Dynamics of Ocean Structures

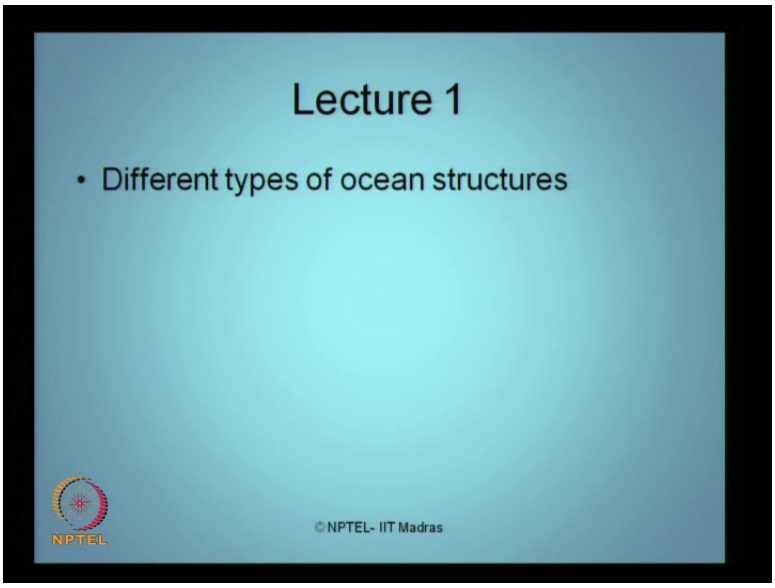
Prof. Dr Srinivasan Chandrasekaran
Department of Ocean Engineering
Indian Institute of Technology, Madras

Module - 1
Lecture - 1
Introduction to Different Types of Ocean Structures I

Welcome to this course on Dynamics of Ocean Structures; this is the first module lecture, which you are attending now; I am Srinivasan Chandrasekaran, Department of Ocean Engineering, IIT, Madras. This course is a virtual classroom course organized under the braces of NPTEL, IIT Madras. It is a web based course. You can listen to the lectures later at the end of the semester.

We will use black board for explaining the concepts. Some of them are discussed in the power point, which will be focused when it is required. So, let us start up with the course. When we ask about question on dynamics of ocean structures, there are two components in this. One is, the fundamentals of dynamics itself as applied to any structural system, which is very important to understand; and two is, those specialties in ocean structures which make them different from other types of structures. Fundamental of dynamics, of course, is a graduate level course. Many of you would have studied some introduction to dynamics at least in your undergraduate program. We will discuss some of the fundamentals back for the benefit of the listeners of the course. Many of you will not have understood the complexities involved in structural systems built for specific purpose like oil exploration, which we call as ocean structures. What are those complexities in mathematical modeling? How can dynamics be applied to them?, Can we do them as easy as land-based structures?.

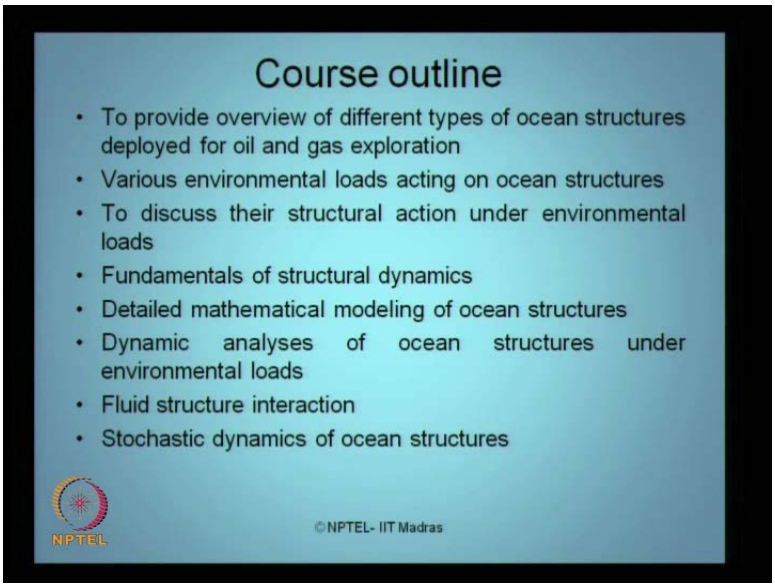
(Refer Slide Time: 02:03)



So, we will try to answer these questions in the total course length, which will be covered in three modules. Lecture one, which we will talk about today is on different types of ocean structures. You may wonder that why we are not focusing on the syllabus outline for this course. As I said, you can log on to www/nptel.iitm.ac.in, go to ocean engineering sub sector, the course on this title is available and the syllabus is already mentioned there. It has about 16 reference books and 72 journal papers listed in the website. All these books are very important to us. We give respect to all these authors who put their energy to write these text books. In that list of 16, I also have written a book on this. So, it is not necessary to follow my book, but some of the concepts what I will be explaining here will be found in that book also. It will be easy for you to follow. The research papers are very important. They are recent updated papers. I want all of you to download these papers from our intranet system in the library; read them, follow them and ask questions, then and there, in the class as relevant to the topic of discussion.

So, today's topic of discussion will be different types of ocean structures. Now, it is very important for one to understand what the different types are. I am not talking about different types of ocean structures. I am categorically dividing them into groups. I am classifying them. I am going to classify based on the function, based on the geometric form, based on the dynamic characteristics. That is the focus of this lecture.

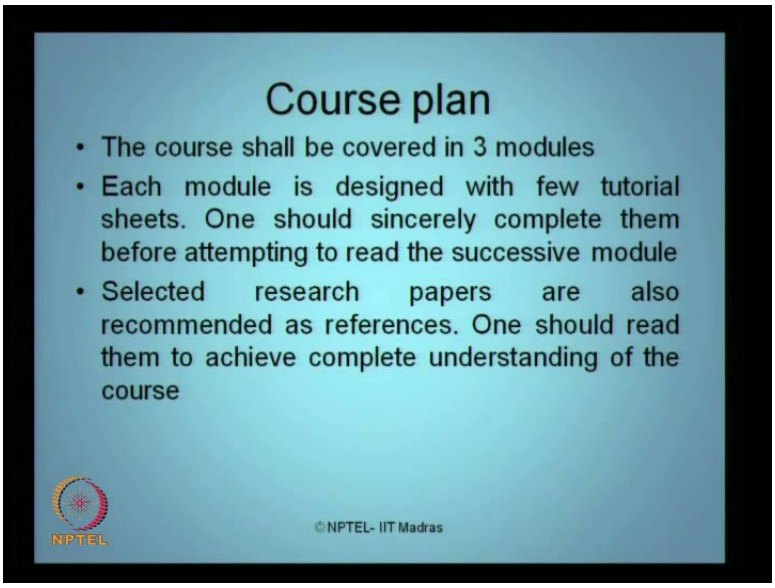
(Refer Slide Time: 03:52)



The course outline will have an overview on different types of offshore structures and ocean structures, which are deployed for oil and gas exploration. Various environmental loads acting on the offshore structures are very important. To discuss their structural action and the environmental loads, it is very important for us to understand the fundamentals of structural dynamicswithout which, we cannot do dynamic analysis of ocean structural systems.

