Design of Offshore Structures
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Lecture - 1
Loads on offshore structures 1

So, the course is designed for you know making understanding of the offshore structures for oil and gas exploration. Course number is OE 6200 those who are new because most of you are new, except some students who are already in our curriculum. We will have 2 quiz, quiz one quiz two, I think most of you will be familiar from the introduction session in sac building and there is a final exam. For this course we have division in such a way that 25 marks for first quiz 25 marks for second quiz and 50 marks for final and if you look at the syllabus first.

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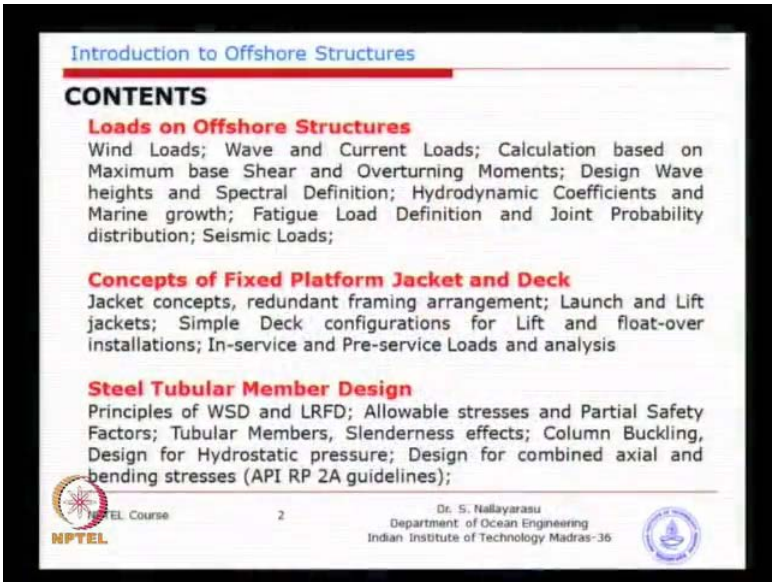

Let us see the syllabus, I have divided the syllabus into 6 chapters I would say.

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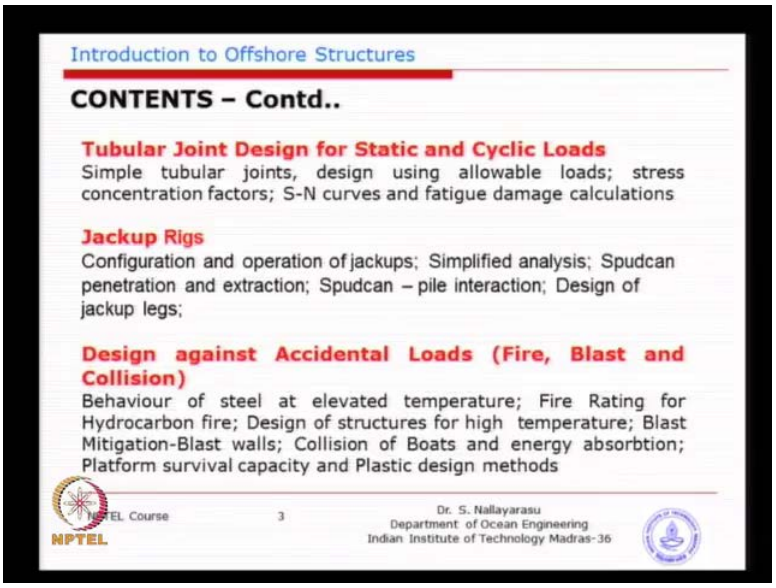

Each would carry equal weightage, so if you look at this we will try to cover the first two or maximum three before the first quiz, and that the questions will be from the first chapters three chapters for the quiz one and two and three or maybe three and four. We will we will try to cover in quiz two and the remainder will be taken for final exam. But, of course final exam we will have all the all six chapters together. So, that is how I am planning and total number of lessons or the hours of teaching will be around 36 to 40. Typically for a 3 credit course typically every week 3 hours class will be there. So, today we will be having eleven to eleven fifty and tomorrow and day after tomorrow.

