Offshore structures under special loads including Fire resistance

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Lecture - 01
Offshore Structures: Introduction

Friends, welcome to the online course on NPTEL titled offshore structures under special loads including fire resistance design. This is an online course where we will talk about behavior of offshore structures under special environmental loads which are not covered in the conventional part of analysis and design.

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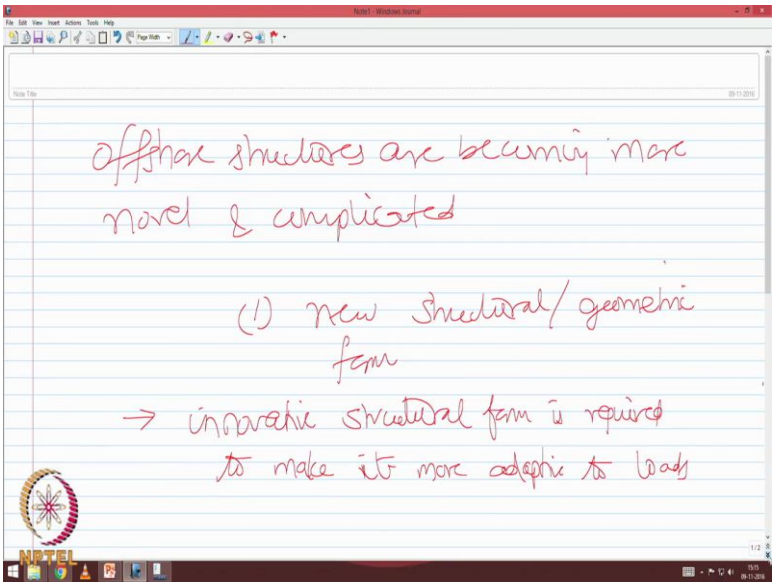

We all agree that offshore structures are special and innovative; therefore offshore structures are becoming more novel and complicated because of various reasons, the foremost reason for it is novelty is new structural or let say a geometric form.

One may ask a question why offshore structures should have new and innovative geometric form. The answer is very simple, innovative structural form is required to make it more adaptive to loads. The primary focus in the whole discussion is how to reduce the response of the given structural system under various environmental loads.

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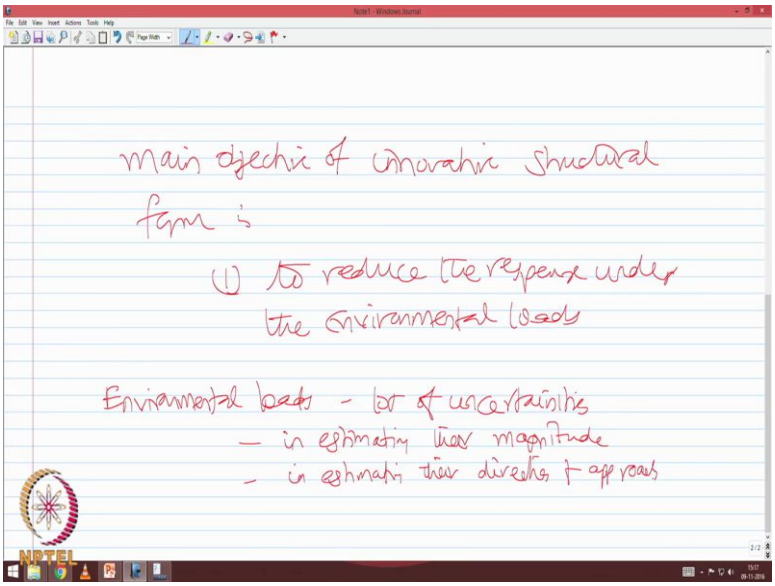

So, the primary objective of innovative structural form is to reduce the response under the environmental loads.

However, if you look at the environmental loads in total, which we will be discussing in detail environmental loads have lot of uncertainties, in sense the uncertainty in estimating them, the uncertainty in estimating their direction of approach and most importantly the return period of these loads make them very complex.

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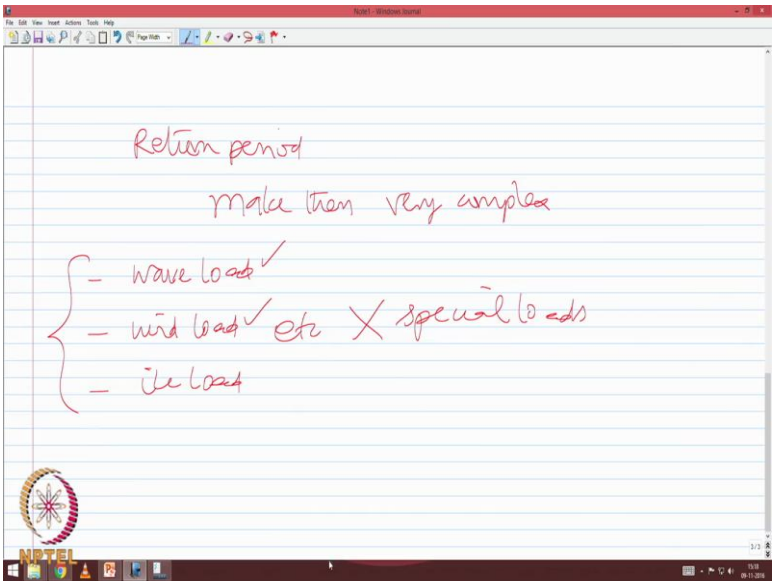

However, we are not interested in explaining the complexities on convention environmental loads like for example wave load, wind load ice load etcetera.

