Risk and Reliability of Offshore Structures
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Module - 01
Lecture - 06
Plausible Reasoning – I

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Friends, we will talk about the 6th lecture today on the online course on Risk and Reliability of Off shore structures. We are now through with lectures on module 1; today we will talk about the 6th lecture, we will discuss about plausible reasoning in this lecture. Just to give a brief over review, we already said that uncertainties control or guide or govern reliability methods. Reliability and failure can be looked do different facets of the same problems. Since, we are not very sure about or very sure in confirming the failure of a given structural system we always make an associate probability attach to this. So, we express failure in probabilistic terms as probability of failure. To give a positive note of this particular behavior we always say reliability is nothing but 1 minus of probability of failure.

Therefore, it is always advantages to express reliability in probabilistic terms because we are not sure about the happening of the failure, as result of which there are many uncertainties governing your statement or confirming your acceptance level. So,

reliability is the probability of success of the system to deliver the intentional content or intentional function within specific period of time under the given specific data or under the given specific conditions.

In the last lecture, we discussed about the rules of the probability; there are essentially ten rules of probability which we discussed out of which couple of them are very important. Rule number 9 talking about total probability theory. Rule number 10 focuses on the reverse problem, which is very interesting for us to know. And we also said how probability of a given event can improve its status provided you have the knowledge status.

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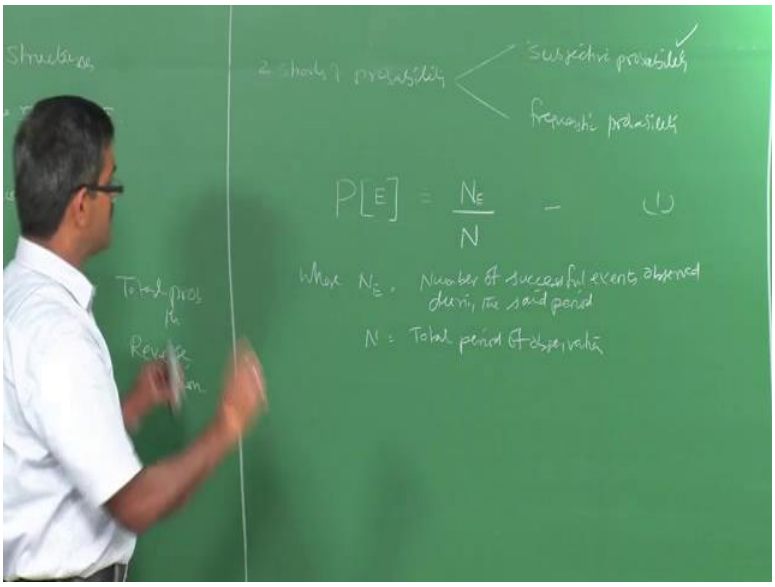

Now, there are two schools of probability let us say one is what we call subjective probability, which we have been so far discussing; the second alternative could be frequenstic probability. Now what is frequenstic probability? Let us say I want to find the probability of a given event E the event can be either will you it tomorrow, the event can be will the structure fail under gravity loads the event can be will the structure failure in the impact loads or whatever event you want to fix up. So, event can be E. So, the probability of that event occurrence of that event, so we all know probability is nothing, but mathematical conversion of a level of confidence on occurrence of a specific event.

So, we are trying to associate some mathematical number to a subjective issue where we say I am confident of saying that this event will happen. So, probability of event

occurrence of this event E or probability of E can be expressed in frequenstic probability like this, which can be simply given by N of E by let us say N. Where N of E could be the number of events which are successful, number of let say successful events observed during the period whereas N is the total period of observation. Let us take a couple of example to understand physically equation 1.

