Risk and Reliability of Offshore structures
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Module - 03
Risk assessment and Reliability applications
Lecture - 09
Risk analysis of Mechanical systems

Friends, let us look into the 9th lecture in Module 3, where we are going to talk about Risk analysis Mechanical systems. This is a lecture in Module 3 of online course title Risk and Reliability of offshore structures. To start continue with the mechanical systems let us try to complete the problem what we had in the last time and try to indicate how we are able to express the risk in terms of financial aspects. So we will continue with the problem what we had.

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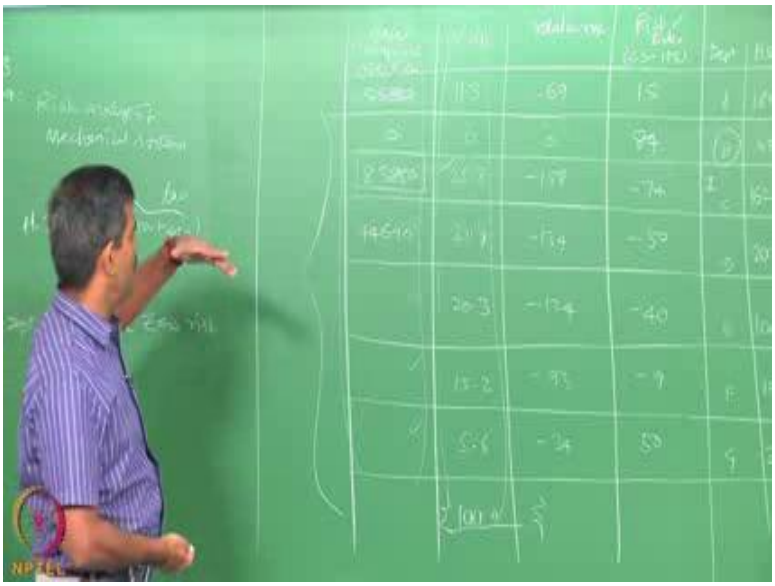

If you remember we had departments A, B, C, D, E, F, G; where the hazard score, the control score and the composite exposure in terms of a Indian Rupee in lakhs that is 10 power 6 is available here. Then we computed the first step risk index which is the control score minus hazard score using the sine convention whatever is available to us. So, the positive one indicates that the control scores are better and the negative one indicates the hazards are far higher compared to that of controls.

To compare the best department we look into the positive scores, because positive scores indicate that the department is got higher control mechanisms. So, the best department indicated is B because the control score positive is maximum amongst these three A, B and G so we picked up B as the best department, then we compute the relative risk with respect to this value so to get this number we set 15 minus 84 I am trying to normalize all the departments with respect to the best department I got the score I get the total and then from the total I compute the percentage risk which I got and this figure which we computed and their sum will be equal to 100.

One can see here since B is the best department whose control score is far higher than the hazard present in the department compare to all other departments. Please do not look into only the control score of B alone, if you look at that then the control score of A is far higher than B. However if you look at the risk index in terms of control score minus hazard A is inferior to B so one is to look at the risk index not the control score alone. So, B is the best department therefore the risk offered by the department in the overall plant is practically 0, because that is the best department it is not suppose to give you our intuitive in risk to the whole plant at all.

The next step could be obviously I want to compute the composite risk. So, I am converting the percentage risk into composite risk after computing the composite expose Dollars. So, I write to conclude this value so this value is nothing but this percentage that is, if I say this is x so x is nothing but 11.3 by 100 of that of 3000 plus 1500 plus 444 which is the composite exposure value of this specific department in terms of lakhs. So, the composite risk again in terms of currency let say Indian Rupee in this case 10 power 6 I will try to compute this and see what happens.