There are different courses, different material available in the literature, which explains the readers to understand the complexities involved in estimating these categories of forces. So, I do not call these forces as special loads therefore, in this course we will not discuss much about these forces of wave load, wind load etcetera in detail. However, we will talk about special loads which are appearing or encountering the offshore structures, which are not otherwise discussed in conventional literature.

One may ask me a question what would be the result of encountering special loads on offshore structures, when special loads are encountered on offshore structures it leaves.

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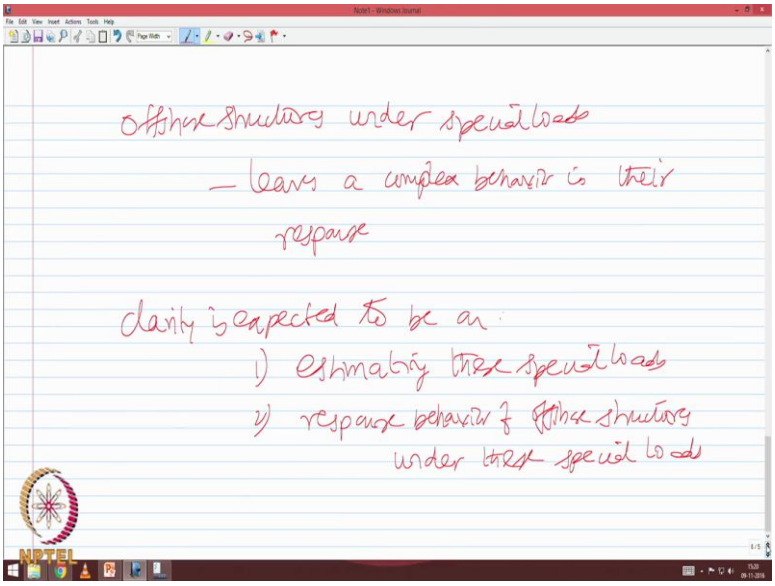

So, offshore structures under special loads leaves a complex behavior in their response therefore, these course is expected to improve the clarity of understanding in estimating not only these special loads, but also the response behavior of offshore structures under the special loads. So, clarity is expected to be on one estimating, these special loads to understanding the response behavior of offshore structures under these special loads. Let see what would be the course objective for this course titled offshore structures under special loads including fire resistance.

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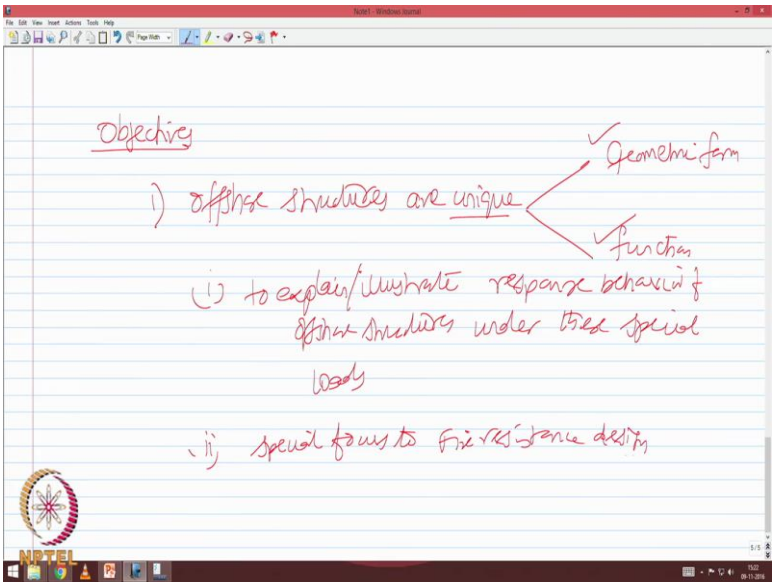

Some other are going to the objectives of this course; one we all agree that offshore structures are unique in nature, the uniqueness comes from two sources - offshore structures are unique they come or arise from two sources, one the geometric form; two they are special functions. Sometimes offshore structures also designed for special category of functional operations, we will talk about that in detail which are called new generation offshore platforms whereas, the functional application of these platforms are completely redefined depending upon the present requirements.

So, offshore structures are unique from two sources; innovative geometric form and special functional operations therefore, the main objective in this course should be to explain or let say illustrate response behavior of offshore structures under these special loads, while doing so we will give you the special focus to fire resistance design.

One may ask me a question why fire resistance design is given a special focus in offshore structures? Looking at the history of offshore accidents, which are highly unintentional, but; however, highly severe consequential effects; one is interested to know what would be the special care I must use to select material with good fire resistance, to mathematically model fire on these material to understand the consequence of spread of fire and explosion in terms of asset management of offshore structures etcetera, which could have been a primary focus about 10 years back, but still at this point of time it is very important that we must realize that fire resistance design is

inevitable for offshore structures, because the asset involved in these kind of damages caused by fire is huge scale.