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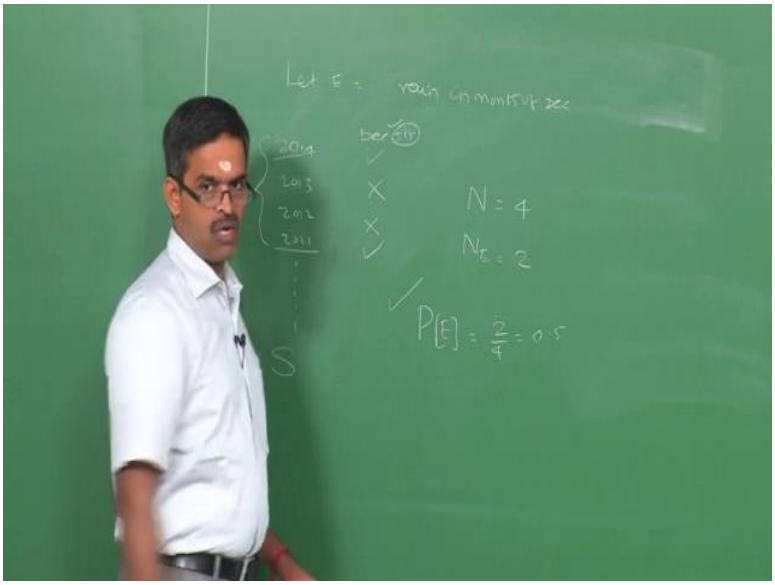

Let us take a simple example. Let E be probability of rain in the month of December. So, what I do is I look at every year let say 11, etcetera I look only for the month of December every year. And see (Refer Time: 05:44) as rain in the month of December or not I am not looking at the quantity of the rain or the day and period or how long it is been raining no, as it rain in December or not.

May be for example let us say on 5th December a specific date, so it would have rain, it would not rain, it would not rain etcetera. Now, what I say is if you consider from 2011 to 2014 1, 2, 3, 4, therefore, in my example for equation 1 n becomes 4 that is the total period what I am looking at for the data and N E that is a number of success of this event I am looking for the success rain must have happened. So, it should be two. So, the frequenstic probability or the probability of occurrence of the event based on the existing data now could become simply 2 by 4, which is 0.5 or 50 percent.

So, I can say depending upon the data of the previous 4 years, I could guess that this year 2015 probably at December 5th, it would rain. So, that is a guess, this will also give you

an idea about how your confidence level can be expressed in occurrence of the specific event based upon the data what you have. We all know this data what you say is otherwise in subject of probability can be also called as the sample of data or the full subset based on which you express this confidential level.

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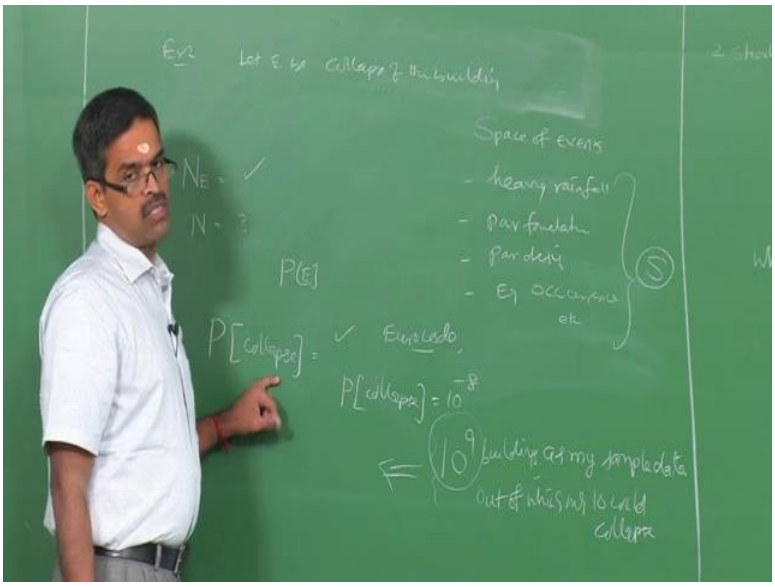

Let us take up another example. Let us say here we take slightly more a technical example we are looking for let E be collapse of the building. Let us say conducting a survey just to find out how many buildings have been collapsed, may be any reason. Now the space of events for responsible of this collapse could be which made this building collapse could be heavy rainfall, poor foundation, poor design, occurrence of earthquake etcetera let us put a (Refer Time: 08:07) let us have a space of events.

