Advanced Design of Steel Structures
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Lecture - 13
Design Methods - 2

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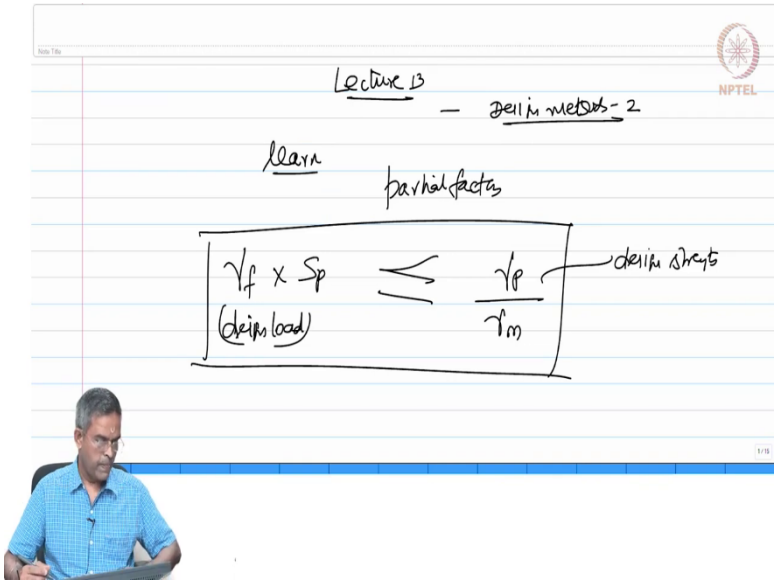

So, friends, welcome to Lecture 13 of the course on Advanced Steel Design, in this lecture we are going to learn more about the Partial Factors. So, this lecture is also focusing on Design Methods. In the last lecture we said $\gamma_f S_p \leq \frac{\gamma_p}{\gamma_m}$. So, we call this as the design load and we call this as a design strength. whereas, the factors address the uncertainties which are arising from various sources as we discussed in the last lecture.

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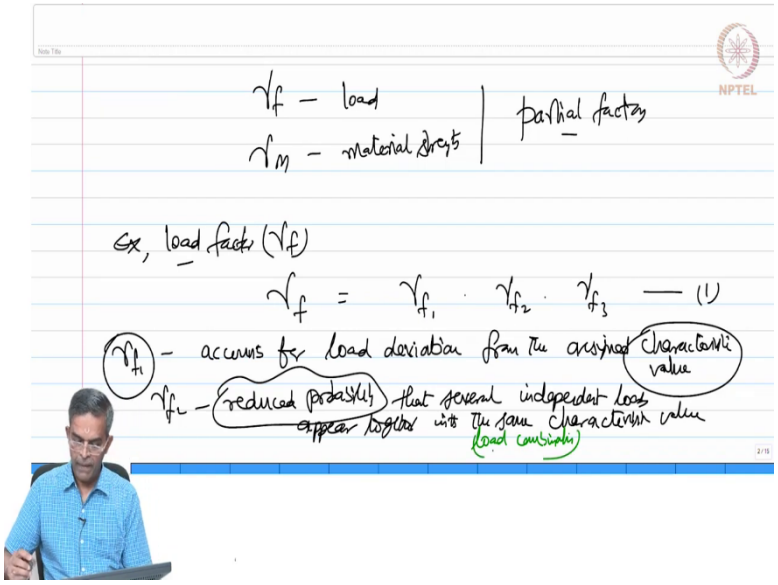

So, having said that the factors present in the load and the strength are going to take care of these uncertainties they are anyway addressed only as partial factors. So, let us take for example, the load factor which is γf, in the literature γ f is actually a product of γ f 1, γ f 2, γ f 3. So, it has got three subdivisions let us see what are these three subdivisions address.

γ f 1 accounts for load deviation from the assigned characteristic value. If you say the characteristic value is 5 percent the exceedance is only about 5 percent, but we exceeds beyond 5 percent what is that exceedance, beyond the characteristic value will be looked at γ f 1 separately.

γ f 2 will account for reduced probability that several independent loads appear together with the same characteristic value. When several loads with the same characteristic value appear together there can be reduced probability of that combination.