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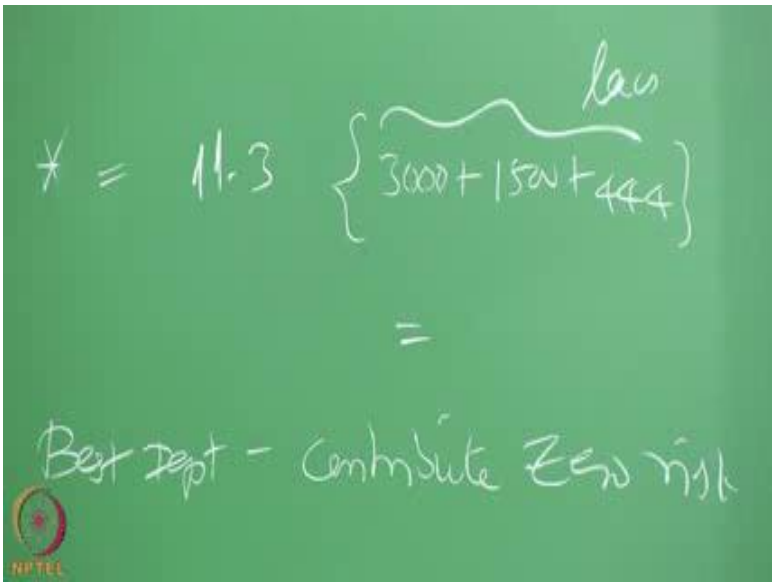

So, let say 11.3 3000 plus 1500 plus 444 is going to be 4944, so this 4944. So, I am writing it here 4944 and this value is going to be 11.3 multiplied by 55 a 67. Similarly one can compute all this values this will be obviously 0 because the percentage is 0 so one can compute all this things and the values are specifically let us say, so 21.8, 11.3 then 25.8, so 25.8 into 1700 plus 450 plus 1100 83850, similarly, 21.8 into 1000 plus 450 plus 600 44690 and so on.

So, from this one can easily find out which department will be able to compute the maximum in terms of exposure Dollars. So, one should be able to clearly understand here the inferences could be the best department could contribute zero risk is the overall plant. If you look at the ranking of risk in terms let us look at this particular ranking and we already said that approximately the department is going to contribute the maximum negative score. Let say C is the highest computer, because C is having the maximum negative score in the given system. So, C is having a very poor control mechanism and very high hazard present in the system. Therefore, in terms of risk ranking C would be 1.

When you apply this particular percentage of risk, now let us come here the department which is contributing to the maximum percentage is also C, because these two are actually relatively compared. And when you apply this particular value in terms of the composite exposure dollar what the department had obviously you know the terms of

loss to the revenue of the department to the whole plant which is again a percentage contribution of the risk may not be same.

So, one please understand that the department C can be ranked in two ways; one without looking the economic perspective which will give me the ranking from here. After looking the economic perspective which will give me the ranking here, so this is what we call first level of risk assessment this is the final ranking. There is no guaranty that the final ranking should be as same as that of the first level ranking because this risk ranking is purely dependent on the control score and the hazard score, whereas this level of risk ranking will be purely dependent on the commercial aspect or the economic perspective of the risk in terms of what we really want.

So, risk is an extension of reliability study, where the economic perspective is also looked into as a contributor for the whole deficit or loss to the economic value of the industry or the plant as whole which is contributed from each department as you seen in this example. So, the financial model or the logical risk analysis will be able to clearly explain what would be the relative risk offered by department in each plant and what is the overall risk the whole manufacturing unit can have.

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Similarly one can also extend the study to identify the logical risk for mechanical systems to do this literature advice a new kind of technique called failure mode and effect analysis which is abbreviated as FMEA. Now, very interesting method which we

can apply to mechanical systems this method is useful to exactly find out the risk priority of components of the system based on the working conditions. This method considers all possible outcomes of the complex mechanical model.

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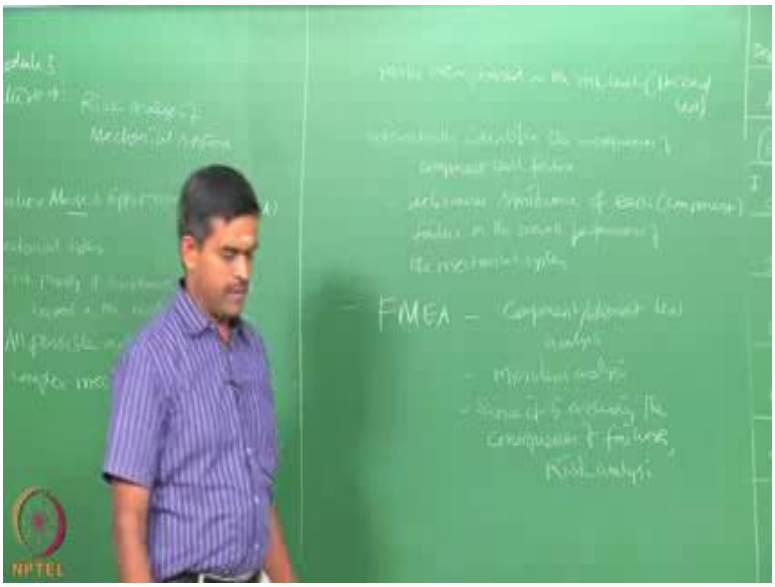