So, all this could be space of events. So, I am just looking at a simple statistic survey on a specific region how many buildings are failed. So, I could easily say the number of events which has failed over a period of ten years would have been simply a number which can be evaluated by a survey and I can also find out what is the period during which I am actually estimating the survey conducting the survey to know. So, I can easily find out what is the probability of this.

So, I can say this probability of collapse of a building can be estimated based upon frequenstic probability approaches as well. I can also find this from subjective probability approach depending upon the space of event, the contribution of this

particular how many times the building would have failed because of heavy rainfall, how many time the building would have failed in a data because of poor design. So, each one of them can be easily contributed I can use either total probability theorem or a reverse probability as well as rule number ten to find out the P of E event which can be determine based upon the equation given to you in the last lecture.

Interestingly, if you look at this particular concept P of collapse referring to Euro code for example, this number actually the probability of collapse of a good design should be as high as 10 power minus 8. So, what does it physically imply this physically imply that I must have 10 power 9 buildings as my sample data which will be subjected to all this possible space of events out of which only 10 cold collapse.

Interestingly, what is the primary difficulty in this kind of data you see the data size what you want to estimate based upon the particular recommendation given by the code is very, very large is because of this particular reason a frequenstic probability approach is not recommended for reliability. On the other hand, if you really want out to determine the probability of failure of a specific or a occurrence of a specific event based upon the data your data should be sound enough to substitute or to provide the input for a analysis.

For example, you are looking for collapse of an offshore structure platform because of let say corrosion or strength degradation. You should have first of all so high value of the data which can feed to the input for this analysis. If you really wanted to use frequenstic probability approach for finding out P of E of that event, it is because of the demand of the input data and very large number as recommended when this specific class of example of Euro code this kind of approaches is not very popular for reliability analysis.

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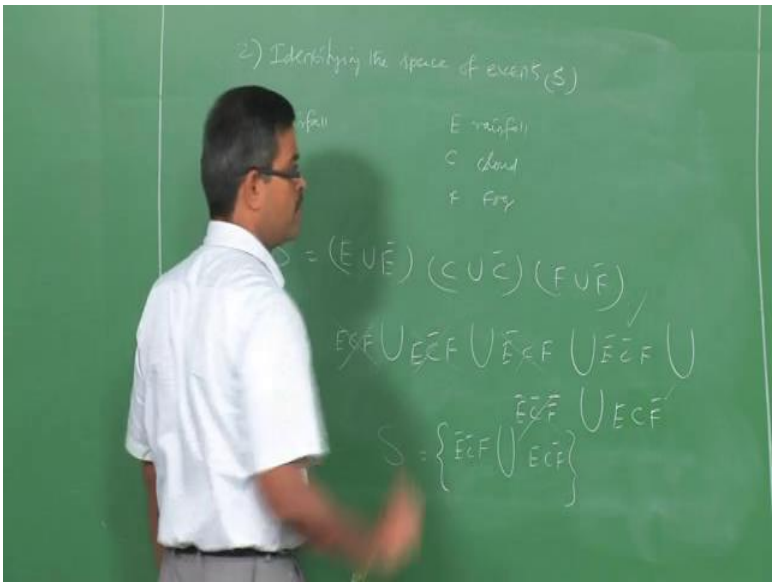

The second argument what we will take up today for discussion will be identifying the space of events. Well, this is a very classical problem, it is very difficult to identify space of events I will tell how this so. Let us say take E as an event for rainfall. What are the possible spaces of events which we saw yesterday, let us say E could be a rainfall, C could be a cloud, and F could be a fog. I am not using S, sunshine because that is give commonness with S here; therefore, let us leave that for one moment. So, my space of event actually can be hypothetically expressed this way that is all the space of event you try to expand this I can easily do that let us say E C.

So, you can also have some commonness between the which are not possible that is a impossible combinations let say E C F and E bar C bar F bar, this combination is not possible. Similarly, E C bar F and E bar C F this combination may not be possible. So, the one which is balanced out could be for example this and for example this. So, one can short down to find the space of events which could be written as let us say in this case and so on.