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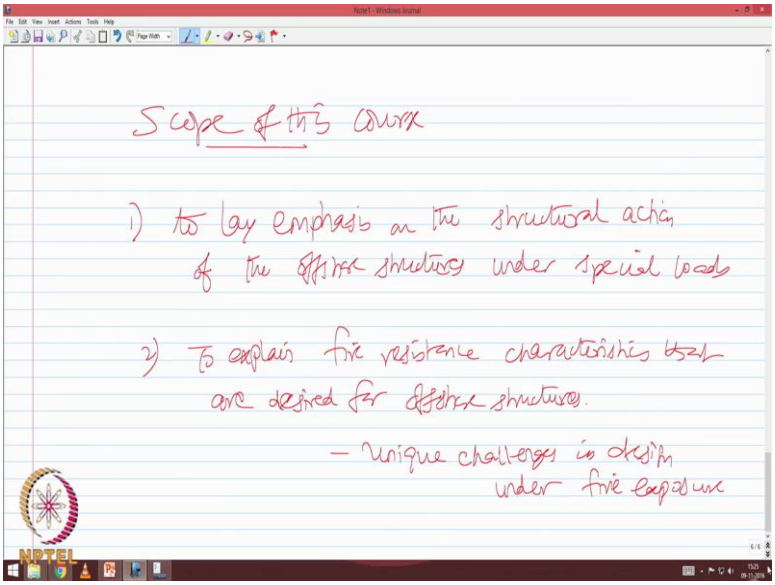

The scope of this present course is to lay emphasis on the structural action of the offshore structures under the special loads and the second scope should be to explain fire resistance characteristics that are desired for offshore structures, because there are unique challenges in design when these structures are subjected to fire.

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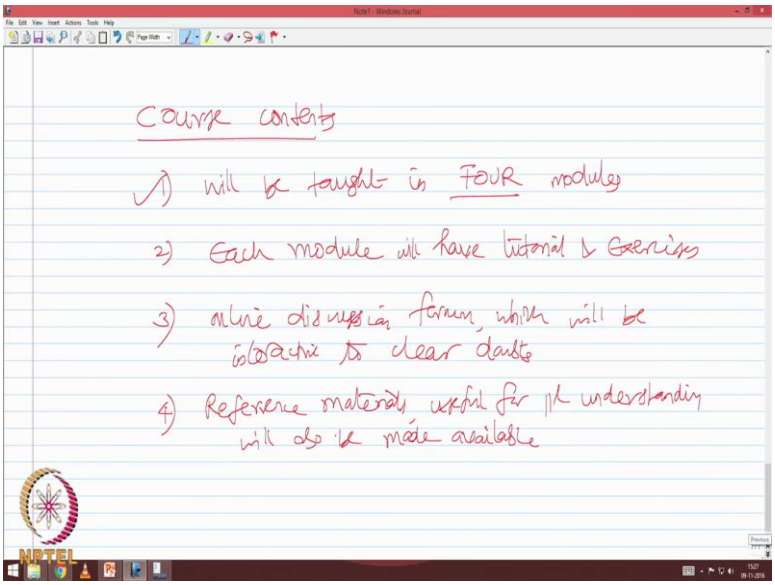

Let us quickly see broadly the course content, how we are going to do this course? The course will be taught in 4 modules, each module will have tutorials and exercises for self learning, there will be also an online discussion forum which will help you, which will be interactive to clear doubts on the content of the course, reference materials which are useful for parallel understanding will also be made available. Having said this let see what would be these 4 modules and what we will cover in this 4 modules.

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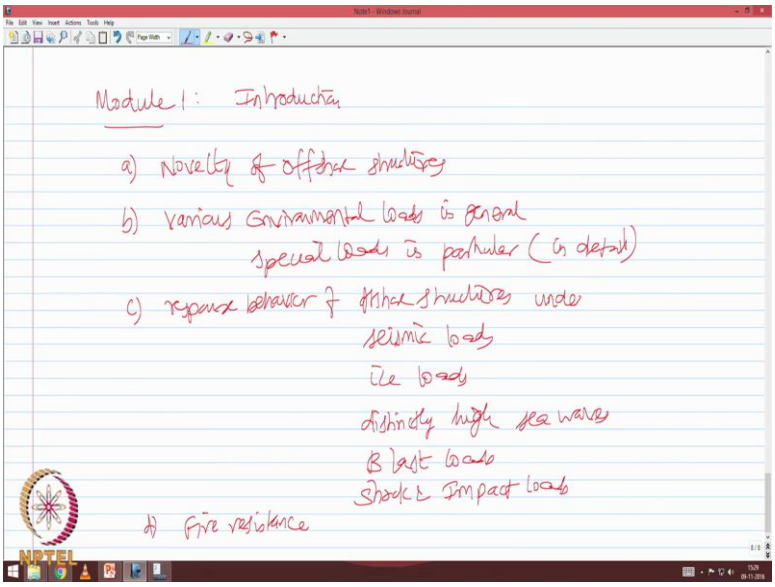

Module 1 we will talk about introduction, in introduction we will discuss novelty of offshore structures, we will talk about various environmental loads in general and special loads in particular maybe in detail; we will talk about response behavior of offshore structures under seismic loads, under ice loads, under distinctly high sea waves, under blast loads, under shock and impact loads and we will introduce fire resistance that is we will see in the first module.