Detailed mathematical modeling of ocean structures will be explained in detail. Dynamic analysis with some specific examples, will be solved here. Fluid structure interaction is an important component of the dynamic analysis of ocean structures. So, one must understand this in detail. Stochastic dynamics of ocean structures is also important, because the variables are time dependent. Can I also do some stochastic introduction in my outline for this course?

(Refer Slide Time: 05:08)

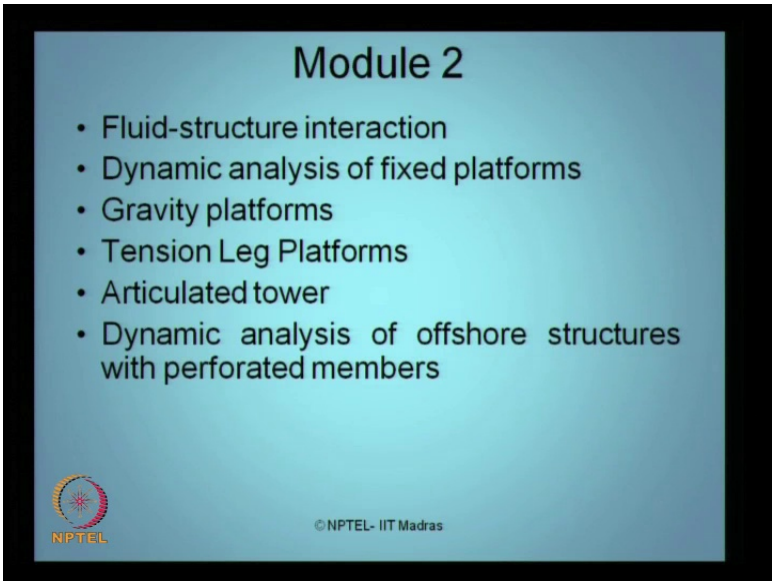


We will also talk about the reliability application and fatigue reliability, slightly, at the end of this course as an introduction. As I said, the course will be planned in three modules. Each module is designed with enough tutorials at the end. So, I want you to follow all of them and read the modules in the same order. Do not read the third one, before you read one and two. It is important, that the order of this module should be followed for you, to better understand this course. The research papers are highlighted. They are not attached, but you can download them from the library facilities, at IIT Madras. Read them, go through them, highlight them, then ask questions in the class. If there is a doubt in the overall structure of the course, please let me know.

So, we are talking about two aspects in this course; one - ocean structural systems as such, how are they classified, how are they mathematically modeled, what are the complexities, what are the elements of modeling, how do you do dynamic analysis of them etc. Before understanding them, let us quickly look at the fundamentals of structural dynamics as well. Let us understand how to interpret the results of dynamic analysis and so on. So, we will club both of these, slowly, throughout the length of the course. We will give you basic information on both of these areas. It is not an advanced level course. There is an advanced level course also on structural dynamics and ocean structures. It is an introductory level course, but nevertheless, it will be interesting and informative to almost all of you.

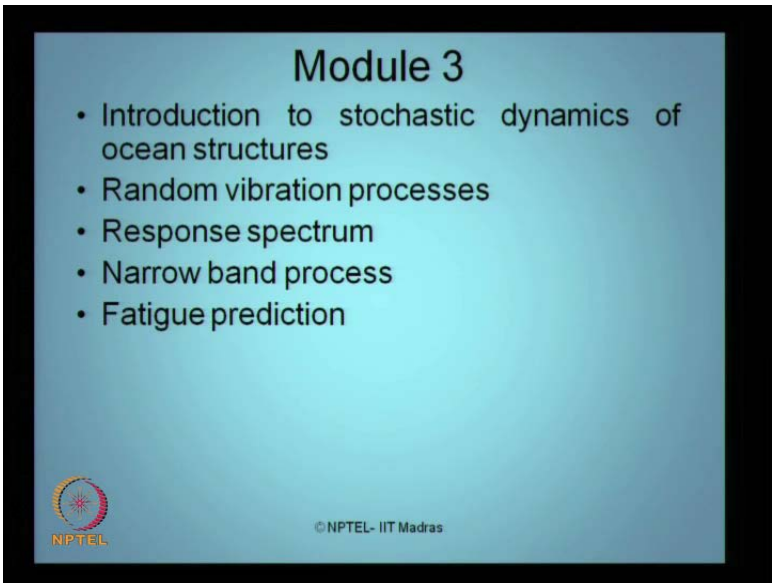
Is there anybody in the class, who has a good background on structural dynamics? Your face has got to be glorious, because that makes my job very easy. Because, if you do not have a dynamics background, I can speak anything I have to speak here. If you have a background, then I can put questions to you exclusively in the lecture, so that in the next class onwards you will be very careful. Because there are couple of PG students in the class, I wanted to check, whether they have any background on dynamics. So, I think, either they do not want to disclose or there is nobody who is having a background; it does not matter. We will talk about different types of ocean structures in this lecture.

(Refer Slide Time: 07:38)



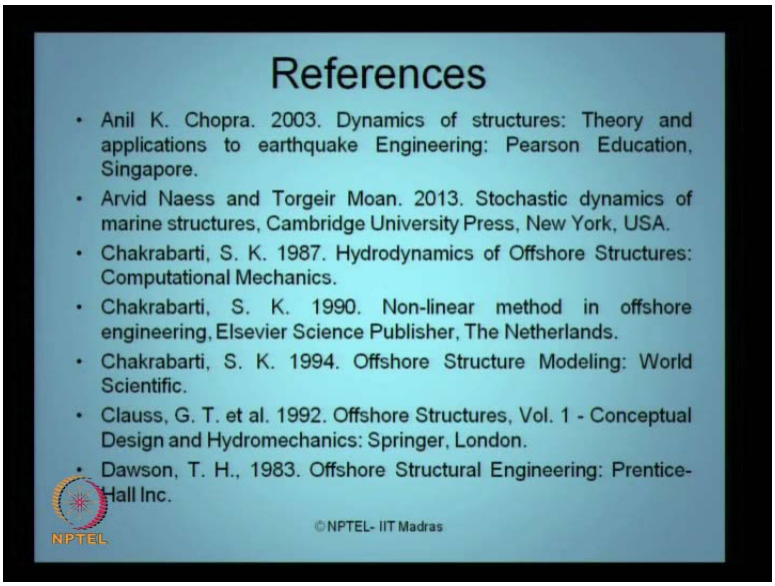
So, in module 2, we will talk about fluid structure interaction; different kinds of platforms in detail and about their mathematical modeling.