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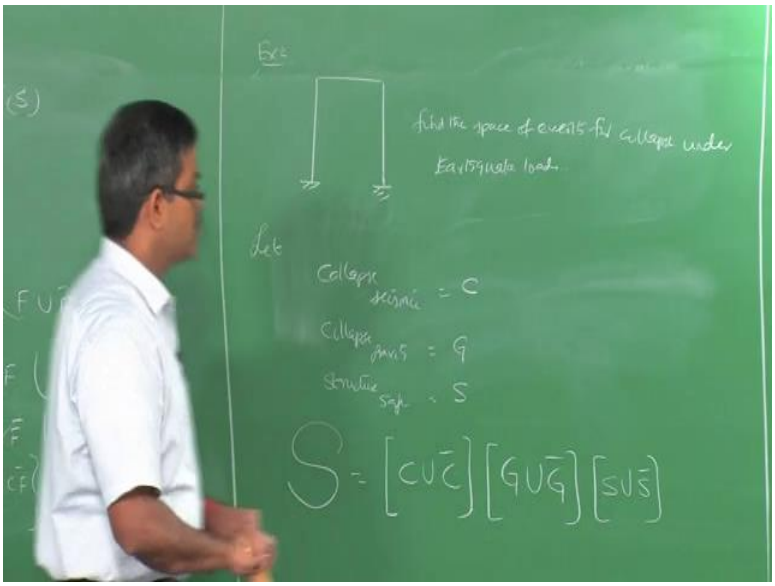

Let us have a single story building subjected to the gravity load and lateral load. I want to find the space of event for collapse under earth quakes loads. Let us call collapse under seismic load as C, collapse under gravity load as G, when the structure is safe and no collapse has happened let us call that as S. Obviously, the space of event S could be, so one can try to expand this take over the impossible combinations and one can find the space of events as we did in the last case. So, ladies and gentlemen, it is very tricky, but it is very important to identify the space of events which contributes to the subjective probability. And therefore, one can effectively use all the rules of probability to estimate the failure or to look at the reliability analysis of a given problem.

Having said this, we all know uncertainties govern the reliability (Refer Time: 16:23) uncertainties are also circumscribed probabilistic approach and probabilistic approach has some serious misunderstanding in terms of identifying so called space of events, combination of events, cross co relation etcetera. Is there a parallel way where I can physically understand probability theory or uncertainty or influence of uncertainty on estimating property of failure by some physical (Refer Time: 16:53), yes the answer is plausible reasoning.

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Probabilistic analysis actually has two classes; one is what we call Bayesian class, the other one is frequency class. In Bayesian class, the prior information subject is included. Therefore, obviously, this improves the knowledge level of the unknown. And hence the derived information the derived information is essentially based on the available data because the data is actually supplied as an input which is called posterior information.

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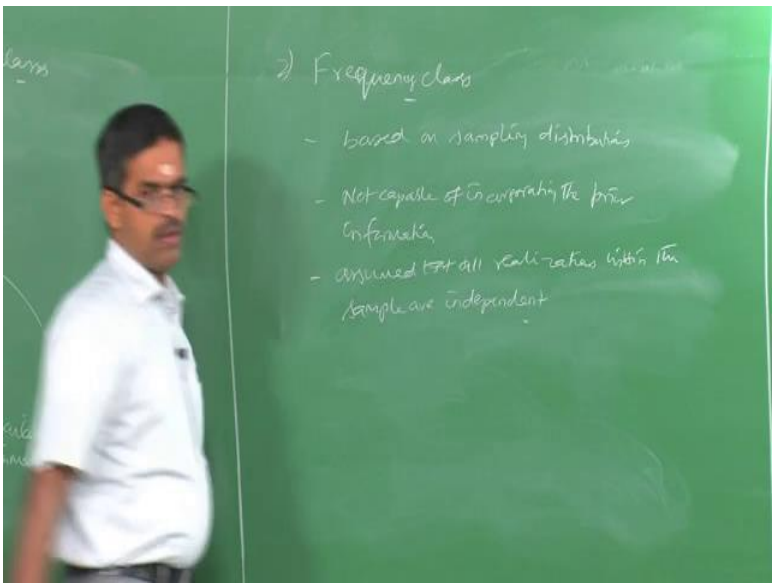

Alternatively in frequency class, this is based on sampling distribution. It is not capable of incorporating the prior information; it is assumed that all the realizations within the

sample are independent. There is a basic assumption that all realizations within the sample are independent, so that two different thoughts based on the probabilistic analysis can be done. Now, understanding this complexity, let us move onto a physical enhancement of knowledge of understanding the failure, but of course not from the probability, but from reasoning.