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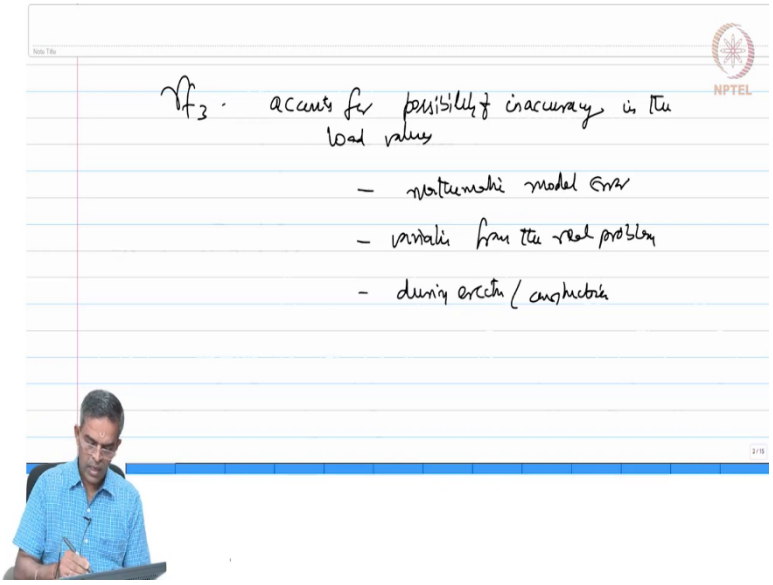

So, γ f 2 looks for that, γ f 3 accounts for possibility of inaccuracy in the load value arising from mathematical error or mathematical model error, variation from the real problem, problem arising during erection or construction etcetera. So, amongst these if you look at carefully γ f 2 addresses the effect of load combination.

So, even within the partial safety factor of load itself there are three sub classifications.

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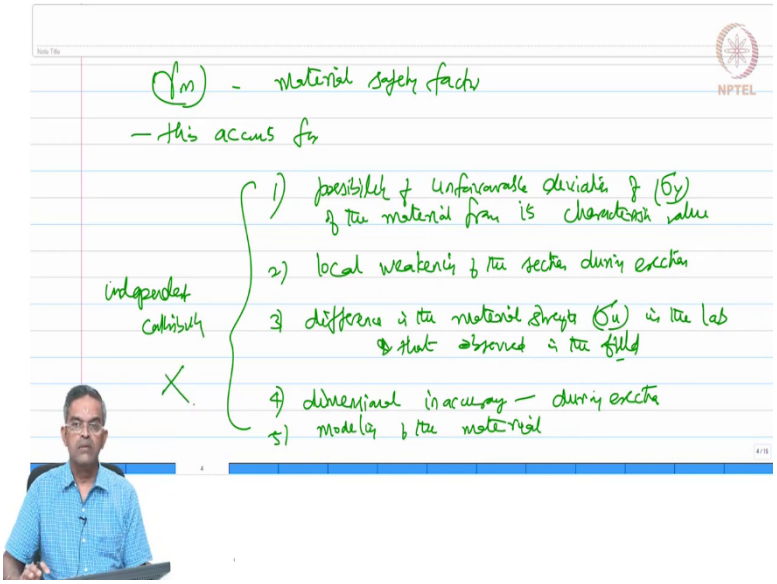

Similarly, if you look at γ m, this accounts for possibility of unfavorable deviations of yield strength of the material from its characteristic value. There can be factors arising from local weakening of the section due to or during eruption. There can be difference in the material strength for example, σu in the lab and that observed in the field.

So, in the field also you conduct experiments, you find out ultimate strength and Young's modulus in the field can compare those data directly with the manufactured supplier's data. So, there can be a variation and that difference is accounted in γ m. Further there can be dimensional inaccuracy which can arise during erection. There can be also error in mathematical modeling of the material.

However, many codes do not distinguish these factors elaborately and do not give the percentage contribution of γ m or γ f from independent factors, they give a single combined number. So, for example, if γ f is 1.5 and γ m is 1.15 as in Indian codes, you will not come to know this 1.5 will be contribution from various sources. What is the effect of every factor on this γ? You will not know these independent contributions, but they are together contributing to γ, we can only know that.