So, three hours on Wednesday, Thursday, Friday is fixed no change unless I inform you. This will be the regular pattern of the classes, sometimes we will have extra classes either on depending on the slot availability on Monday and Tuesday. But, I think mostly we will stick to Wednesday, Thursday, Friday. So, you have to most of the subjects if you see the syllabus I do not know whether you have seen the syllabus book which was given to you during the admission time, bit of advanced mechanics. So, if you have background to basic mechanics it will be easy to pick up, if you are not go to the library pick up basic mechanics book start reading. So, that when we are talking about few of this discussion in the class. It will be easy to follow up otherwise you will find it little difficult and many times you may not understand.

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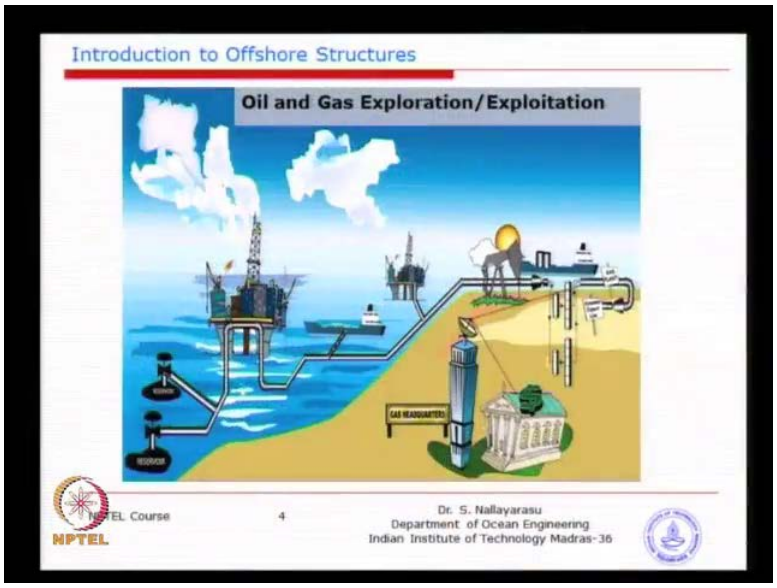

So, typically you see this picture you see this picture the purpose of offshore structure I think is a very good cartoon picture to see. There idea behind why we build offshore structures basically for the purpose of exploration as you know very well oil and gas is becoming a it has become a essential part of our life. Without which I think every activity that we try to do requires some kind of energy. And basically oil and gas play a major role in addition to other natural resources.

So, exploration of oil and gas is continuing forever until we complete it, that means we adjust it. So, you see here this picture gives you an idea when you build an offshore structure for the purpose of exploration. We try to make sure that the revenue out of is positive. Nobody is going to build offshore structure for the purpose of just making nice design because it is too expensive. So, the idea behind is we need to see whether the exploration is beneficial to the community the idea.

So, when we start working out when we when we look at what type of structure is feasible or is technically feasible economically viable. We need to put together the collective ideas and calculate the revenue behind. And basically the time frame by which you can get it back we can get the revenue in hundred years it is no use. So, basically you need to see the time frame, so this picture shows a offshore structure. Either under water subsea we call it under water structures or conventional fixture structures. On the right

side you see their which can be connected to the subsea structures for taking the oil and gas and then bringing by a pipeline to land.

So, of course we need to bring it to land for usage and then it goes to a refinery. You see on the right hand side on land where in you see supposed to show this like this. So, you see the refinery there and then finally in the refinery you breakdown the hydrocarbon chain into usable products from kerosene all the way upto jet fuel of good quality. And then the subsidiary products user for even for road surface you know the asphalt is used. So, every change small products are also used for this type of purpose, so that is why hydrocarbon chain is highly priced item in the natural resource. So, basically you can see this picture gives you why we build a offshore structure where it ends up ultimately we all want to make money.

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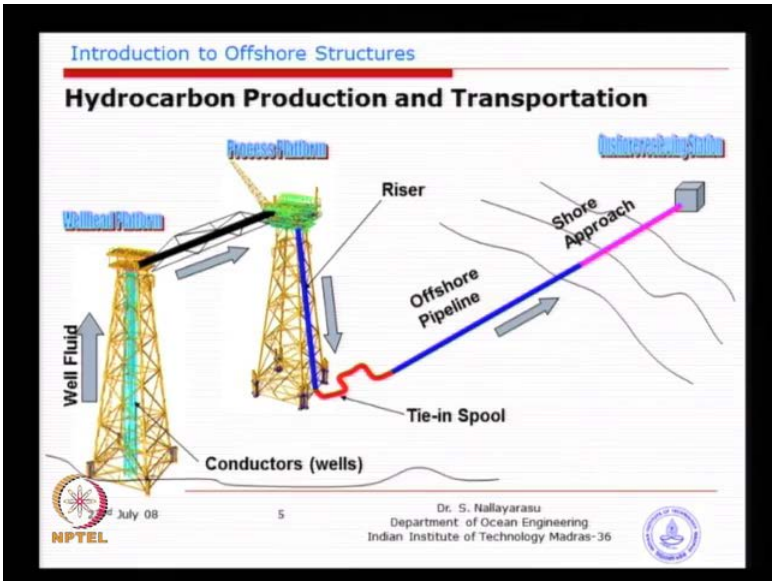