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So, what we call plausible reasoning. Now what is plausible reasoning? Plausible reasoning is nothing but rules of thinking. Probability theory are complex in nature, we know that. The systems of probability based on plausible reasoning looks like abstract in the beginning, but everything will become derivable later. Therefore, this would leave no choice for confusion. Probability theory of course, as said by Laplace is nothing but common sense deduce to calculation. Therefore, I am looking at not the calculation part, but the common sense itself that is what we call rules of thinking, we established in theory as plausible reasoning.

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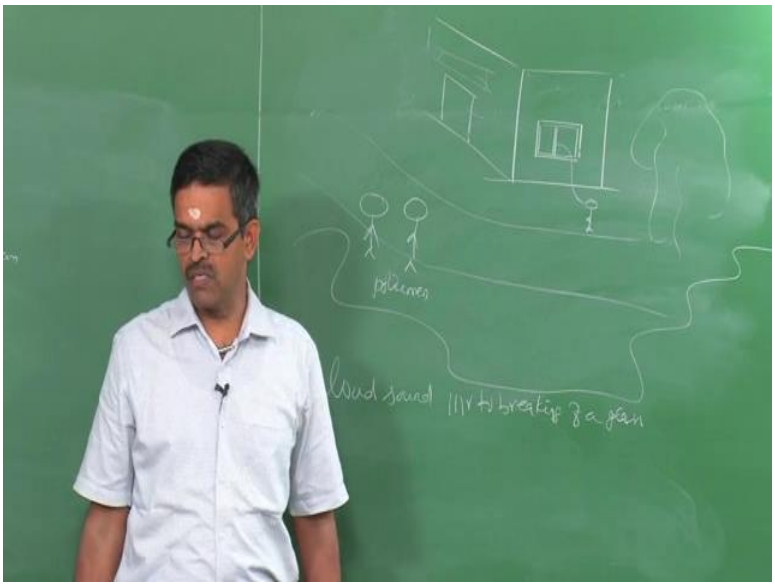

Plausible reasoning can be explained with a simple example let us take the event. Let us see this is a scenario, there is a shop here, front side of the shop. Let say there is a window here. Of course, this is interior of the shop and shop has some name etcetera, etcetera and so on. There is a road. Let say there are two policemen who are patrolling on the road. On a late night, policemen are doing patrolling duty on a main road of a city center.

They heard a loud sound similar to that of breaking of a glass; they also notice the person who is jumping probably also notice the person or a man running in the dark wearing a mask on his face. The man was also carrying a big bag in hand and the policemen would thing he is a robber that may repeat the event back again. Two policemen were doing patrolling in the night on a city center; there was a shop may be a jewellery shop. They heard a sound of breaking of a glass, parallely they could see a man wearing a mask on his face in a dark night, carrying a big bag in his hand running in the dark (Refer Time: 23:48). Therefore, policemen came to a conclusion rather that he is a robber.

Please understand policemen did not know the complex information about the incident, there is no prior information available as you had in the case of probability theory. The policemen did not know complete information about the incident. The person was noticed to be running in the dark can also be the owner of the shop whose is coming out of the shop, after closing the shop. One may ask me a question say then how would the

glass, there would been a chance the glass was already broken and a complaint was return to the police station about replacement of glass and the sound of breaking similar to glass may not be exactly from this window, but somewhere else.