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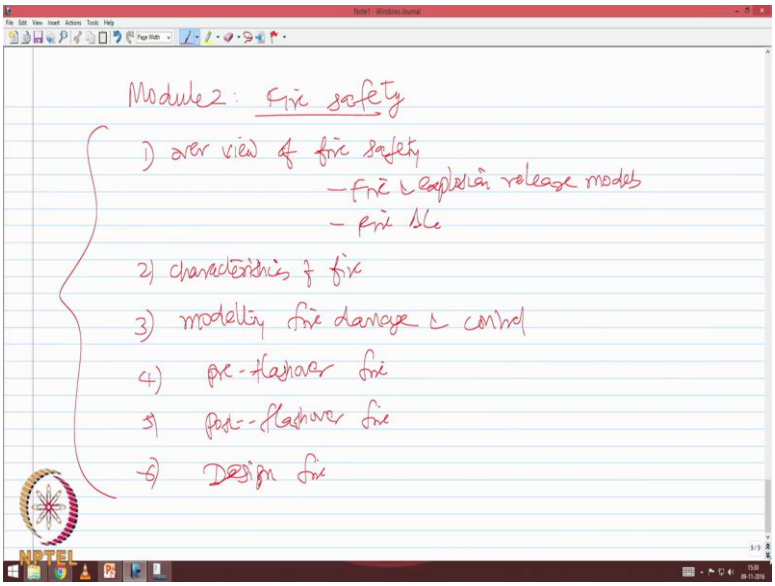

In the second module, we will discuss about fire safety, in this we will have a overview about fire safety, where we will talk about fire and explosion release models, fire triangle; we will talk about characteristics of fire, we will talk about modeling fire damage and control, we will talk about pre-flashover fire, we will also talk about post-flashover fire then we will talk about something called design fire in the second module.

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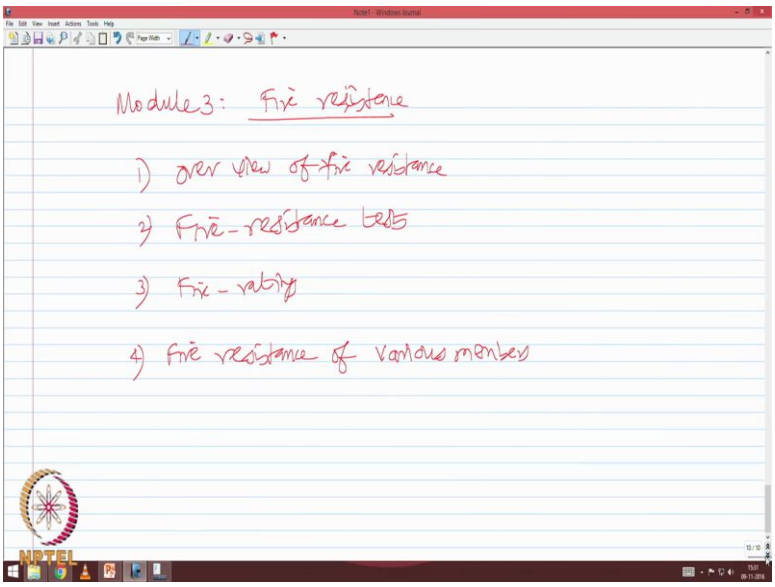

After understanding this we will move on in the third module, where we lay emphasis on fire resistance, there we will discuss about over view of fire resistance, we will talk about

fire resistance tests, we will be talking about fire ratings, we will talk about fire resistance of various members having said this.

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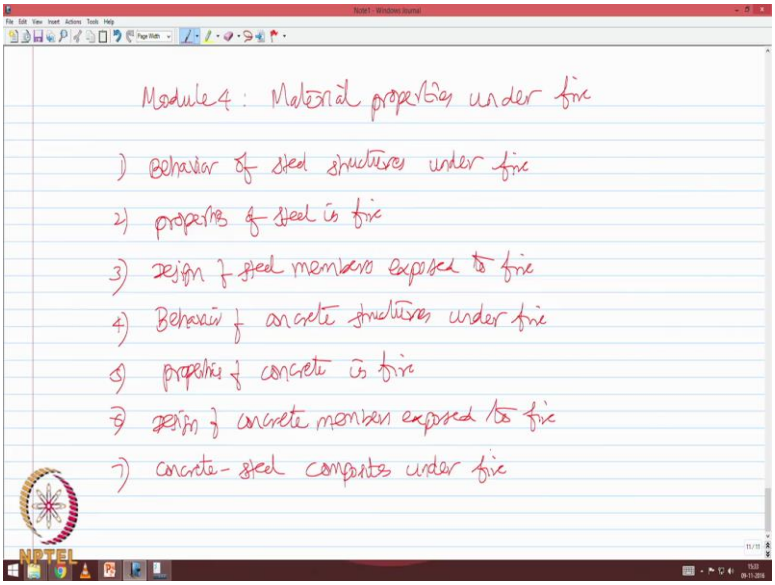

We will move on to fourth module, where we talk about material properties under fire, we will talk about behavior of steel structures under fire, we will talk about properties of steel in fire, we will talk about design of steel members exposed to fire, we will talk about behavior of concrete structures under fire, we will talk about properties of concrete in fire, we will talk about design of concrete members exposed to fire and finally, we will talk about concrete steel composites under fire.