So, this gives you a slightly different perspective of how the oil and gas is produced. So, you see here in yellow colour on the left side is called a platform to drill. Why do we build this platform basically for drilling into the sea bed. Suppose if the same oil and gas is available on land you do not need all this you can simply go and drill using a bigger drilling machine. But, unfortunately on almost all the land based oil and gas reserves have been exploited for the last 50 60 years by the time. Now, we have to look for offshore means not available in onshore areas.

You could ask why it is only isolated locations oil and gas is available like, if you go to Middle East or you go to North Sea you go to US or some part of Europe. And some part of India and some part of South East Asia you see their isolated locations only oil and gas is available why not other locations. It is based on the history of the place where the deposition of this material basically the organic material decomposed into oil and gas for a several million years. So, it is not that everywhere you drill you will get oil it will be wherever. So, you have to look for, so identification of this locations is a is a bigger subject.

You know doing surveying both remote surveys magnetic methods or other methods, which are economically feasible. Then finally after identifying you start drilling ((Refer Time: 07.12)) manner that means you will mobilize the drilling ring and drill to find out whether the oil and gas is available in that location. So, basically this platform the purpose of building a platform because this is in water you cannot mobilize the drilling rig. There the reason we built this structure is to put the drilling rig on top of this platform. So, that we can start drilling reach the oil and gas reserves below water below ground. And you could ask the depth of that could be few kilometres.

Later we will in the lessons you will come to know the oil and gas reserves are available not just hundred metres. Like what we are taking water we got to reach almost 6 kilometres below ground or below sea bed. That is the kind of typical depth 3 to 6 kilometre is the drilling depth that is required to reach these kind of hydrocarbon deposits. And that means the drilling rig what we are talking about it is not going to be a simple rig what you see on the on the land based drilling for water you know. You might have most of you might have seen a mobile drilling rigs for getting water I think most of the villages nowadays you will see them. They are very small can reach as much as 100 feet 200 feet, but what we are talking about is few 1000 feet 6 kilometre means you can imagine what type of drilling rig is required.

So, that is why the structure that we designed needs to have sufficient strength and basically also depends on the depth of water at that location. If it is 10 meter water depth maybe we can build very strong structure. But, if it is 100 meter water depth what will happen, the structure itself becomes vulnerable to the forces arising from the nature. So, that is why the design of offshore structures slightly in fact different from the land based structures. Number one is the water depth number two is the environment you see, the

environment is different from land you have a different scenario. There you have water you have sea waves you have associated problems. So, we need to find out what are those problems and then design the structure for. So, if you can design offshore structure designing a similar structure on land is becoming as simple as that, very simple because the environmental conditions are very easy compared to the offshore.

So, that is where these structures purpose designed to drill or support drill facilities is called well platform sometimes we call it drilling platform. You can call them either way or you can call well platform it does not matter the purpose for which it is built is to support the drilling rig and then allow the drilling to happen in a stable condition. So, you can imagine why not we do the drilling without this structure many times you suppose to ask question is not it. So, if you have a ship why do you build this structure because a ship can go there do the drilling and come up come to another place, which can also be done in earlier days in 30 40 years back the technology for station keeping of this floating vessels were not there.

So, those days we have no other choice other than making a fixed platform stable platform where you put your drilling rig and drill. Whereas, nowadays when you go into a deeper water depth say 2000 water depth 1000 meter water depth building a structure like this probably impossible. So, those kinds of situations where we actually use a mobile drilling rig, we will talk about it when we go into that chapter. How these drilling rigs make possible to drill when it is floating.