Instantly there was a loud sound being heard which was similar to the breaking of a glass, but however the fact remains verified that the shop window was found broken much prior to the incident happened because it was reported in the police station. There could have been a reporter in the station. The man who was walking with bag in his hand, wearing a muffler or a scoff because of the cold weather could be even the own shopkeeper, who could be misunderstood with the police as a thief. Well, the police when decided that he was thief while the policemen decided that he was a thief he could also be the owner of the thief whose is returning home after closing the shop.

Now, let us examine the reasons of what the policemen thinking the man as a thief. One of the main reasons which made the policemen come to the conclusion could be their past experience making plausible thinking that the man is a thief. So, here I am not associating probability because probability should have space of events, should have data, should have a mathematical difference of your confidence level, whereas in plausibility it is only the reasoning or the rules of thinking.

So, based upon the previous experience of the policemen who could have heard, investigated, similar instead in the reason past they could come to the conclusion that the man who was carrying a bag, wearing a mask on his face (Refer Time: 26:10) visibility of the shop where they could hear a loud breaking sound of a glass could be a thief where the man could have also been the owner of the shop. Therefore, the following propositions holds good let us see what are they.

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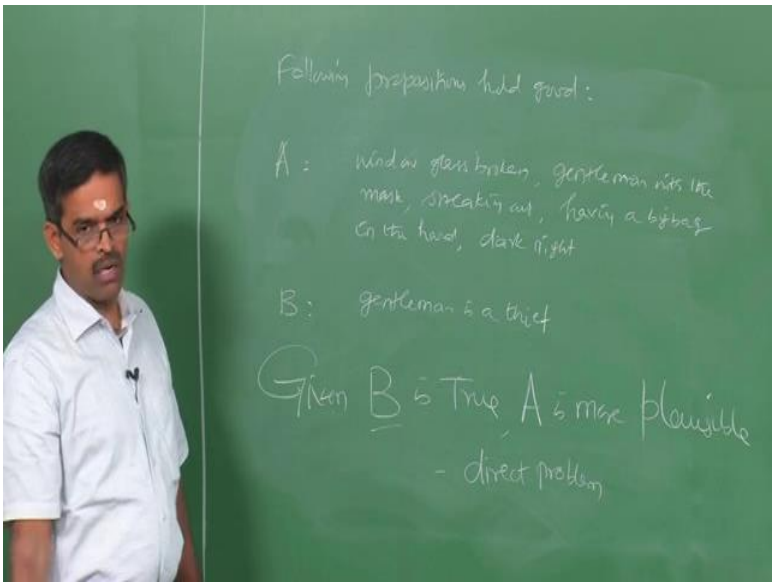

Let us call A the window glass broken, and let us say B gentle man with a mask. All A could be gentle man with a mask, sneaking out having a big bag in the hand, dark night. Let us say B could be the gentle man is A thief. Now, let us try to make a statement here. Given B is true, A is more plausible, it is a direct problem. This is a direct problem, because if we know for sure the gentleman is a thief from the previous records from the memory of your photograph of a thief which you have seen in the police station, if you know for sure the person whom you saw half way is a thief then for sure A becomes more plausible. He would have broken the glass, he would be the man wearing the mask, he would have been the man carrying the big bag, and he would have been the man sneaking out from the dark night. So, given B is verified A is more plausible. So, direct problem.

Now, what the policemen saw was not B, they could not see the man, he is wearing a mask. What the policemen saw was A. Since A is true since A is true because they could see, they could hear the window glass broken; and of course, they could see the glass was broken. They could see gentlemen wearing a mask and sneaking out with a big bag in his hand it was a dark night. So, A was verified by the policemen. Since, A is true the policemen decided that the man is a thief. In fact, scene A is true, B becomes more plausible, but that was the inverse problem. Following logics such an interesting and highly relevant in the plausible reasoning.