(Refer Slide Time: 07:49)



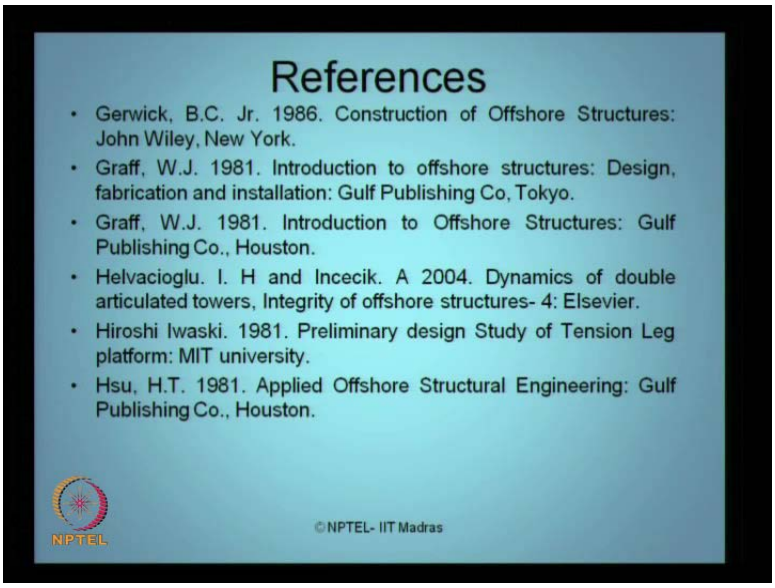
In module 3, we will talk about introduction to stochastic dynamics, which is by itself a research area. But still we will introduce you to stochastic dynamics in this course.

(Refer Slide Time: 08:02)



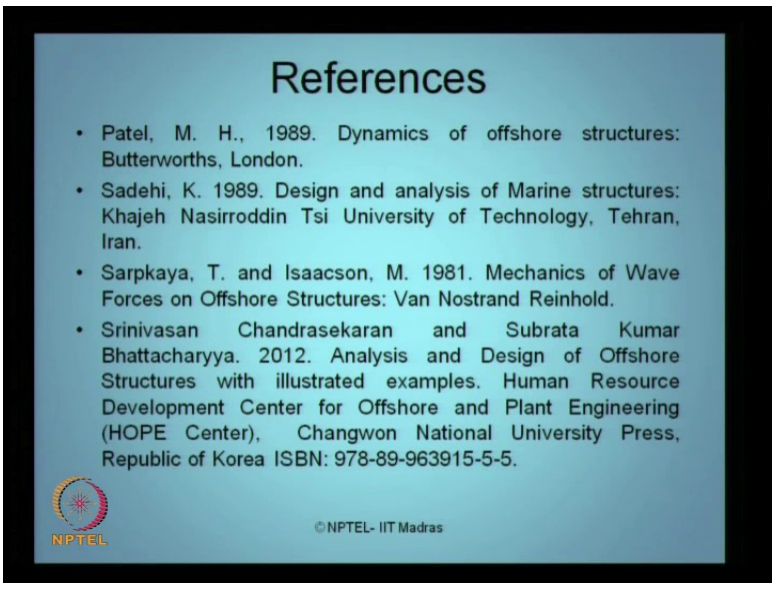
There are interesting references; I am just skipping them, because they are available for the purpose of demonstration. I am showing them slowly one by one. But they are not important, they are not in order; it is an alphabetical order actually. So, all books are equally important for us. So, I am showing them for their purpose of the viewers in the you tube.

(Refer Slide Time: 08:27)



These references are available in our library. You can download them and read them. All books are equally important, and all of them cover different dimensions of dynamic analysis of offshore structural engineering.

(Refer Slide Time: 08:37)



The last one is a new book, which was released in December 2012 by myself and Bhattacharya. Of course, there are no questions focused on this book, for the examination. But still you can understand this book; it is very easy to follow.

(Refer Slide Time: 09:06)

When we talk about offshore structural systems, there is a fundamental question. Why these offshore installations are actually constructed? It is very important to know their different classifications. More than about 6500 installations are constructed around the world, spread in about 53 countries. These installations are actually built for varied applications. We will look at them quickly, some of them are essentially for drilling, preparing water or gas injection system, to enhance the efficiency of the reservoir; some others for processing for oil and gas, which is obtained from the reservoir, cleaning the produced water. It is also an important area where people will platform. And, of course, to create necessary accommodation facilities for making people to work on the platform. So, there are varied purposes. Obviously, you can see that one of such important purpose is, exploratory and production drilling. Can I build any kind of structural system, which can ensure exploration and production drilling, at any depth of water, in any sea environment? The answer is NO.

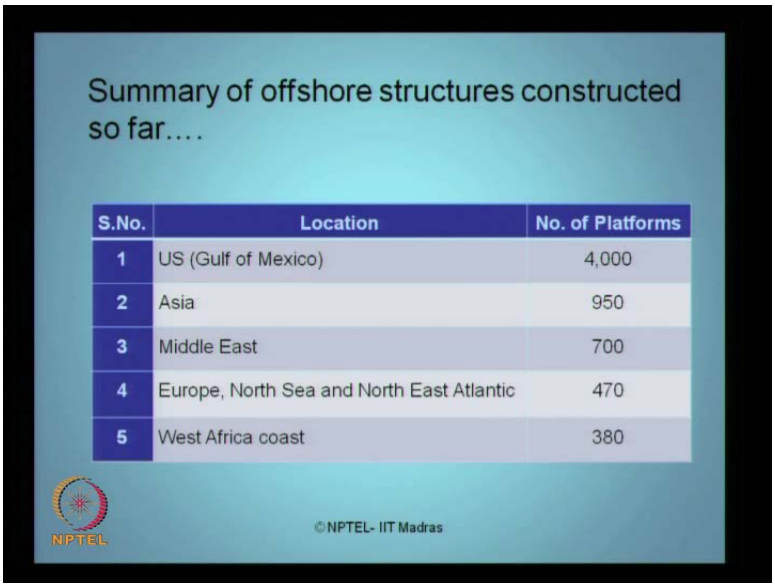
Systems, as you go deeper and deeper, get complex. The structural geometry gets realigned and it is not the same structural system, which you will use for exploration and drilling at shallow water depths. For medium and deeper water depths, the structural form has got to be innovative. When I say a structural form is different, then, of course, the complexities involved in the dynamic analysis, will also be different.