Because floating means it is not very stable is not it that is what we can understand if you gone by a boat you will realize how unstable, whereas this type of fixture structures is almost creating a ground stable. Ground where in you put a drilling rig you can drill without any trouble as good as drilling on land. So, the purpose of building such a strong structure is to create such situation because 1960s and 70s. The technology for drilling itself is primitive you do not have the machines of capability of that we have today. So, 30 40 years back it could have been so difficult to have any drilling even if you have a movement of small amount. Whereas, now we have drilling rigs of a different capability fourth generation drilling rigs have such a capability even if the ship is moving can stabilize and do the drilling.

So, second on the right side you see one platform where you see another structure standing there, which we have mentioned as the process platform. The reason behind building that you could actually see later on these two structures could also be combined. But, in this particular picture I have shown to be showing two different structures for the purpose of drilling and processing. So, when this drill fluid comes from the ground it contains impurities is not it will have sea water mixing. Surely nobody is going to send you nice crude oil is not it. So, basically you will have impurities of sea water probably sand content probably particles of soil and chemicals unwanted chemical materials constituent part of the deposition.

So, what we were trying to do here you can transport the whole thing without any segregation. That means the whole thing to land and you do a refinement of stage one stage two stage three stage four, but what will happen when you try to do that on land. For example if you do not have this platform you directly transport all the way to the land. The volume of transportation becomes larger number one and then after you process on land the disposal of unwanted material becomes a problem. Especially the environmental issues related to disposal of this effluent from the refinery becomes a bigger issue.

You have to take it back to sea and dispose of at a specific point where in it may not contribute to pollution to the life in and around that region that becomes another problem. Because you have to take it very far because in the coastal areas you have habitants you have marine life. So, that is why people have thought about instead of bringing all the way here why not we do some segregation offshore some not completely.

So, we build another structure where we put equipments and facilities where you can take out the sand very simple sedimentation process. I think most of you might have studied if you are civil engineers you have studied sedimentation process no, by gravity the solid particles settles down. So, if you allow a longer time a larger area to travel the the solid particles can settle down. So, this process what we are doing here is basically a very simple process by which you try to segregate the solid fluid and gas. Basically three phase separation liquid solid and gas, so you have typical equipments in the industry.

Basically you pump it at certain pressure solid particles will go down sea water will be heavier than oil. So, sea water will also get at the bottom and only the oil content will be

floating on the sea water is not it and then the gas will anyway go upwards. So, you can take it and then separate it. So, this three phase separation seems to be this is happening down there. The idea behind is reduce volume of transportation reduce impact due to environmental conditions. Because you bring everything on land it becomes a problem, but then you can ask one simple question why not we do everything here offshore itself. So, that we get the direct fuel like gasoline the problem is the refining the further second stage refining on offshore you need a bigger plant. So, you bring the whole refinery have you seen refinery when you travel around in many parts of our country even in Chennai if you go north you will see a big refinery.

The refinery is large area requirement because of which various stages of breaking down from a crude oil coming from offshore. You first take out the primary products like gasoline petrol diesel kerosene, then it goes to second stage breaking down of all the secondary products. So, the equipments requirement the storage requirement is too large that we want to build the whole refinery offshore. It may not be economically viable and maybe it will take too long. So, that is why the stage one processing is done in offshore as minimum as possible, so that the transportation issues are resolved and then brought to the land.

So, the whole spectrum of activities for any oil and gas project you see here drilling and associated activities it is happening down here. And then a initial screening and removing impurities it is happening on the process. And the third stage will be the offshore pipeline transportation system you have to design them you have to install them. So, that it can bring the hydrocarbons to land, so the whole process involves several disciplines not only structures you see here it is not only just putting a structure. You are getting oil you have drilling systems you have pipeline systems structures process mechanical equipments all this to operate you need electrical power.

So, you need a power plant nobody is going to supply power, so you have to produce your own power. That means you need to have a power plant on board, so that all the equipments can operate you cannot going to bring the power from land. That becomes too expensive you cannot think of bringing a power from land and then putting a power cable in some cases in fact it has been done. But, normally we try to produce a power on the particular platform wherever it is required.

So, it is totally captive no input is taken from land everything is produced here and resources are exploited. So, ultimately at the end of the day after doing this you need to see whether you are able to get profit out of it is not it. Because you can do all that and then the cost of investment versus cost of the revenue coming out of the project has to be positive.