And then ranks them based on the risk level, essentially here is hazard level. FMEA systematically identifies the consequences of the component level failure and then determines significance of each failure on the overall performance of the mechanical system.

One can say in general FMEA is a component level analysis. So, one can say also it is a micro level analysis, since it is assessing the consequences of failure it is also called as one of the methods of risk analysis.

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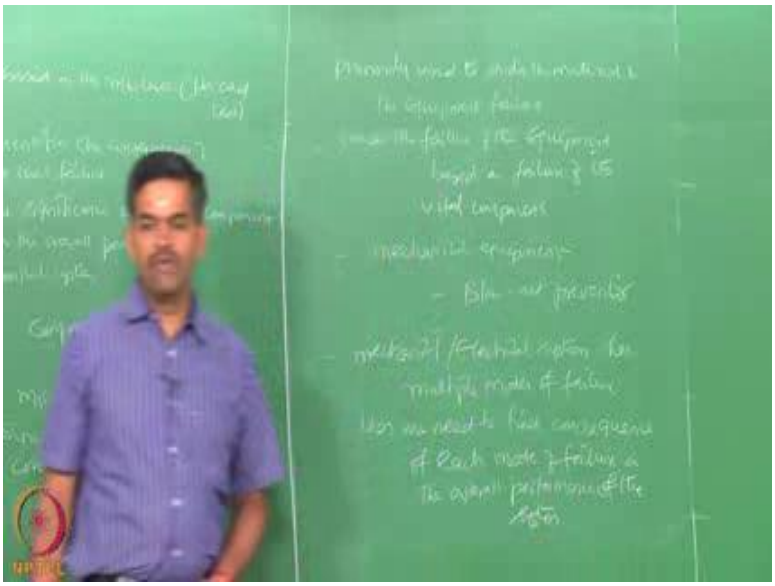

This method is primarily used to study the method the material and the equipment failure. Then it traces the failure of the equipment based on failure of its vital components. Now friends' very interestingly offshore structural system or offshore process involves lot of mechanical equipments, whose failure can be always diagnose based upon the failure each component of those systems. For example, take a blow out preventer. The failure of BOP as a mechanical device can be always diagnosed intercepted based upon the failure of different components present in the blow out preventer. So, one can as to do a component level analysis is to find out the consequences of failure of those components on the overall failure of the complete system.

Since the process indicates or quantifies a component level failure in terms of it is consequences on the overall failure of the system this is also included in the list of risk analysis, though it may not touch the commercial aspect of the directly but it talks about the consequence of it is where as reliability talks and stops only where we have talk about the probability of failure or 1 minus probability of failure as reliability index. So, the consequences of the failure in terms of economic perspective, in terms of design perspective may not be discussed further in the reliability study, whereas in risk analysis and risk assessment is very vital to be discussed. For example, select a mechanical electrical system in which one can identify a multiple failure modes then for each failure mode we need to find it is effect on the overall performance.

If the mechanical system or the electrical system has multiple modes of failure which are very commonly issue, then one need to find the consequence of each mode of failure on the overall performance of the system such a very intrinsic tool which talks about the failure in detail. One needs to actually find out the effect of this failure that is called failure mode and effect analysis.

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This method includes the effect of various failure modes and hence called failure mode and effect analysis or simply failure mode effect analysis. For example in certain issues when we are talking about the critical events or critical modes of failure; if critical modes of failure are also identified and let say ranked then the study is called FMECA, C stands for criticality failure mode effect and criticality analysis. If the study extends ranking those modes of failure in terms of it is criticality in the overall performance of the entire system. So, whenever there are multiple modes of failure one needs to actually identify the sequence of this failure.