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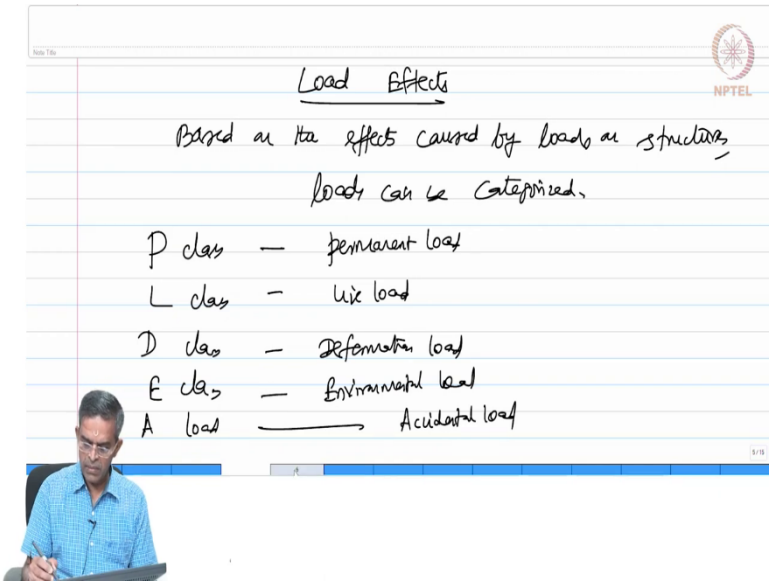

Let us now see something called load effects, see, what is the load effect? Based on the effects caused by the loads on structures loads can be categorized as P class load, L class load, D class load, E class load and A class load.

P class refers to permanent load, L class refers to live load, D class refers to deformation load, E class refers to environmental load and A class refers to accidental load.

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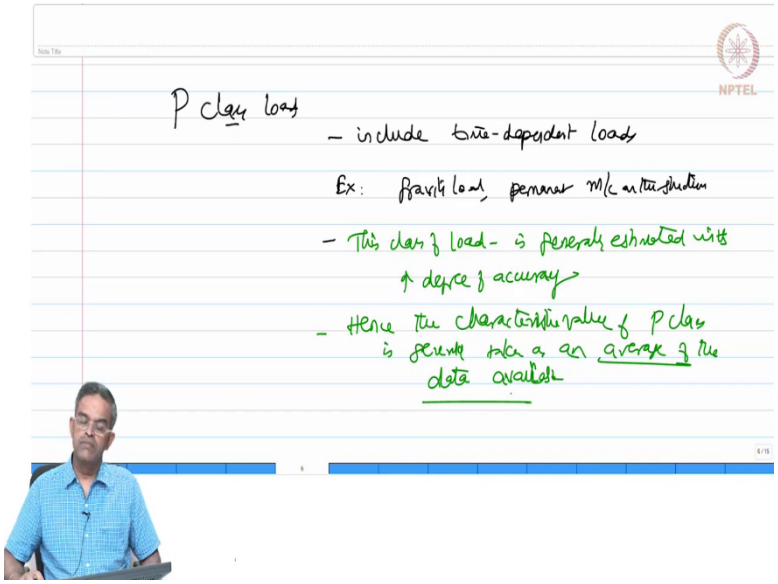

Let us see them slightly elaborate P class load, which are permanent load they include time dependent loads. Examples could be gravity load, weight of any permanent machinery on the structure and their variation over a period of time. So, the good thing about this class of load is this class of load is generally estimated with higher degree of accuracy.

Hence, the characteristic value of P class load is generally taken as an average of the data available and we can compute this with higher accuracy.