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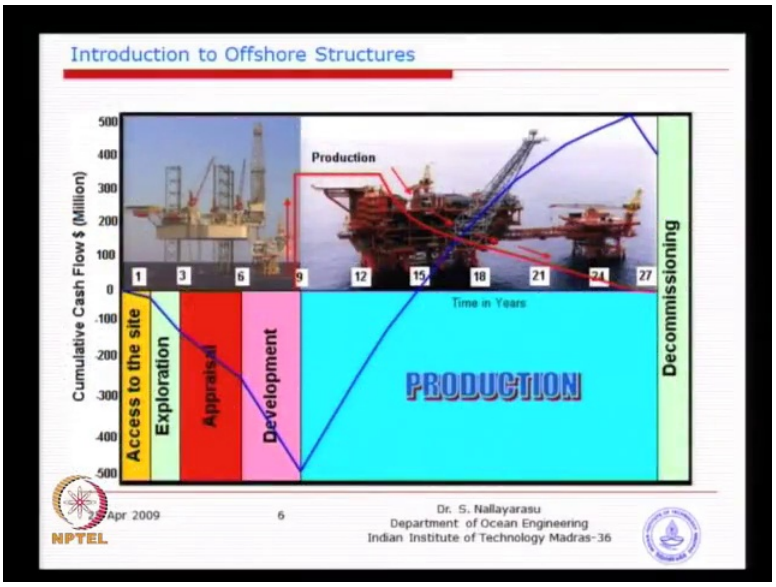

So, you see there one picture I have that is what you will try to see. This picture gives you an idea of how much time and patience required for a typical offshore oil and gas field development. You need patience because it is not one day activity you go today and drill it tomorrow you take the oil it takes several years before you see money at all. So, you can see in this picture from going to the site going and starting exploration. Exploration indicates that you are trying to figure out whether this particular area has oil and gas is not it. You have to do a lot of money spending to survey the area several means are available at the end of the day if you are able to locate possible oil and gas reserves in that particular location.

You do the drilling there is a third stage is basically mobilising a drilling rig like something like what we have seen on the in this particular picture. There you see a drilling rig jack up basically drilling at that location. Once the drilling is done then you take the samples because you do not decide immediately yes I have got oil of some kind,

whether it is usable form easy to break down or economically viable to bring it up, and the pressure temperature as well the properties of the constituent material.

Then you do bring to the laboratory do the testing and make sure it is good. Then only you plan for further activities of planning and spending more money on developing. So, basically this takes is almost 10 years and that is how the oil and gas projects are going on. Unlike other projects on land where most of the activities you may try to finish it in 1 or 2 years 3 years if you start planning. But, of course nowadays even other projects takes longer time 10 years 20 years 50 years it is stalled because of other reasons not because of this. But, here physical nature of the type of project we are handling it is a little bit of longer process above 10 years.

If you can get a oil and gas field developed within 10 years it is very good sometimes is there also lot of hurdles not due to indecision in the process, but also due to some hazards in the drilling hazards in the surveying. So, it can take a little longer time, but typically it is this is kind of time frame that we are talking about. Once you see this blue line going forward or the production is taking place, that is the time we are talking about cash flow positive means all along we were spending and that is a time that you start earning money.

So, the typical number in a typical project is something like this. So, you could imagine the reason I am showing this is to make sure that you understand the business. Because the design involved here is high risk unless you understand that you will never become a good structural engineer for design into offshore. Because unlike land based structures you do something maybe nothing to worry nothing will happen even if something happen easy to remedy.

Whereas, here things are very serious business you make a mistake has the largest impact. That is why you have to understand design of offshore structures is little bit tricky. So, once you see here starting to produce, so almost it takes about 15 years before you can break down break even into the cost whatever you have spent you have taken back. So, that is the kind of business on most of the time it is not going to be even that this going to be true because while going through you will see that lot of expense is increasing because of change in scenario. Because you are taking oil from below ground

you may actually expect initially very good production coming in suddenly it start reducing you never know, so typically is this is kind of high risk business.