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So, when a mechanical system is subjected to multiple modes of failure then one should look into two things; one what are those modes of failure and their consequences on the overall performance there is one issue one should look at. The second could be what would be the sequence of this failure and that is also important. So, FMEA gives both of this. FMEA not only tells me what are the modes of failure but it also ranks, lists, prioritizes the sequence of failure. So, I will know that A will fail prior B or the mode A will fail to the mode B, therefore cascading effect of these successive failure modes will have serious consequence on the overall performance of the given system which can be noted, which can be seen a prior to even the problems under difficulties.

Therefore, friends a systematic tool for identifying the effects or consequences of different failure modes and it also suggest me the methods by which this can be eliminated or reduced the chance of failure. FMEA study actually generates a document which can be used to anticipate the failure and then prevent this failure from occurrence. So, FMEA can be done at different stages; one can also do it at the development of new design or product.

We know that offshore structures or innovative structural form whenever talking about development of a new structural form one can also do in design FMEA for that, that is called design FMEA. We will do a design FMEA later in the next lecture; how the design FMEA can be computed or done for a newly generator offshore structural form

we will talk about that in the next lecture I will show in example how a design FMEA is carried out. So, FMEA can be done in different stages; one at the development stage itself.

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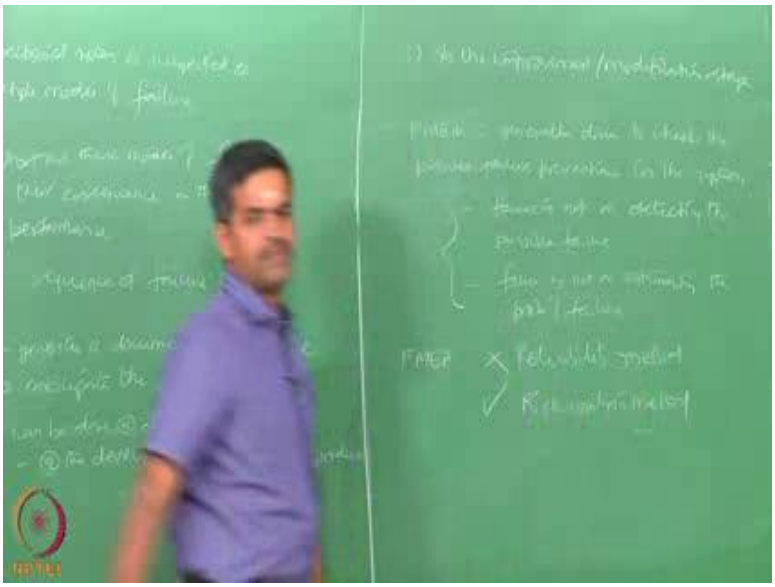

Secondly it can be also done in the improvement stage or in the modification stage; one can needs to modify the component function so that the probability of failure of the component and the probability failure of the overall system can be reduced, can be changed, can be decreased, so you want to make some design changes so you want to modify the existing design. So, one can also do a FMEA at to carry out at the modification stage itself.

FMEA is generally done to check the possible failure preventions in the system. It is not focusing on detecting the possible failure; focus is not on estimating the probability of failure. It means FMEA is not a reliability method, it is a risk analysis.

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Let us quickly see what is the methodology for doing FMEA. For doing FMEA first; we have to define the system in terms of the components or elements their working, their interrelationship. Let us define the system first completely. Next step could be we have got to identify the functional relationship of the components and we should also assess their ideal performance requirements.

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Then one needs to establish the level of analysis. We have to clearly say whether the analysis is leading to assessing a new design, focusing towards process modification

etcetera. So, what is the level of the analysis? So to establish that then one need to identify all possible failure modes of the components, if at all we are able to identify the failure modes of the components what are the causes for this failure, what are the effects of this failure on the overall performance of the system. One should also I have to identify the detectability of failure. If the component is going to fail can we detect that failure and the possibilities for rectifying the failure?