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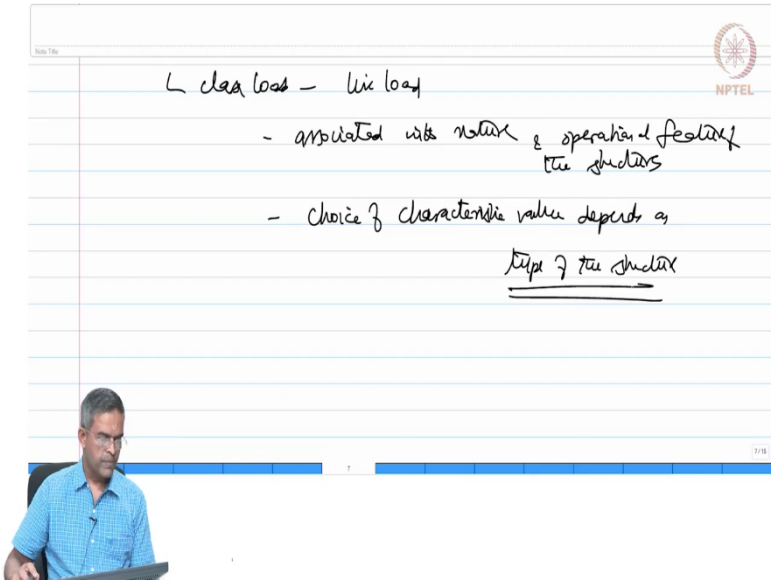

Let us come to L class load, L class load anywhere refers to live load, live load are associated with nature and operational features of the structure. That's why they are called live load. So, now, the choice of the characteristic value depends on type of the structure not on the type of the load.

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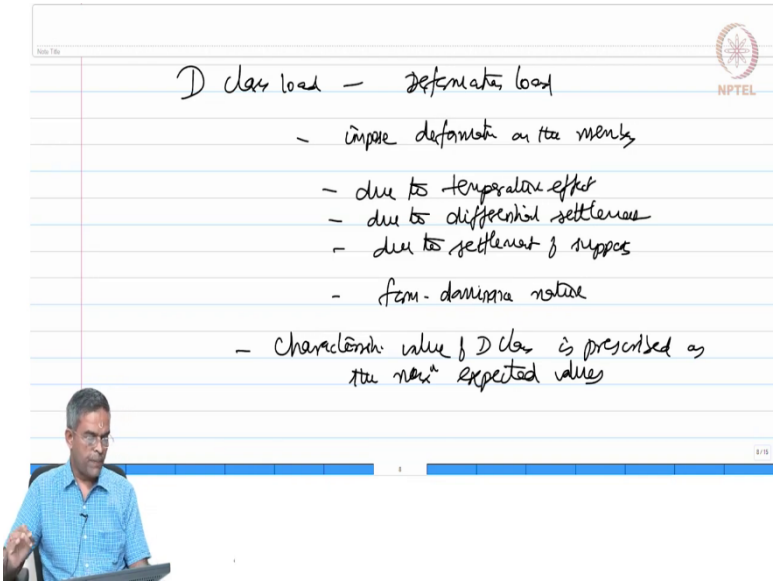

When we talk about D class loads which refer to deformation loads, these loads are imposing the imposed deformation on the members. It may be due to temperature effect, due to differential settlement, due to settlement of supports, due to form dominance nature of the

structure. So, the characteristic value of D class is prescribed as the maximum expected values, it is an upper limit.

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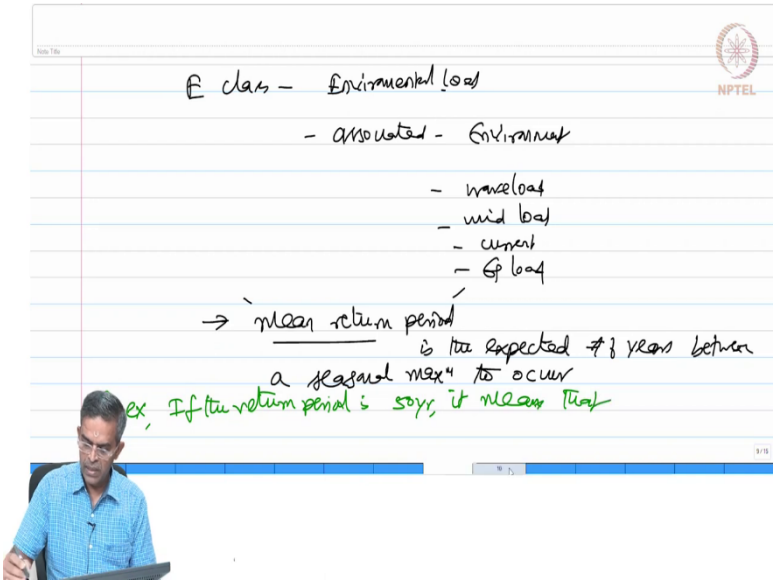

