabilities especially those that involve loss of human lives those limit states that involve loss of limit loss of human lives.

We see a reluctance to derive the target liabilities from cost considerations from cost optimizations and that is understandable because there are moral and ethical issues of trying to put a value of human life. Although society does that from time to time and we see evidence of that in the form of compensations or damages awarded in the event of loss of one life or several lives. Now the latest revision of ISO 2394 that came out in 2015 has attempted to derive target reliabilities from monetary considerations.

But they have avoided putting direct value on human life but rather used an indirect metric which is the society's willingness to pay to save an additional life. So, this is the thought process the first realization is that saving lives is not free and for a proposed measure to save lives or one additional life would only be applicable or only be acceptable if the marginal life saving cost so the cost incurred to save an additional life it is less than or equal to the that society's willingness to pay for that additional life saved.

So then only such a safety measure could be adopted. Now taking this thought forward and making one one decision variable P which is the central factor of safety which is mean of strength divided by mean of load they developed an optimization problem and so what you see in the equation is the marginal cost to increase the central factor of safety by one unit it must be at least greater than the marginal the amount that society is willing to pay so negative of delta n over delta P times G of d which is society's willingness to pay.

And going through the algebra and certain assumptions the answer comes to be the allowable failure probability P F star is of the order of a divided by N F, so a constant which depends on various factors and N F is in the denominator with power of one so that is important the earlier revision in of ISO2394 had N F to the power of 2 but here P F star comes out to be directly to be integrated proportional to 1 to N F and it is a throwback to the 1977 report by CIRIA.

Now let us see let us define all these parameters in the next slide and then we will just refer to a couple of examples of how this process yields acceptable failure probabilities and if they are really acceptable or not.

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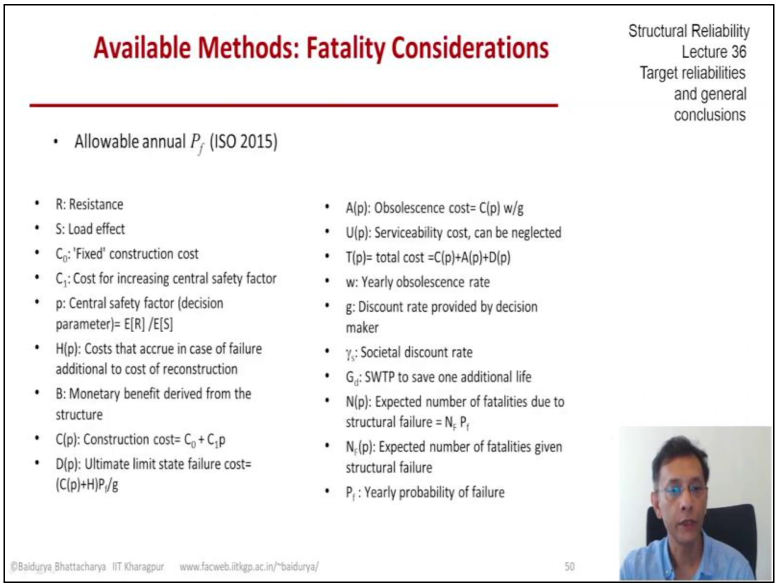

So here are some of the terms that enter that derivation. So there are costs the construction cost obsolescence cost the central factor safety as I mentioned the expected number of people that can die and then SWTP Society's Willingness To Pay the other cost, cost of increasing the certify for safety the obsolescence rate the discount rate and the answer is finally P F star which is the annual probability of failure.

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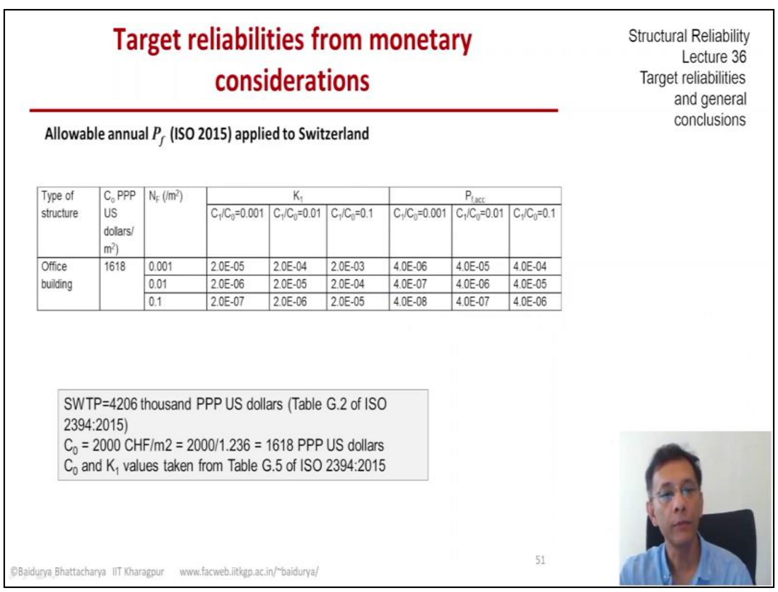

Now when this approach is applied to one of the European countries Switzerland in this case so this is an example that is worked out one obtains numbers that are actually very much within the acceptable range and we see the annual P F depending on the type of building and various ratios of C 1 over C 0 is of the order of 10 to the -6 or even less and in some cases 10 to the -4. So, these are all within the very much acceptable range or somewhat acceptable range that we have reviewed earlier.