So, let us first understand for the benefit of all the viewers what are those classified structural systems? We have dedicatedly constructed offshore applications only, and how are they different, in terms of the structural action, compared to other structural systems built onshore. Once this difference is understood, it becomes easy for us to really appreciate the mathematical modeling of these kinds of structural systems. You will understand the differences between modeling of these structures, which are built for non-offshore production systems.

So, it is easy for us to appreciate the difference once we understand the classifications of this. I am sure, that many of these students, who have understood a course on earlier semesters, will realize different classified systems on offshore installation, because it is an ocean engineering program. You would understand that. But many of the new registrants are there. For the benefit of them, let us quickly go through this lecture in three stages, for you to understand and comprehensively summarize them.

So repeatedly, we will keep on writing some important points on the black board here, which will be an essence of the lecture of the PPT. At the end of the lecture, we will have 5 to 6 questions given to you, which you would like to answer. This will be a part of the assessment at the end of the semester. So, you will answer them, but you will submit this to me, with a date, at the end of the semester. Is that clear? Any questions from anybody, any doubt, any view from anybody?

(Refer Slide Time: 12:45)



So, we will move further. If you look at the summary of different kinds of offshore structures constructed so far, it is important to know how many of them are constructed. It is not the number, but the types, the complexities etc. Let us look at them quickly. This is a very brief statistics given. Gulf of Mexico actually dominates the construction of offshore platforms in the world. Around 4000 platforms are constructed in Gulf of Mexico alone. There are two reasons for this; one - Gulf of Mexico has got an enormous reserve of oil potential, which can be explored; two - the United States dominate an advanced research of geometric form, which can be installed in deep-water locations. They were the first pioneer in the world, to attempt different structural forms at different water depths. Therefore, they keep on attempting different kinds of platforms in Gulf of Mexico, If you look at Asia and Middle East and Europe put together, they are close to around 50 percent of what is constructed in US. Of course, countries like West Africa also have reasonable number of platforms.

So, this summary prompts me to understand, that offshore installations are not as common as buildings or any other structures and bridges. They are very rare. As on today, in the entire world may be there are only four thousand structures. They are very countable in number. Can you tell me, the reason for such a small number of offshore constructions being done in the world? Somebody says, cost is an important factor. Suppose if we get that the potential of oil exploration is specific location, which is a very important resource generation,then for any country, cost should not matter; whatever may it be.

Suppose for example, if you have a gold mine located near to IIT and there is surety, there is a gold mine there, I can invest, I can invite group of companies in the world to say there is an gold mine available here, please invest and we will share the property. So, cost should not be a matter, if you have potential of a reserve, I agree. Without investment, without returning my investment, the cost is useless. Yes, they are enormously costly, agreed, but is that the only handicap which limits the number of installations in offshore platforms? What is the other factor?

Student: (( ))

Professor: You have to say one by one; otherwise it will be very confusing for all of us. Any one?

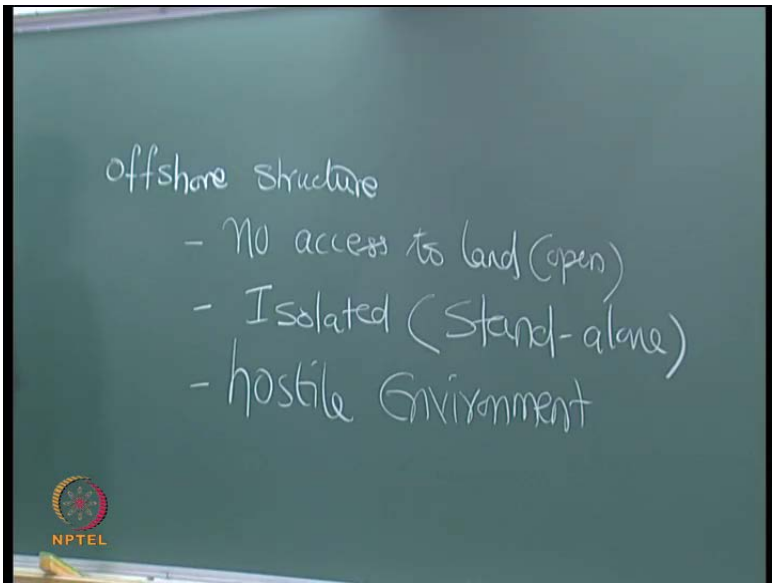
Student: Technological complexities

Professor: Technological complexities. So there is a gentleman, who says it is technological complexities. It means, we all agree, that the advancements in research of analyzing and designing these kinds of platforms, are not updated. They are not open domain resource generated files. We cannot access them; for example, if we construct a platform today at a depth of 2000 meters, the technological knowhow this platform installation will not be available in open domain. So, there are technological complexities in analyzing, designing, creating a form, which is adopting that sea environment and also installation, construction, fabrication, decommissioning. There are different process stages involved in construction of offshore installation. So, all of them are technologically complex. Therefore, they are not very common categories of structures, agreed. Any other reason?

Student: (( ))

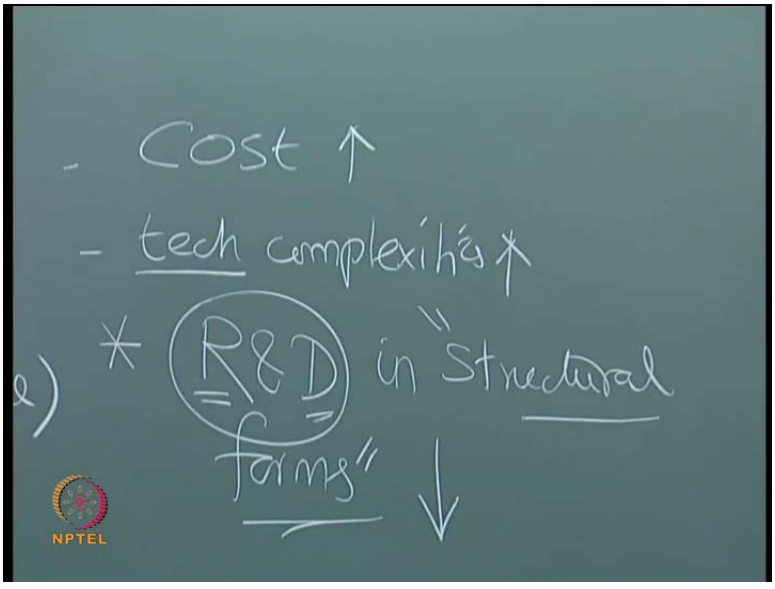
Professor: Yeah interestingly, very intelligently, these assets involved are of a very high manifold in terms of commercial advantages. So, a huge investment goes on to this top side. So, people have not assessed so far in reality, what would be the risk of these kinds of platforms. If they fail, then your return investment becomes actually zero. So, people do not want to take such a high risk of investment. The reliability aspects and safety aspects become very important. They are all under hostile condition; they have no access to these platforms.