If you come to the E class load which refers to environmental load, they are associated with loads arising from the environment. Examples could be wave load, wind load, load arising from current, and earthquake load etcetera. They are generally classified with the help of a term called mean return period.

Mean return period is defined as the expected number of years between a seasonal maximum to occur. For example, if the return period is 50 years.

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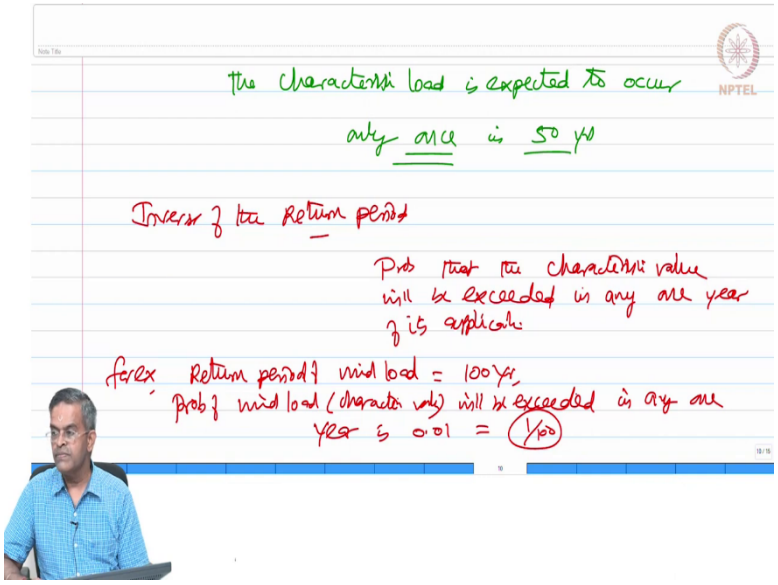

It means that, it means that the characteristic load is expected to occur only once in 50 years that is the return period. Now, inverse of the return period is a very interesting parameter, this is the probability that the characteristic value will be exceeded in any one year of its application.

For example, if the return period of wind load is 100 years, inverse of this is going to be 0.11. So, we can now say that probability of the wind load that is the characteristic value will be exceeded in any one year is 0.01 which is nothing, but 1 by 100. So, 99 percent it will not exceed in any one year, but 1 percent there is a probability it may exceed. That is what the meaning of inverse return period.

Now, friends we have the return period which is expressed for the environmental loads we have seen the inverse of the time period also.

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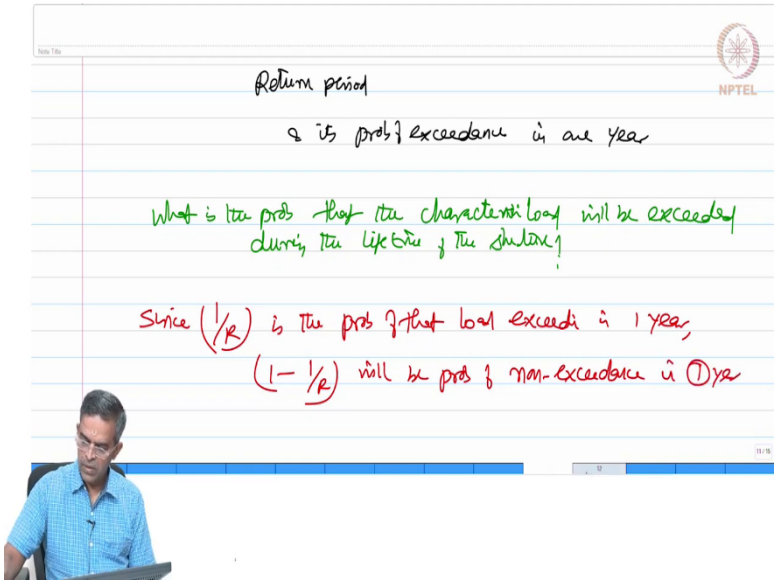

Now, we have seen that return period and its probability of exceedance in one year. Now, what the question we want to know is; what is the probability that the characteristic load will be exceeded during the lifetime of the structure? What is the probability?