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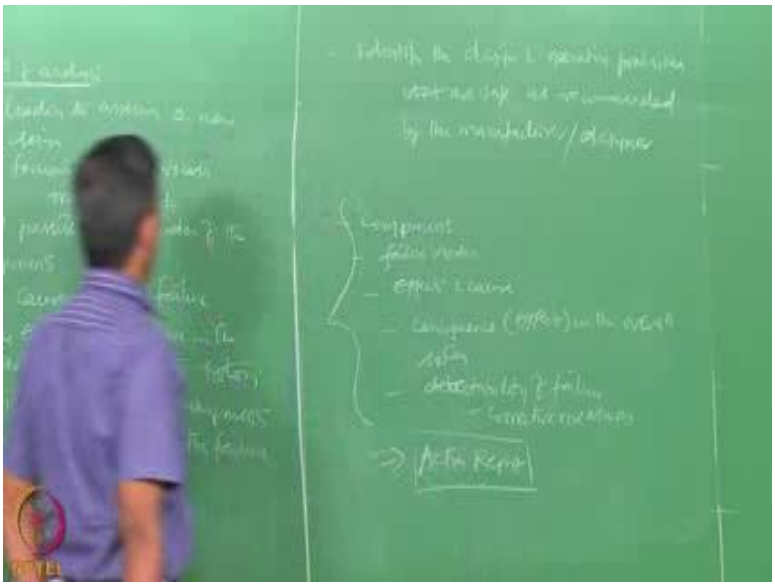

One should also I have to identify the design an operating provisions that are safe as recommended by the manufacturer or the designer. Now we are identified the components, we have identified the failure modes, we have identified the effects and causes of failure, to identify the consequences which I called as effects on the overall system, we have also identified the detectability of failure and the corrective measures. I need to summarize all of them and try to finally recommend what we call as an action report.

So, FMEA is actually a (Refer Time: 28:16) level of study which is done at the components of mechanical or electrical systems or even structural systems which will help us to ultimately understand what action should be taken, at what level this action should be taken; at the design stage, at the modification stage, at the maintenance stage, what level the action should be taken all will be clearly and explicitly recommended at the outcome of an FMEA study.

We all know the process is a combination of complex systems, in fact structural system is also a combination of different members or elements with different boundary conditions we need to break the entire system into component level and diagnose are assess the risk of each component and the effect of failure on the overall system, that why we call failure modes and effect analysis. FMEA study is a very elaborate method of doing study and component level which can give me the performance failure of a system based on the effects of those failures of the component of the system.

FMEA generally perform on individually systems to micro level to such an extent that they are predefined even before study is conducted. The actual system we know is a large and complex model therefore FMEA will not be possible to apply to on the entire system, so we do on component levels and then we try to get the effect of this and overall system. So, one need to pick up the segment of the given system and try to understand the FMEA of that particular segment in a given plant or a system, then also identify the interdependency of the segment on the remaining segments of the entire plant.

So, FMEA done in parts can be always cumulatively viewed so that the effect of each segment on the overall system can be also studied. So, prior to the FMEA study it is important to know the full working principle of the system.

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So, prior to FMEA one should know details of full working principle of the mechanical or electrical system. One should also know interaction of various components of the system. One may also know the material characteristics of the component of the system.

One should pre decide the level of analysis is it for the design stage, is it for modification, is it for maintenance stage, etcetera, one should pre decide this. Therefore, the level of FMEA is decided based on the functional structure of the system and not on the physical component of the system, this is very, very important.

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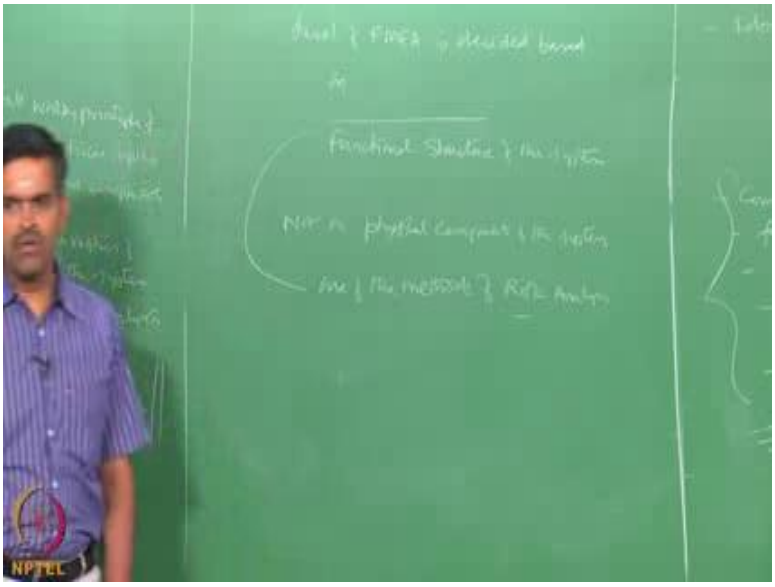