(Refer Slide Time: 17:34)



So, foremost condition for an offshore structure is? For any offshore structural systems, the foremost requirement which is dangerous is, it has no access to land which is openly available. So, they are isolated; what we call them as standalone systems. They are subjected to hostile environment. In case of any correction, any repair or any emergency, you want to attend but they are not readily accessible. So, this limits the number of installations to be very less.

(Refer Slide Time: 19:01)

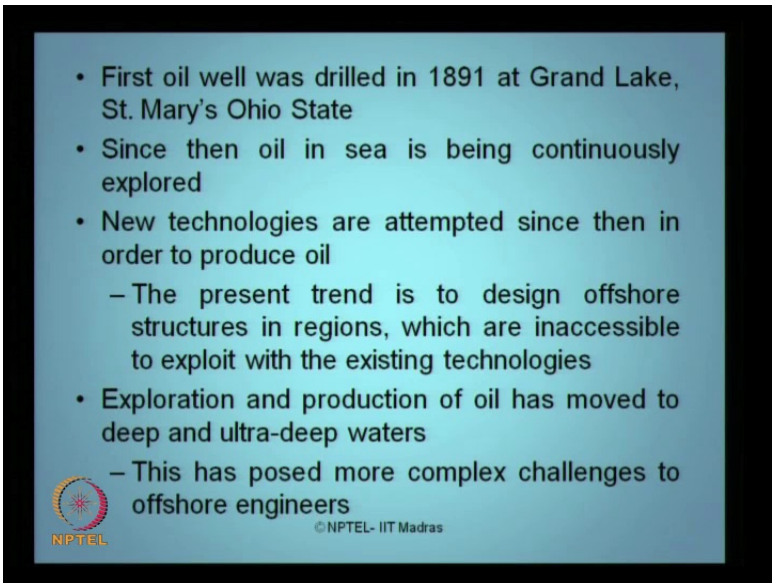


In addition, as we all agree, people also said cost is increasingly high; this is very important factor. Technological complexities are also high. To make it more interesting, the research and development in structural forms are less. So, the moment I say structural form, one will be wondering to know, what are those conventional forms which have been tried by people for installing these four thousand platforms? That is what we are going to see now. So, structural form, as you go deeper and deeper, has got to be uniquely designed, which actually comes from enough research and development. This is on the lower bed.

So, this makes it interesting, that if you are able to arrive at a new geometry of the platform, which I call structural form of the platform, that can suit deeper water depths and cheaper as well, the form will gain its importance in the research. We will discuss about this in the last part of the lecture, where we say innovative structural forms in the recent past; how many people have done it, what are those forms, why are they innovative and how are they special? So, this will be very important message to all the viewers, that there is very good potential for research and development in offshore structural systems as such. Whereas, this is not available in any other structural system ladies and gentleman except offshore structural engineering. If we look at bridges, look at schools, hospitals, buildings, public buildings, anywhere libraries, museums etc, most of the structural form are common. I am not talking about monumental structures or esthetic structures built. They are very rare structures built for functional requirements; forms are not very highly innovative. Whereas, in offshore structures, forms have to be innovative. Not esthetically important, but they should be functionally innovative. It becomes very important for me to arrive at a form, which is functionally innovative and cheaper.

So, this is the complexity what we have in dynamic analysis of offshore structure. Because the form is complex you will not have an existing model by which you can mathematically model this in a software. Because the form is not arrived based on the copy paste of the existing structure. So, a new innovative form, which is function derived and of course, it has come from R & D of any organization, which is not available to you for understanding. So, that makes it complex. That is what we have put in this point technological complexities and so on.

(Refer Slide Time: 22:41)



It is interesting and amazing for you to understand, the first oil well was driven even about 120 years back, it is in 1891. So, oil drilling is not yesterdays or recent past business. People have been doing it in Ohio state much earlier. So, since then structural systems have been on the innovative mode. So, it is been continuously explored, new technology were attempted in order to produce oil. Now the present trend is to design the offshore structures and regions, where they are inaccessible to exploit with the existing technologies. Because, oil is available at a specific location, it is not accessible to be a conventional methodology what we have here, can I look for a form structural form which can solve this purpose. So, innovation comes from there. You may wonder why the oil exploration has gone to those inaccessible areas. It is because of the non-availability of oil at a shallow depth, which were available about hundred years back. Now the oil reserve is available at deeper regions. So, the platform or the offshore installation has got to be installed in such a different manner. It has got to be designed using innovative techniques such that they can serve the purpose of functionality for which they have been designed. So, existing forms will not work.

And the service life of these structures essentially depends on the amount of oil reserve available in the location, may be maximum twenty years. So, imagine a huge investment done only for a shorter period of twenty years for a specific purpose after which what will you do with that investment. So, this is another hidden question, why many installations were not built all over the world. So, if you look at the exploration in deeper

waters, it has posed more complex challenges to offshore engineers in the recent past. So, when you move the platform design deeper and deeper, the complexity generates in a higher scale. What are those complexities, why deep-water platforms are complex in nature, we will talk about that in structural action of these platforms.