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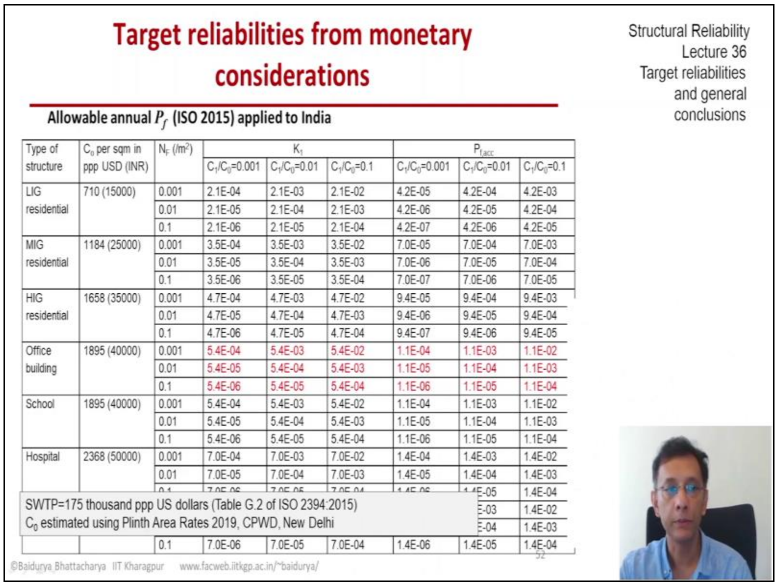

Type of structure	C_0 per sqm in ppp USD (INR)	N_F (/m^2)	K_1			$P_{f,acc}$		
			C_1/C_0=0.001	C_1/C_0=0.01	C_1/C_0=0.1	C_1/C_0=0.001	C_1/C_0=0.01	C_1/C_0=0.1
LIG residential	710 (15000)	0.001	2.1E-04	2.1E-03	2.1E-02	4.2E-05	4.2E-04	4.2E-03
		0.01	2.1E-05	2.1E-04	2.1E-03	4.2E-06	4.2E-05	4.2E-04
		0.1	2.1E-06	2.1E-05	2.1E-04	4.2E-07	4.2E-06	4.2E-05
MIG residential	1184 (25000)	0.001	3.5E-04	3.5E-03	3.5E-02	7.0E-05	7.0E-04	7.0E-03
		0.01	3.5E-05	3.5E-04	3.5E-03	7.0E-06	7.0E-05	7.0E-04
		0.1	3.5E-06	3.5E-05	3.5E-04	7.0E-07	7.0E-06	7.0E-05
HIG residential	1658 (35000)	0.001	4.7E-04	4.7E-03	4.7E-02	9.4E-05	9.4E-04	9.4E-03
		0.01	4.7E-05	4.7E-04	4.7E-03	9.4E-06	9.4E-05	9.4E-04
		0.1	4.7E-06	4.7E-05	4.7E-04	9.4E-07	9.4E-06	9.4E-05
Office building	1895 (40000)	0.001	5.4E-04	5.4E-03	5.4E-02	1.1E-04	1.1E-03	1.1E-02
		0.01	5.4E-05	5.4E-04	5.4E-03	1.1E-05	1.1E-04	1.1E-03
		0.1	5.4E-06	5.4E-05	5.4E-04	1.1E-06	1.1E-05	1.1E-04
School	1895 (40000)	0.001	5.4E-04	5.4E-03	5.4E-02	1.1E-04	1.1E-03	1.1E-02
		0.01	5.4E-05	5.4E-04	5.4E-03	1.1E-05	1.1E-04	1.1E-03
		0.1	5.4E-06	5.4E-05	5.4E-04	1.1E-06	1.1E-05	1.1E-04
Hospital	2368 (50000)	0.001	7.0E-04	7.0E-03	7.0E-02	1.4E-04	1.4E-03	1.4E-02
		0.01	7.0E-05	7.0E-04	7.0E-03	1.4E-05	1.4E-04	1.4E-03
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.4E-05	1.4E-04
							E-03	1.4E-02
							E-04	1.4E-03
		0.1	7.0E-06	7.0E-05	7.0E-04	1.4E-06	1.4E-05	1.4E-04

In this lecture but when these numbers are applied to a country such as India clearly it gives rise to failure probabilities acceptable failure probabilities that you see in red which would definitely be considered unacceptable. So, there would be questions of of adopting such a measure without further consideration in countries that ISO2394 did not consider when they developed such an approach.