So, the course will be now taught in 4 different modules as you saw in the previous slides the course of course, will circumscribe around various textbooks. You can look at the screen now.

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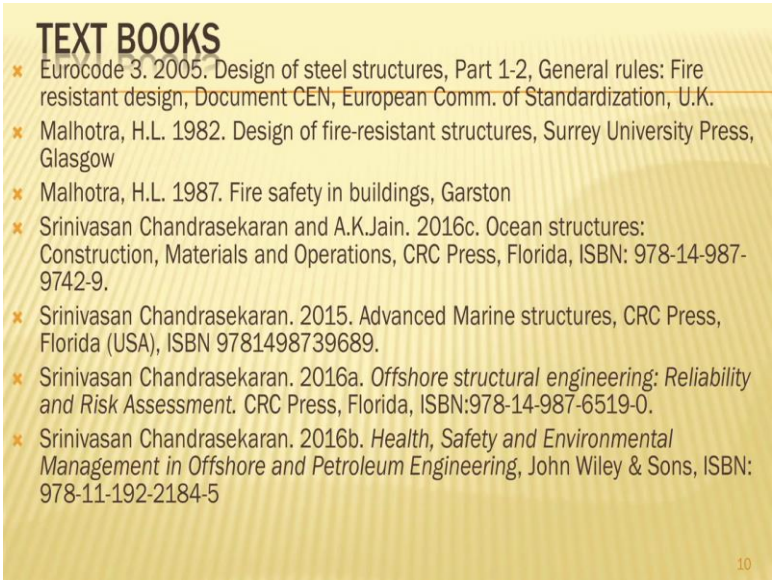

So, there are various textbooks as Eurocode 3 2005 Malhotra 1982, Malhotra 1987 fire safety in buildings, then the textbooks authored by myself with different co authors, which talks about basics on offshore structures, the advancement and design methodologies then the reliability in risk assessment involved in offshore structures and of course, health safety and environmental management in offshore and petroleum engineering program as well which are all discussed as textbooks in the given system.

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For additional reading you also have references taken from different journal papers, BS 5950; structural use of steel works in buildings paper authored by Srinivasan Chandrasekaran et al, talks about Curvature ductility of RC sections based on Euro Code, behavioral of triangular tension leg platforms under distinctly high sea waves in earthquake motion, also paper on structural response of offshore TLP under seismic excitation.

So, we are now interested to extend our discussion on understand the novelty in offshore structures, we already said that offshore structures are constructed for different functional requirements.

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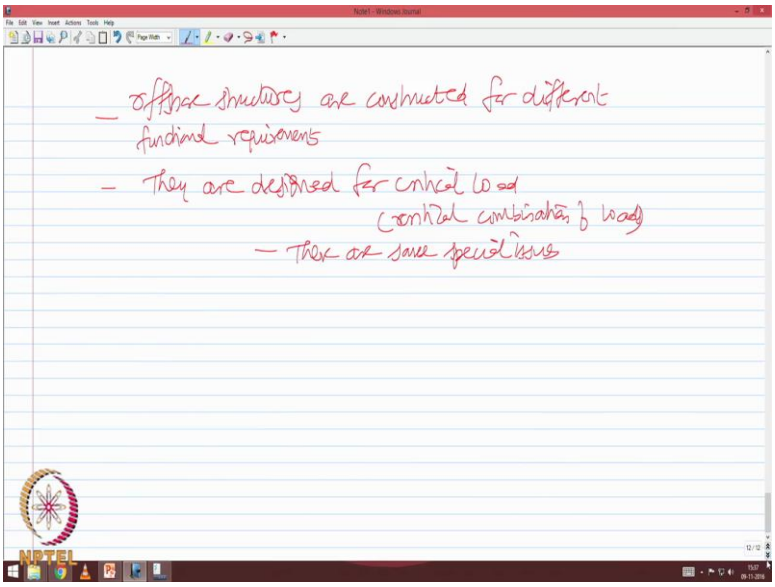

So, offshore structures are constructed for different functional requirements. Although they are designed for critical loads, but there are some special issues generally they are designed for critical loads or I should say for critical combination of loads, but there are some special issues.