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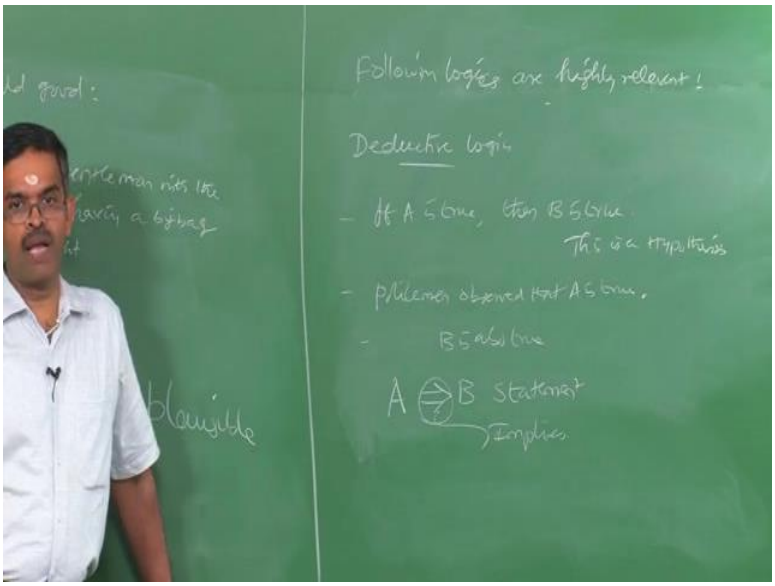

Following logics are highly relevant let us say what are they deductive logics. What I can deduce from this if A is true B is true when this is a hypothesis. Now considering the example it is seen that the policemen observed that A is true. So, policemen observed that A is true this is established which means that see B is also true this is A famous A implies B statement this is called implies the famous A implies B statement. The statement also means that B is false, A is also false. The statement confirms that there is only a logical dependence and there is no physical dependence.

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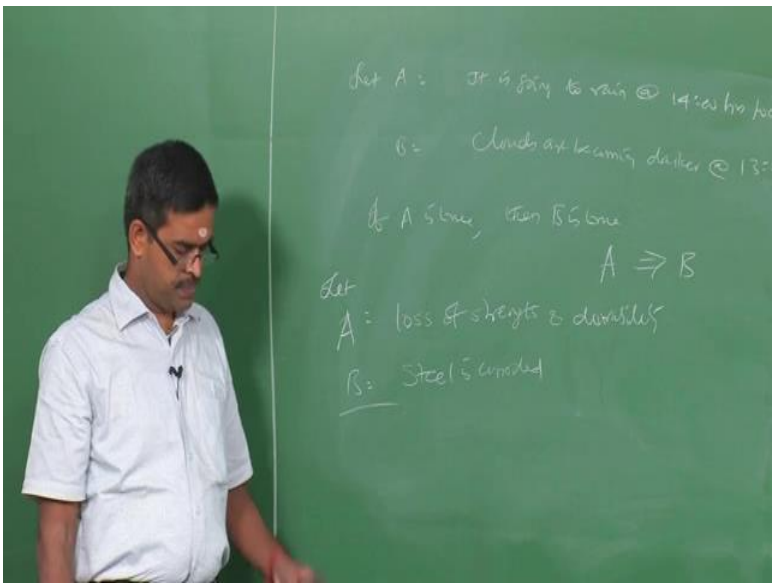

Let us take another example let now the event A be the statement it is going to rain. Let the event be the statement it is going to rain at let us say 14 hours today. And let us say B represents clouds are becoming darker at let us say 13 hours today. So, if A is true then B is true, which implies that give me a statement A implies B; or if you do not see the cloud at 13 hours today, if B is false A must also be false it will not rain at 14 hours today. In this logic A and B have only 2 values, namely either true or false the Boolean values. Applying this top floor engineering, let A now be an event representing loss of strength and safety or let say loss of strength and durability.

Let B be an event related to steel is corroded with above logic one can establish reasons for the loss of strength and the factors that affect durability because given B is true, A is also true. But more interestingly such (Refer Time: 33:29) logics that are straightforward and strong reasoning are not more practical. In plausible reasoning, one is more interested in the weaker reasoning that is if A is true, B is true this is called deductive logic as we just now saw. For B becomes true, A becomes more plausible, but if A is false then B becomes less plausible.