So, now, since 1 by R is the probability of that load exceeding in 1 year 1 minus 1 by R will the probability of non - exceedance in 1 year, is not.

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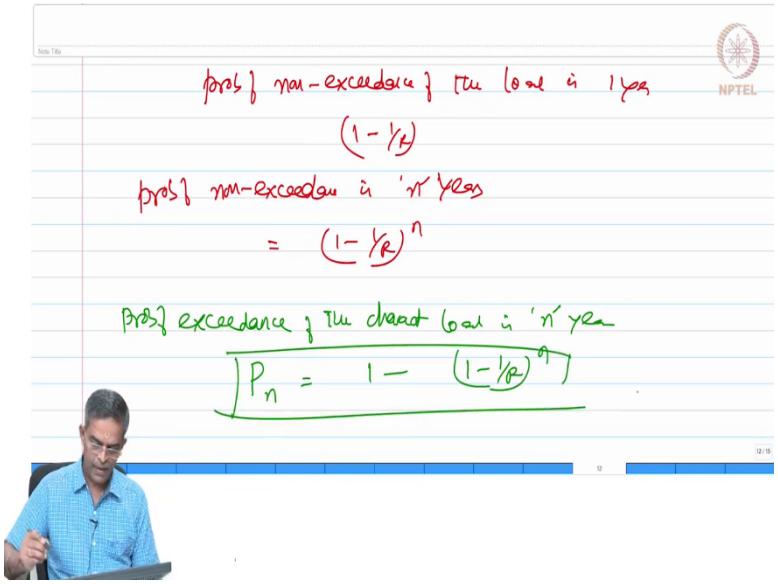

So, the probability of non - exceedance of the load in 1 year is 1 minus 1 by R, what is the probability of non - exceedance in n years will be 1 minus 1 by R to the power n. Now, we are looking for what is the probability of exceedance of the characteristic load in n years.

So, I should say probability of exceedance in n years 1 minus 1 minus 1 by R to the power n right.

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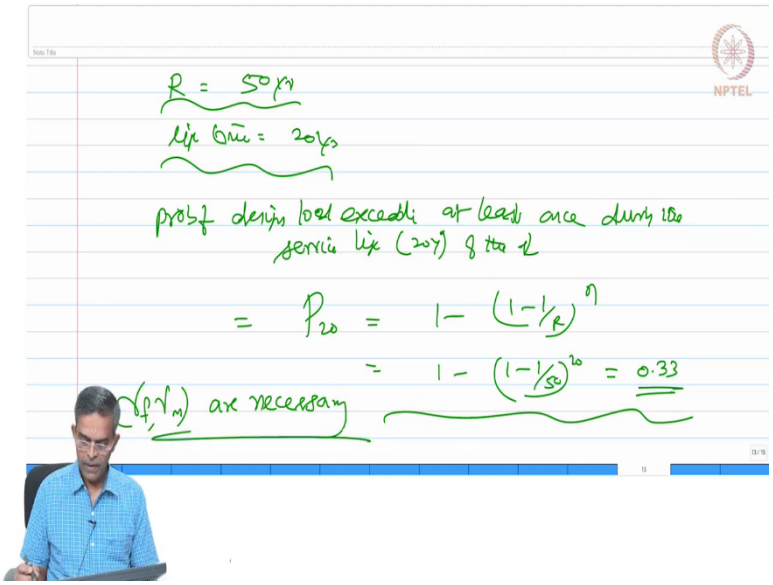

For example, if the return period is 50 years and the lifetime of the structure is 20 years we can now say the probability of design load exceeding at least once during the service life that is 20 years of the structure could be P 20 which is 1 minus 1 minus 1 by R to the power n 1 minus 1 minus 1 by 50 to the power 20. So, it has got an exceedance of 33 percent, which is an alarming number.