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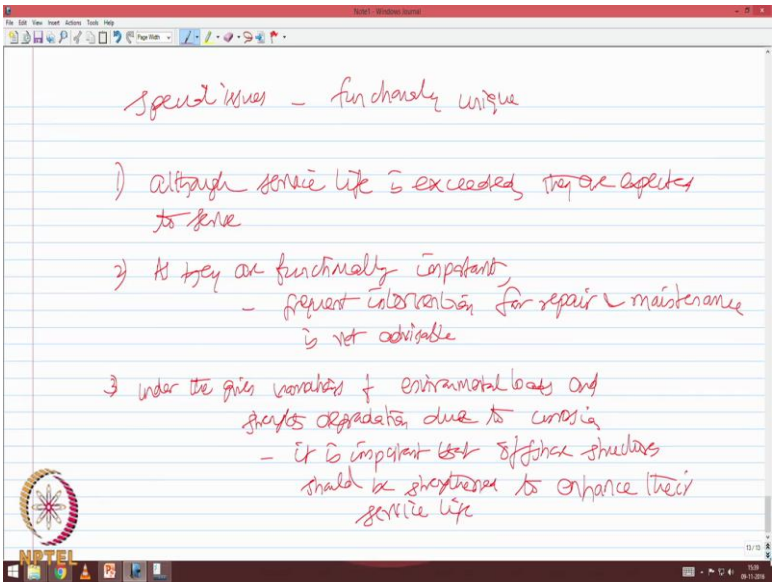

Let us see what are they, what are the special issues? The special issues which makes them functionally unique are the following; one, although the service life is exceeded they are expected to serve. Secondly, as they are functionally very important frequent intervention for repair and maintenance is not advisable under the given variations of environmental loads and strength degradation due to corrosion, it is important that offshore structures should be strengthened to enhance their service life.

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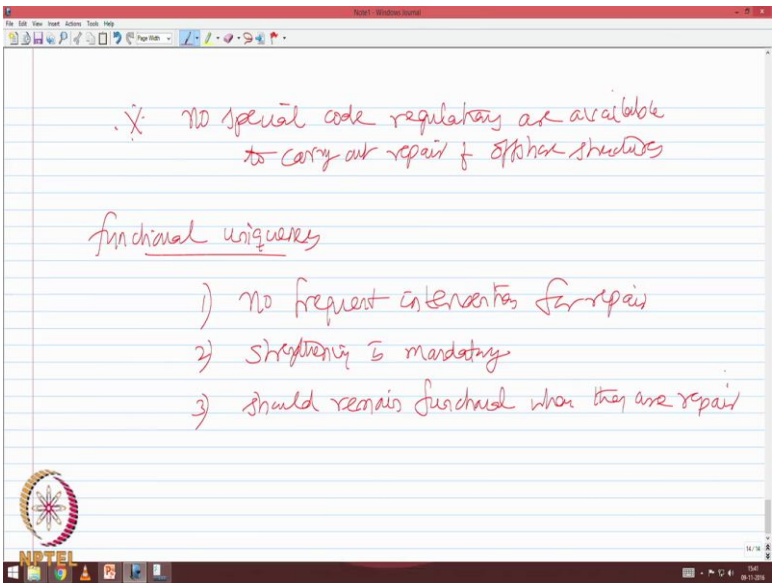

More interestingly no special code regulations are available to carry out repair of offshore structures. So, we have very important points of functional specialty, let say functional uniqueness; one, no frequent intervention for repair, strengthening is mandatory, most importantly the structures should remain functional when they are repaired I mean that is a very classical problem we have in offshore structures. You cannot shut down the offshore platform for the sake of repairing the platform, it is expected that the functional requirements by enlarge is not affected while the repair or strengthening process in a platform is being carried out. So, there will be a functional isolation of the platform for a particular sector or portion of the members of the platform, which will be repaired or strengthened while the remaining parts of the platform have to remain functional under the given environmental loads.

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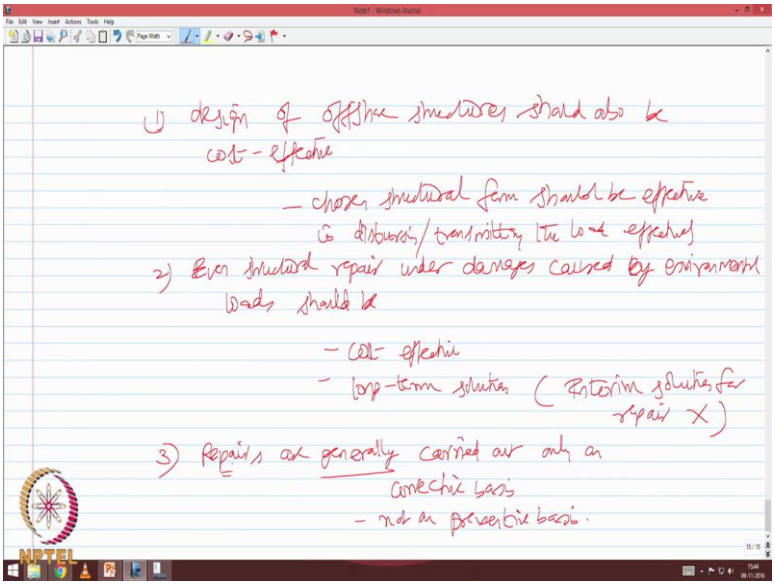

In terms of special challenges further continuing design of offshore structures should also be cost effective; it means the chosen structural form should be effective in disbursing or transmitting the load effectively. Even the structural repair under damages caused by environmental loads should be cost effective and should provide a long term solution that is very important, you cannot have an interim solution for repair; that is not advisable because frequent intervention of the structure is not desirable. Most critically repairs are generally carried out I am saying generally carried out only on corrective basis and not on preventive basis.