For example, at let us say thirteen hours there is no dark cloud then raining at 4 teen hours becomes less plausible. In case of deduce reasoning conclusions have certainty. Thus plausible reasoning shall be helpful in arriving conclusions through probability theories. So, you can apply plausible reasoning in parallel with probability theory. So, you can diagnose the space of events like dependence on occurrence of confidence level of a specific event. Therefore, you can be sure of identifying the factors related to the confidence level establishment of the specific occurrence of an event.

Now, let us relook that the policemen example again. Given A was true policemen made up their mind to conclude that B is a thief that is B is true. This is based on similar experience they had in the past. Plausible reasoning makes conclusion more justifier; this is true when the knowledge status about A is improved. A implies B means that if A is true B is true; if B is false, A must be false. A strong reasoning supports the statement which is (Refer Time: 35:19) deductive logic. Please note that if A is false the above equation does not clarify any status on B.

For example, policemen (Refer Time: 35:30) the broken glass or hearing the sound or sneaking from the window or a man walking at the dark night, they would not bother

about identifying the thief at all. So, if A is false then the above equation deductive logic obtains from plausible reasoning will not clarify any status on B. Also for if B is true it nothing says about A. So, there is no physical dependence there is only a logical dependence. So, there are cases where more additional information is required on weaker reasoning side. The above statement also says that A implies B to mean that B is logically deducible from A, but formal logic A implies B means only that preposition A and B have same true values. In general whether B is logically deducible from A does not only depend on preposition of A and B, it also depends on the totality of the prepositions that is what are all those factors which can establish occurrence of A.

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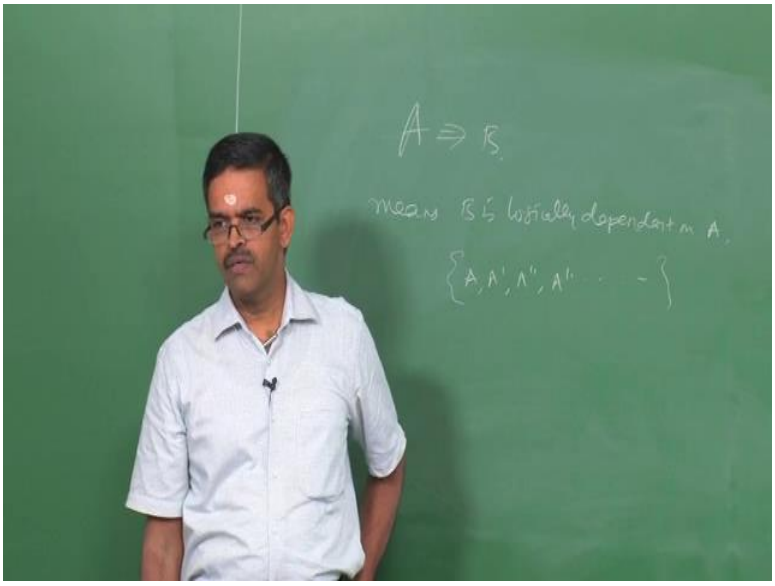

So, A implies B which tells me that B is deducible from A, B is let say logically dependent on A, does not only depends on the prepositions of A and B alone, it also depends on the totality of prepositions of A. Similarly A, A dash, A double dash, you have to verify you have to strengthen the knowledge about A - the event A to deduce B with higher degree of confidence. So, therefore, merely knowing the prepositions of A and B alone or establishing that A and B are true does not provide enough information to decide whether is a logical deducible from one another.

So, ladies and gentlemen, in this lecture, we discussed about introduction to plausible reasoning. We also set how frequenstic approach of probability compared to subjective probability can create an error or (Refer Time: 37:54) lack of confidence because they

(Refer Time: 37:58) to establish and confidence level in a given event is much higher when you talk about collapse of problems like structural engineering problems which are very rare in nature as per offshore structures are concerned. So, we go for a physical reasoning which is allow about of rules of thinking where plausible reasoning (Refer Time: 37:58) but however, from deductive logic we have also seen that it requires additional information or knowledge level to really qualify that B can be with great confidence deducible from A.

We will extend this discussion further to understand how probability theory and plausible reasoning can get along parallelly to establish a level of confidence in occurrence of a specific event.

Thank you.