(Refer Slide Time: 25:17)

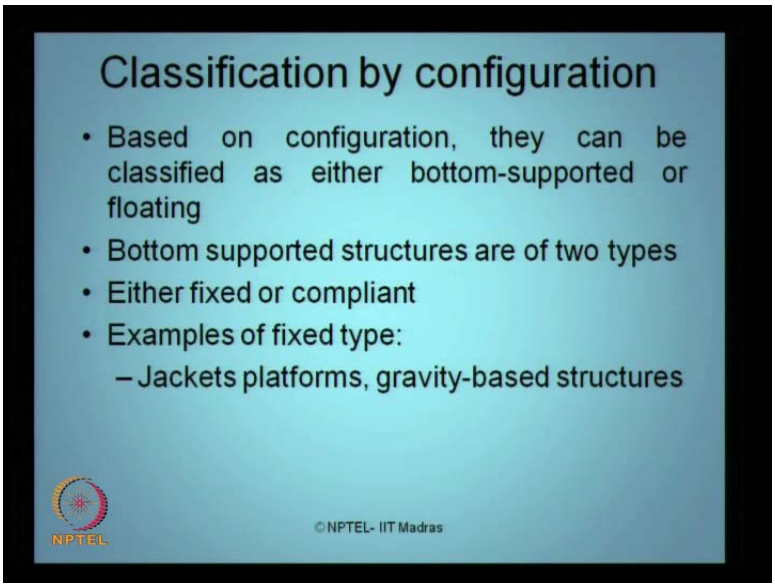
They are unique in many respects. Their efficient design and installation are especially a challenge for offshore engineers, they are not common. Every platform has got its own complexity, because the sea site installation, sea site characteristics, their geographical conditions etcetera are different for every kind of platform. So, every installation is a challenge for an offshore engineer. An offshore platform does not have a fixed access. So, in case of any emergency, you cannot actually access to this platform to repair it or rehabilitate it. That keeps the platform in isolation. Therefore you got to be very careful in selecting the structural form, geometry analysis, design, installation etc. when you want to design a platform. It is not like a land-based structure whereI can inspect and correct the repair as and when I want. Offshore structures either may be fixed to the sea bed or they can be even floating also. Now the classification starts from here onwards. Once the structure is fixed to the sea floor, then how does it behave in dynamic action?. When the structure is floating, what would be the difference in the dynamic action of this structure compared to fixed?

(Refer Slide Time: 26:47)

Classification of the structural form depends on how are you fixing it or how are you holding it down in position. Majority of the structures support exploration and production both; the functions are different. But many of them are meant purely for exploration only not for production and drilling. So, depending up on what kind of platform we are looking at, even the classification starts from the functional aspect of the platform also. All of them are not meant for production; some of them are meant only for explorative drilling, just to identify whether oil reserve is there in a specific location or not. In addition to this, ocean structures also cover a very large extent of wave energy devices, because renewable energy is a very important sector all over the world now.

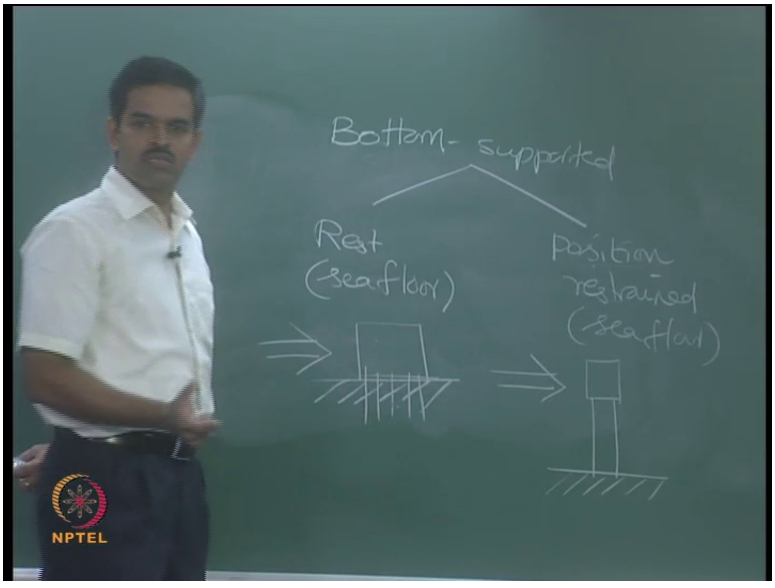
So, people design structural systems for renewable energy. People want to create offshore base for naval applications. So, you need to construct a platform. There are offshore airports existing for example, Japan. So, these structures are also considered as ocean structures. Sometimes these structures are classified based on their structural and geometric classifications. How are they defined?

(Refer Slide Time: 28:11)



So, we will move forward. Llet us talk about classification by configuration. The functional aspect is different. I want to now classify the platforms based on the geometric configuration. They can be either classified as bottom-supported or floating. Bottom supported means the platform can rest on sea floor.

(Refer Slide Time: 28:33)

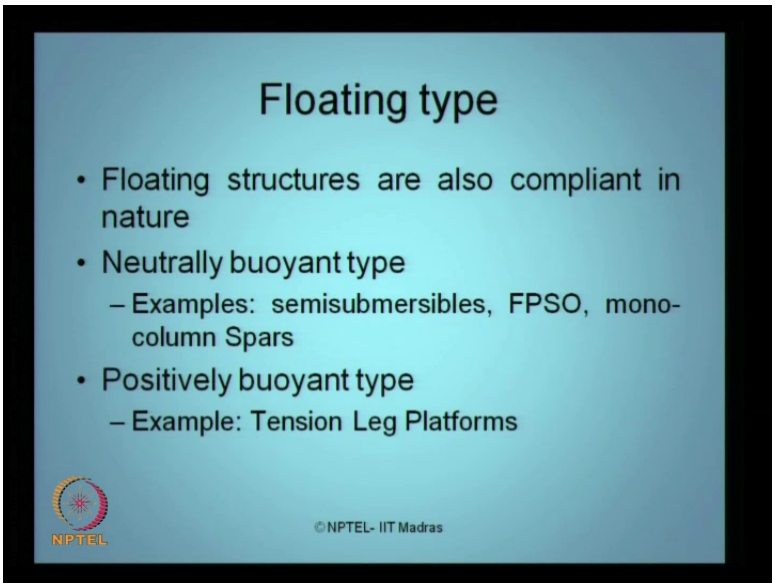


So, if we say bottom supported, the platform can either rest on the seafloor or it can be position restrained to the sea floor location. You may wonder, what is the difference between the platform resting on the sea floor or seabed, and position restrained on the

seabed?. I have a bluff body, this is my sea floor, it press through piles etc. I have the same bluff body, but the sea floor is here I am holding this bluff body to the position by some arrangement. So, bottom supported or floating. Either it can rest on the sea floor or it can be position restrained to the sea floor. So, the dynamic action under the given external loads in both the structural systems is entirely different. So, how you are holding the structure in position matters a lot in dynamic analysis? We classify this based on structural configuration first.