So, what does it mean? It means that repair is generally attempted only when the platform actually needs a repair or the damage is of a very sever order. So, time availability to do detail analysis, diagnosis and concluding certain methods of repair becomes very scarce and the solutions provided should be also long term and cost effective, under these circumstances offshore structures therefore can be classified as unique and novel.

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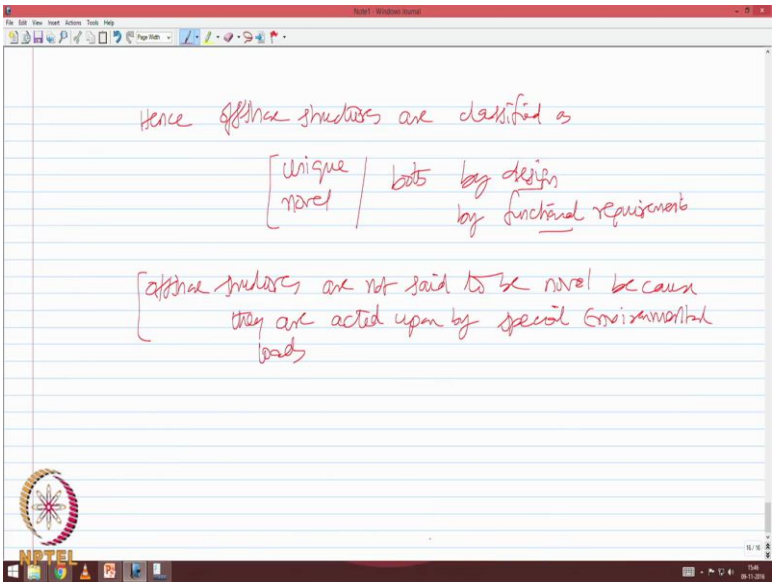

Hence offshore structures are classified as unique and novel both by design, by functional requirements. Please understand the novelty of the classification does not come because of the loads. So, I must say here very clearly offshore structures are not said to be novel because they are acted upon by special loads, the novelty does not come from the source of loading, it comes from the source of geometry and functional requirement; that is a very important and very interesting statement which you have got to understand.

Now, let us ask a question when we are looking for a novelty by design and functional requirement generally, what factors are considered in arriving at this novel geometry?

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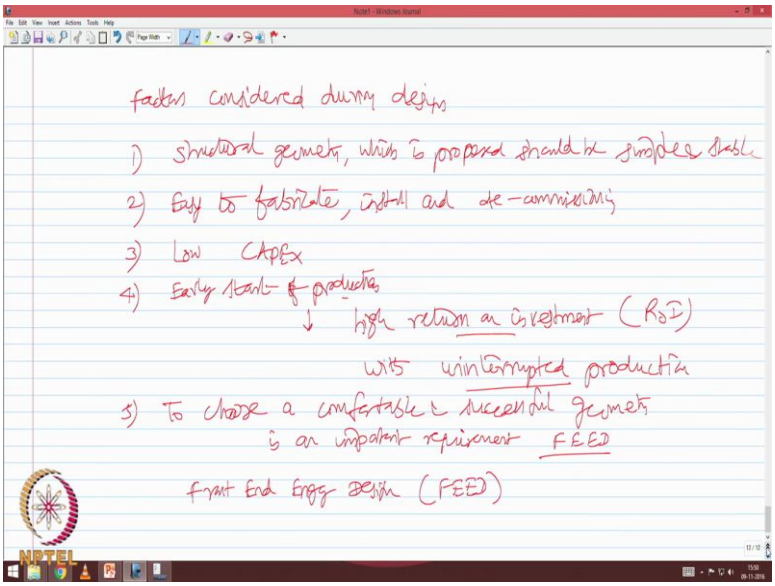

So, let us talk about factors that are considered during design. The structural geometry which is proposed should be simple and stable that is the first requirement we have. The second requirement could be it should be easy to fabricate, install and most importantly decommissioned.

The third factor could be I must encounter with a low capital investment which you call as CAPEX. I should always enable the design for early startup production it means the structural form should be installable in a very short period of time, so that the production of the well through the platform drilling can happen as early as possible, which can result in high return on investment which we call ROI. Where the investment capital in construction of an offshore structure is phenomenally high, one always accepts to have a good return on investment with an uninterrupted production. So, therefore, under any kinds of loads encountered in offshore structure, it is important that we must realize as a designer, as a constructor or an offshore engineer, we should not allow the downtime of the platform to happen or the shutdown of the platform to happen, because of it is non-resistance to any special kind of loads encountering them.

It is therefore important to understand the response of the structure and then therefore then select an appropriate geometry to withstand the encounter environmental loads acting on the system. Rather this is one of the important requirements to choose a

comfortable and successful geometry is important requirement in Front End Engineering Design, which we call shortly as FEED.

Interestingly the whole discussion can be successful if we are able to understand different existing structural forms of offshore platforms, their merits and demerits in encountering the environmental loads, the necessity for new generation offshore platforms, the special kind of members and connections which are enabling them to alleviate the environmental loads effectively and what are those special loads which can cause serious damage to these platforms when they have encountered even under a rare phenomenon.