So, level of FMEA analysis is decided based on functional structure of the system not on physical components of the system. So very interestingly, since the functional aspect is focused here this is also called as one of the methods of risk analysis. We all know the risk is a focus on system under operation. Since the functional aspect is focused here this is also accepted under the bases of risk analysis. Once we identified the system either mechanical or electrical system consisting of various physical components FMEA does not analyze the physical component of the system, but only the functional study on the components and their effects of the system will be examined.

Therefore, FMEA very clearly is a functional level analysis and not a physical level analysis. It is a component level analysis and not the system analysis at all. The failure modes of the components are expressed and their effects are then found out on the system. For example, if you take a physical component of the system and if you know

the effect of that failure on the overall system then it is easy for us to really know, what is the contribution of failure of that component on the overall failure of the entire system? So failure modes are expressed as failure to perform a particular function and not as a physical damage of the component. That is very very important.

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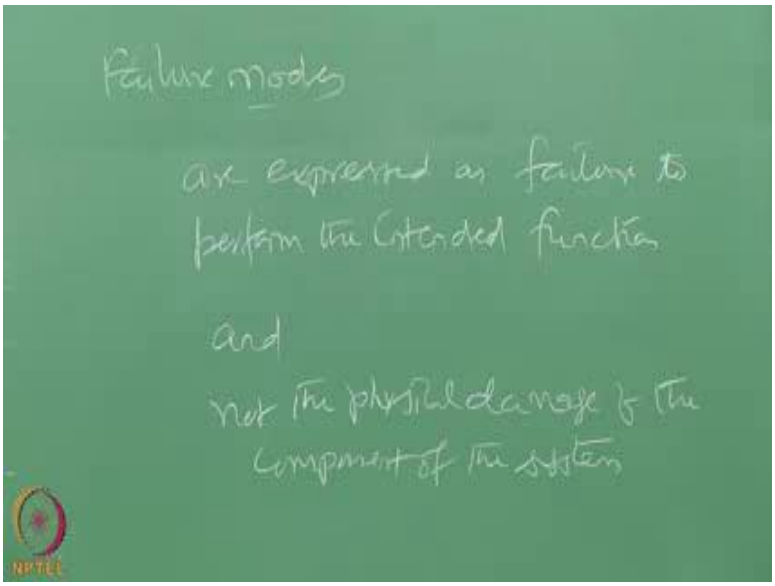

So, failure modes are expressed as failure to perform the intended function and not a physical damage of the system. So, when I talk about failure to perform the intended function we can recollect this word or the brace related to reliability. Since the failure to perform intended function is applied on the working model we call this as risk analysis as well.

So, there are very implicate statements made in this lecture which will tell you how this method can be qualified to be risk analysis method, all possible failures should then we consider in the analysis. There are different kinds of failure modes which one we can see in a given system. We will talk about failure modes and their applications; we will pick up an example in the next lecture where I will do an FMEA study for a new structural system which is offshore triceratops which has been a new innovative geometric form which is used for deep and ultra deep oil exploration.

Friends I think you hope to understand how the risk assessment methods or risk analysis tools are slightly deviating in interest compare to reliability analysis methods applied to structural systems. Risk have to definitely focused on the economic perspective and risk

can be applied only to the systems which are operational or remain in operation or which are intended to function for a specific requirement in a given system.

If it is a mechanical or electrical system one can use FMEA, if it is an overall structure which is going to challenge the economic perspective of the system one can also use logical risk analysis as recommended by Franken Morgan. So, one can do actually a risk ranking, relative risk rating of all the components present in the given system. One will exactly know which component is more critical, which is more vital in terms of causing highest possible risk to the overall system in terms of preventing the system to perform it is intended function which is the reliability. So, risk analysis in fact helps to understand reliability better in terms of functional failure. So, they are interlinked risk and reliability or any way coupled interlinked one looks scientific way, one looks economic a mathematical manner.

We will see one more example in the next lecture about FMEA applied on offshore triceratops which we will try to elaborate more functional details of a FMEA study applied to a system in a working model.

Thank you very much.