So, if you look forward, bottom-supported structures can be of two more types further sub classified. They can be either fixed or compliant structure. Spelling is very important. It is not complaint; it is compliant. Compliant means moving. So, the moment you introduce this flexibility to the system, the dynamic action of this structure under the wave forces or environmental loads will be entirely different from that of a structure which is rested on the sea floor. So, it can be either fixed or compliant. Fixed type can have examples jacket platforms, gravity based structures, in brief you call this as GBS. It is very difficult, ladies and gentleman to see a structure of this order. We have countable numbers of them around the Indian coast. But nevertheless, I will show you some photographs at least to have a feeling how large these structures are just have an idea. We will compare them with the land-based structures and then see how they are different in terms of its form. So, jacket platforms and gravity based structures are few examples of fixed type. Talk about compliant structures, for example, guyed tower, articulated tower, tension leg platform are few examples. How are they looking like we will see them.

(Refer Slide Time: 32:02)



If you look at the floating type, they are also compliant in nature. Because of floating motion, it enables flexibility or movement to the platform or to the structure. If you ask me sir ship is also floating and sailing, can ship be considered as one of the compliant structure?, It is a floating vessel at a specific drop. So, can I consider ship as one of the compliant structural system or a floating type system? Answer is yes, we have classical examples like drill ships. There are ships, which are meant for drilling in offshore production systems. Nothing but the same ship, which is a naval vessel or any passenger vessel. It is altered for drilling facilities and used for drilling.

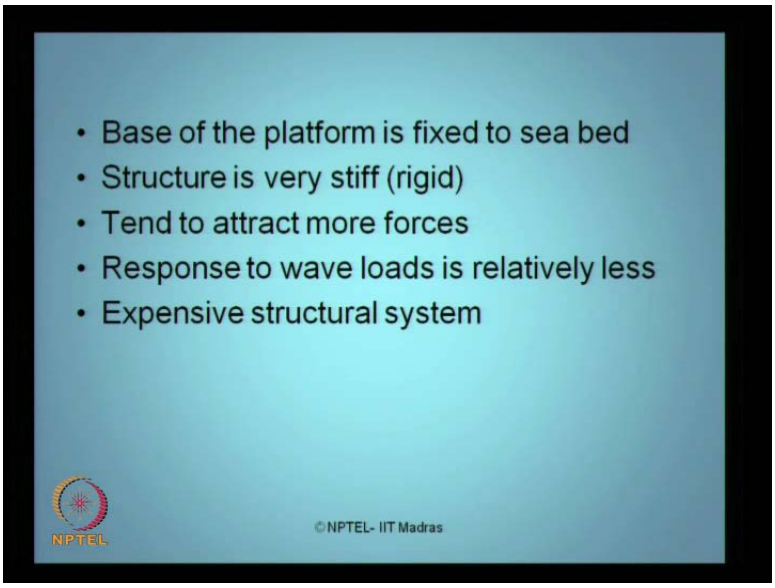
So, essentially they are meant for exploratory drilling sometimes, they can be also used for production drilling depending up on how you maneuver these ships in location using dynamic positioning systems. The ships can also be considered as floating type structures. So, there are some types called neutrally buoyant type, for example, semisubmersibles, FPSO - floating production storage and offloading - FPSO, mono column spars some of them are classical examples of neutrally buoyant type which are all floating type. If we look at positively buoyant type, we have classical examples of a TLP, which is a positively buoyant structural system. Therefore, in the whole list of forces acting on structural system, buoyancy plays a very important role in those kinds of offshore platforms, which are floating.

The moment I say buoyancy, the moment I say structure is floating with a specific geometry, then the weight of the structural system, weight of the topside, the operational loads on the system and the buoyancy forces have got to be in a balance. Because it is important that these floating type structures should remain stable during operation. So, stability is an inherent feature of a dynamic analysis of ocean structures. Stability is not an outward concept of analysis of offshore structures. It is an inherent part. For example, in ships you must ascertain the stability of the vessel before you want to afloat it. Similarly in floating type offshore structures, it is important that I must focus on stability also.

(Refer Slide Time: 35:11)

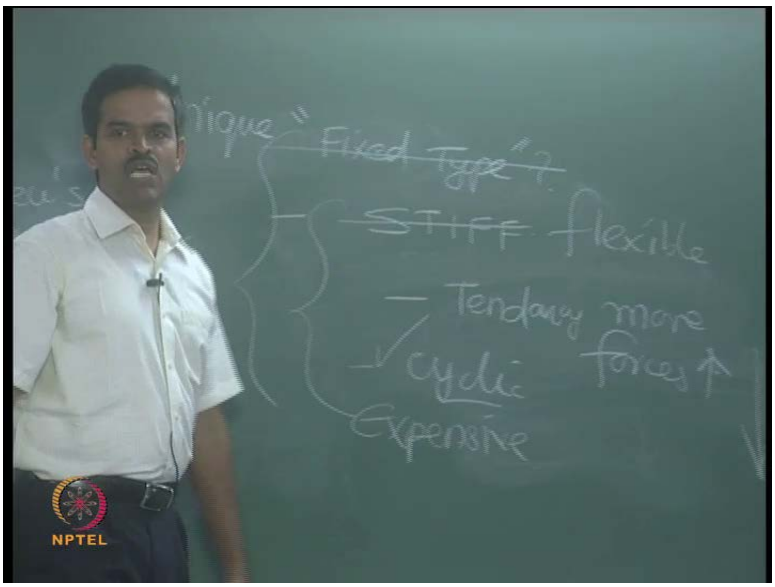
So, to address this specific concept in offshore structural system, we had a specific type of stability called Mathieu's stability. It is a type to stability study done on positively buoyant structures like TLPs. So, we will talk about this also in the second module of the lecture, how to do a Mathieu stability analysis. You may wonder why in dynamics, we talk about stability. I repeat it again. It is a floating type structure; therefore the combination of buoyant forces, weight of the topside, and weight of the platform under the given action of environmental loads should make it stable for working. So, stability has got to be ensured before we afloat the structural system for any functional operations. So, it is an inherent part especially for floating type offshore structures or ocean structural systems.

(Refer Slide Time: 36:14)



Talk about fixed type platforms, the base of the platform is fixed to the seabed as I showed you just then. The structure is very stiff, it is a very important aspect what you understand the moment I say fixed type platform.

(Refer Slide Time: 36:34)



If I say fixed type platform, I must understand the structural configuration makes it very STIFF. How it is important in dynamic analysis point of view, the moment you have any structure which is STIFF, it has a tendency to attract more forces. It is very simple. Classical example is that you and your friend are walking. You are lean by weight and

geometric configuration and he is thick by geometric configuration. He is heavy. He is around 80 kg and you are 60. You encounter some problem which is normally happens in student life. Under the given example of the present situation in the press release, the case referred to Delhi it is a very common phenomena happening.