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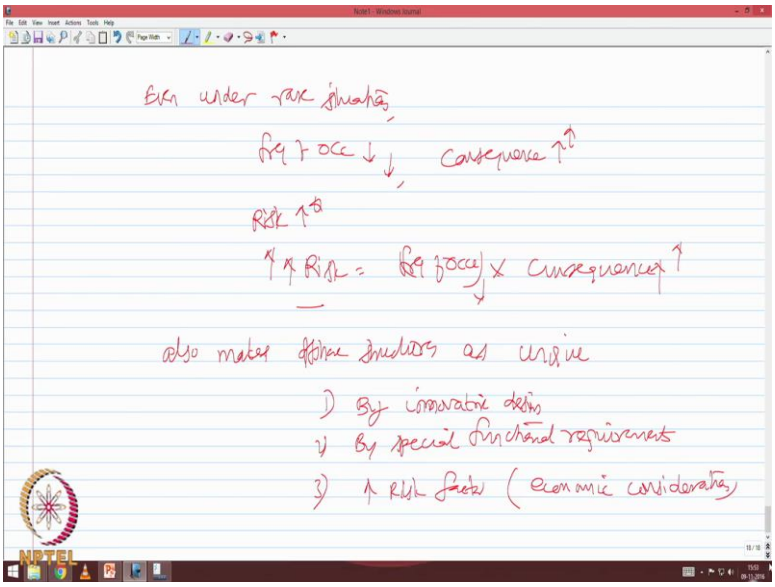

So, the argument here is even under rare situation, to put it more scientifically even the frequency of occurrence is very very low, since the consequence of damage is very very high, offshore structures generally have very high risk because risk is actually a probability a product of frequency of occurrence of an event multiplied by the consequence. So, one of them can be low, but this is phenomenally high therefore offshore structures are under high risk. So, this risk factor of high value also makes offshore structures as unique.

So, friends, novelty or uniqueness in offshore structures arise from many factors, the first factor is by innovative design, by special functional requirements and thirdly high risk

factor. The moment I say risk it also includes the economic considerations because we all agree risk is a term related to finance management as well.

Let us quickly see how offshore structures are categorized, how are they classified?

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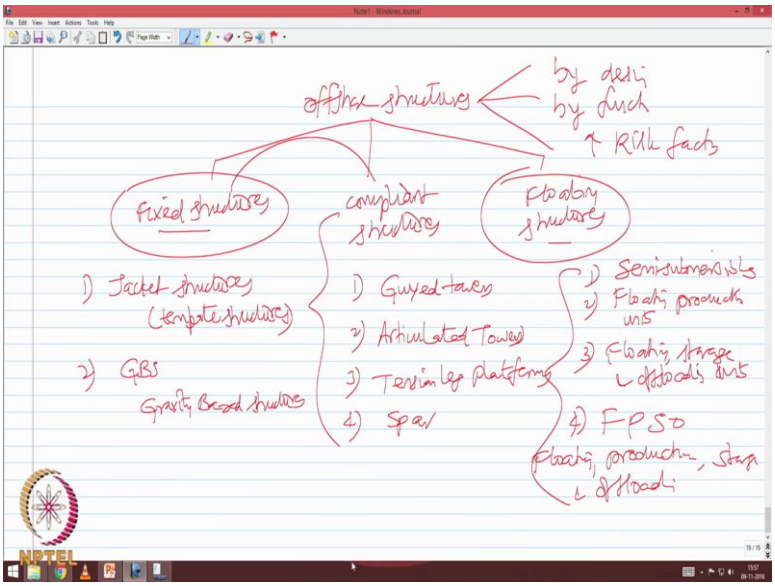

So, offshore structures can be classified essentially in 3 forms; the first could be fixed structures, the next could be compliant structures, the third could be floating structures. As an engineering graduate or as an experienced professional executive in engineering, you will be able to easily understand the varied difference between these classifications starting from the geometry required for a fixed system to that of completely floating.

So, one can easily understand here the classification essentially deals with the support system on which the platform is resting. So, fixed structures can be examples of jacket structures, otherwise called as template structures, the second could be GBS which we call as gravity based structures. Compliant structures can be guyed towers, articulated towers, tension leg platforms and spark platforms. Floating structures could be semi submersibles, floating production units, floating storage and offloading units, floating storage offloading and production systems which is FPSO, Floating production storage and offloading.

So, friends, one can very easily see from this comprehensive slide that support systems essentially make the difference in classifying offshore structures, which are unique by design, by functional requirements, by having very high risk factors.

So, in the next lecture we will discuss about some brief details, advantages and disadvantages of different classification of these structures, when we move on from one system to another let us talk about the demerits of this and how this demerits of design are overcome in design of these systems and further overcome in design of these systems. Even at the system design what are those lacunas, we will talk about this in the next lecture. So, in this lecture the summary is very simple, offshore structures are unique in nature, they are novel by design functional requirements and high risk factors and they are generally encountered by various environment loads they are not called special loads or the novelty of the offshore structures does not come because of environmental loads, but the novelty arise from the design.

So, offshore structures in general are form dominated design and not function dominated design. Amongst these three categories you will see that from dominated design is the majority in terms of implication in the novelty. So, it is form dominant and less function dominant.

So, friend's thank you very much for this lecture, we will talk about more in detail in the next lecture.

Thank you, bye.