So, it is interestingly friends, the return period is 50 years, service level 20, you may possibly think the exceedance will not happen at all see here it is about 33 percent. So, it is clear from the example that there is a chance of design load exceeding at least once in the service life is about 33 percent which is an alarming number. Therefore safety factors are important.

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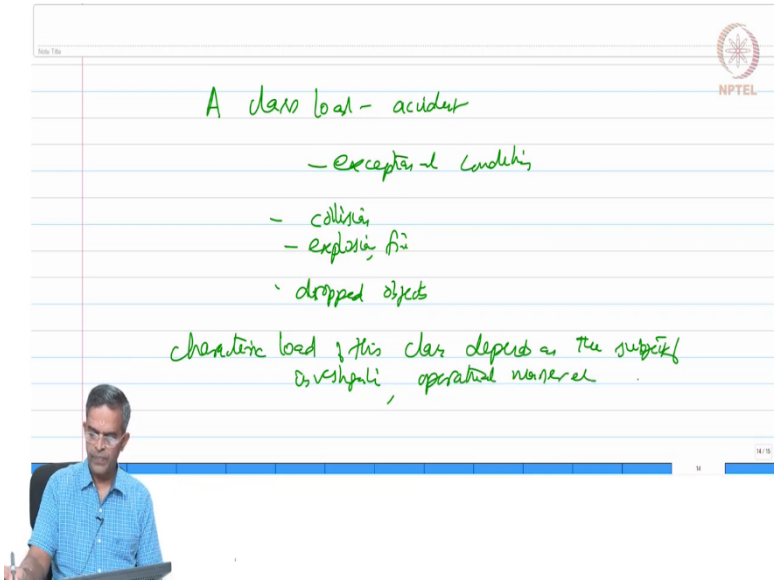

The last one is an accident class loads A class load refers to accident class, these loads are exceptional cases, they arise when there is a collision, when there is an explosion or fire or there can be accidents crossed due to dropped objects. Now, the characteristic load of the dropped objects or accidental load of this class depends on the subject of investigation and operational manner etcetera.

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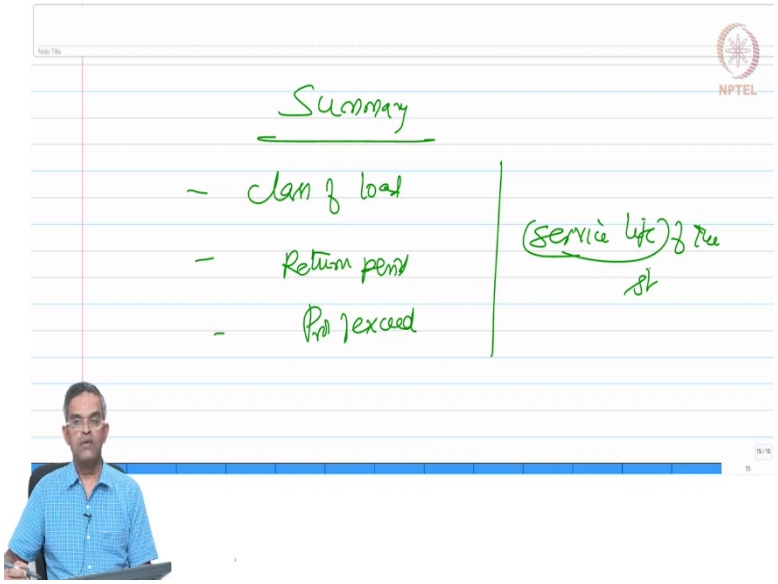

So, friends in this lecture we have discussed about different class of loads, we have discussed about return period, we have discussed about the probability of exceedance of the return period and we have seen how the return period is connected to service life of the structure.

So, please revise these concepts and take many examples from the textbook, try to look into them, read research papers from various journals in this connection and update your knowledge and know how on these friends.

Thank you very much have a good day.