If you a pick up a fight; obviously, the person who is stiff in configuration, who is rigid in configuration will always have a tendency to pick up a force. He will always get into fight and he will always challenge. Whereas the person who is flexible or lean will always have a tendency to run away, he will try to avoid fighting, because he will never win the game. He knows that and he is flexible; even if you slapped him, he is accepting it. So, the question here is when the structure is becoming stiffer for me it is dangerous, because it will have a tendency to attract more forces.

You may wonder sir what is the problem if a structure attracts more force?. The problem here is these forces which are attracted by the structure are not unique, but they are cyclic. Any force of a higher magnitude if it is reversing also, it is very dangerous for structural system. Because if we look at the fatigue failure, fatigue failure is focusing on number of cycles of failure or repetition of forces whose magnitude is very small, but the cycle is repetitive, but here have a problem. I have a structure, which attracts more force magnitude is very high and it is reversing also. So, the damage if at all will be caused to the structural system will be very high. Then you may wonder sir why is such structures are constructed, ladies and gentleman it is very interesting for all of us to know all these problems were realized only after constructed. Before construction, they did not realize this; after construction, they started realizing, because they had failures. They started investigating them then they realized. I must go for a different structural form, which should attract less force, which should remain flexible and should withstand cyclic forces.

So, now the question here is, the structural form is re-altered based on the structural performance. Remember such kind of reverse engineering has never happened in any kind of design except in offshore engineering. Therefore, the structures are unique that is why the reason is you will not find the same structural system getting repeated again and again. Every structural form will be different. There is always an improvement between one platform to the other platform. The basic reason is people do constant research on this to elevate the structural performance standards between the successive platforms

constructed. Therefore, we have a continuous innovative research happening in offshore structural engineering in terms of dynamics analysis perspective what I call as structural action.

So, that is what we are listing here, but one good thing about these kinds of structures are that they are relatively less in response to wave loads. The response of the structure to wave loads are less, because they are stiff. But if at all the damage caused it will be very high. Do you understand the difference? Response may be lesser, because they are stiff, they will not respond back, but if the damage is caused because of high magnitude and cyclic nature of the stresses encountered on these members, the damage will be very severe. Because of this massive geometry to make it stiff they are also expensive.

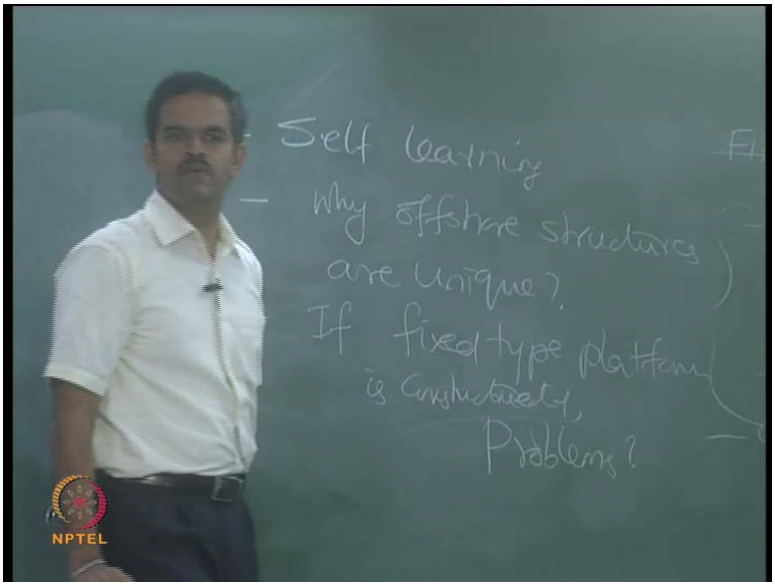
If you would not have your friend who is a body builder who has to accompany you all the time remember you have got to feed him, probably he will eat more than what you are eating. So, any stiff system, which will tend to attract more forces has got to be expensive you cannot have both; right. You can have very rare examples like people like Bruslee who is thin and lean, who is also stiff in nature, who can fight with people that is a very rare example. Generally if you see, all body builders eat well. So any stiff system has got to be expensive, because its structural form is massive. Now these massive structural forms also have a parallel problem. For example, if you look at case studies in the medical history, any fat person or any person who is obese in nature will always have problems on his knee to start with. He may have problems with his brain and head; he will not bother about that, but his problems in the hand and ears and eyes will not be there.. If at all the problem starts, it will start only with the founded portion, which is the leg and the knee.

Similar problems are here. Any bottom founded structure, which is vary massive in geometry will create impact in the sea floor. This will cause erosion, what we call sea beds scouring. This is an important aspect of these kind of structures on environmental impact. Structure being stiff is one advantage; structure being massive is another demerit, because it causes an impact on the environment also. The third most dangerous impact is decommissioning of structure is impossible practically. Because I do not want the structure after 20 years, 25 years. I cannot leave it in the same site. I have to dismantle it and this will be as expensive as commissioning the system. So, people

realize this in due course of time and said that I am not going to do this kind of structure anymore.

The tendency of construction of these platforms have started delineating from fixed type to floating type. And this delineation is not because of the cost factor. I am putting this cost at the last factor. It is not first. It is also an important factor; no doubt on that but not the foremost governing factor. The important factor is structural action. It is the dynamic behavior. I mean, it is one and the same for me, it is dynamic behavior for anybody else who has not following this course in structural action. So, we must slowly focus on identifying the classification of platforms in the dynamic perspective, which we will be doing in the successive lectures. any questions?

(Refer Slide Time: 45:20)



So, we have few questions for you quickly which I want you to write down based on this lecture. Few questions for self-learning,

one - why offshore structures are unique?

why are they unique? You can give many reasons.

Second, if fixed type platform is constructed, what are the problems associated with this?

If fixed type platform is constructed, what are the problems associated with this platform? So, you will try to answer these questions for self learning. If you have any

doubts, you can always file them up, put me in the next class. So, we will meet here as per the time table schedule four days a week for the time being (( )). And you are free to ask questions during the lecture start and end of the lecture. Otherwise, you can always meet me in the department if you have any difficulty. you can also clarify your doubts in absence of this class. Syllabus outline is available in NPTEL, IIT Madras website, Ocean Engineering name of the course. You can download a PDF file from that. Reference material, reference books, literature, papers are all available; download them, read them follow them parallely as we do the course. Any questions?

Thanks.