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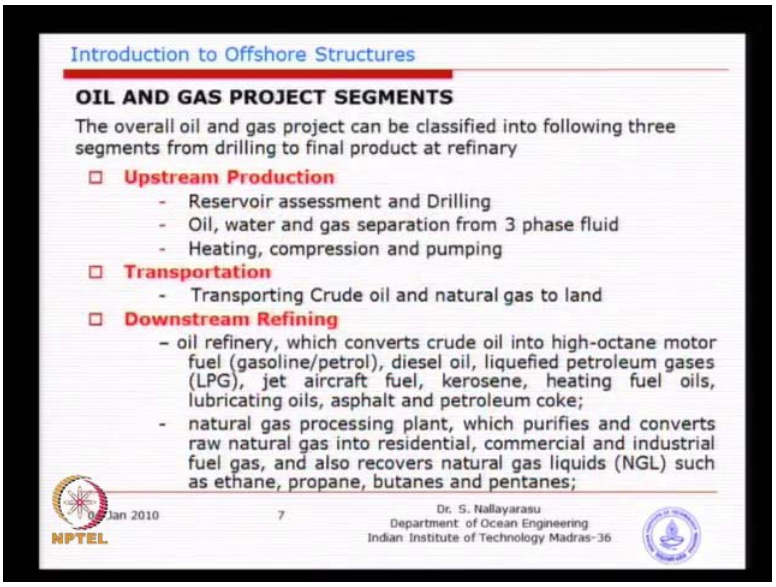

So, this basically if you go back to this picture we can divide them into three segments. That is what I am going to talk about it is upstream downstream and transportation. So, the upstream what we are trying to do is drilling associated activities and initial processing means upstream processing which is called the upstream production. You should not get confused with that production means you are not getting the actual oil and gas. It is the crude oil is the production coming out of the upstream activity plus middle stage is the transportation and downstream is basically the refinery on land, which we will be able to see from the next picture, you can see their very clearly.

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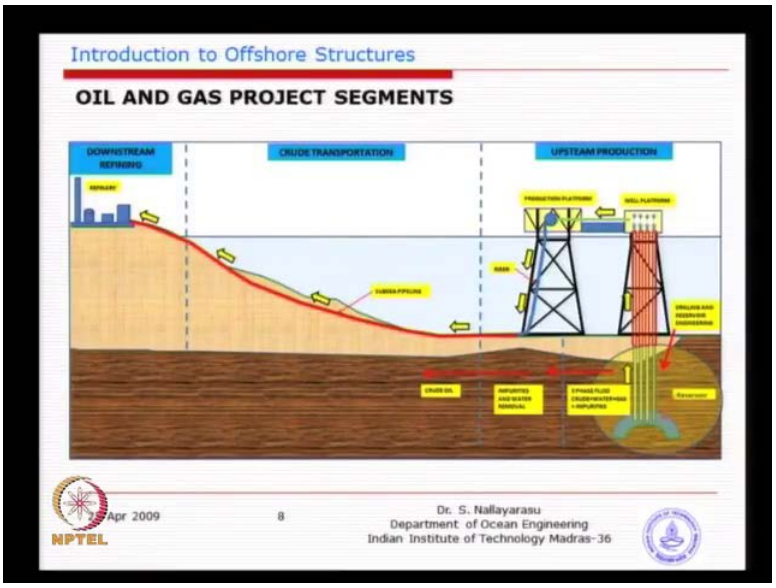

You can see there the drilling brings the oil above water using conventional techniques and then transported by out linking bridge. Normally, sometimes we see in the oil and gas development we can actually have a combined drilling cum production platform. Some cases where the water depth is larger we combine them together to make one structure instead of two structures.

When we make two structures safety is the concern you know basically drilling platforms are high potential for accidents that is why we keep them separate. But, you could ask why in some cases we have a combined platform again we introduce additional safety there to reduce cost. Because two structures versus one structure, one is definitely going to be economical. So, depending on water depth and transportation segment basically most of the time instead of oil tankers we do normal transportation by pipelines continuous. But, in case of marginal field for example this oil and gas content is very small.

Sometimes we do have transportation by tankers instead of pipelines and then the refinery does all our breakdown purpose into usable products, which you could see starting from high octane motor fuel gasoline petrol and you have diesel oil highly utilised in our country LPG jet fuel refined form of petrol added constituents kerosene. And other subsidiary products like fuel oil lubricating oil asphalt coke. So, you can see every piece of the chain hydrocarbon chain is utilised in terms of gas you have natural

gas processing plant instead of refinery. In some cases I think if you go to east coast we have got two big plants in Kakinada. Where the Reliance have put up a big gas processing facility other than that, I think that we do not have anywhere we have one more in Gujarat for the Bombay high gas processing facility.

So, only very few if we go to Middle East you will find every country has several number of gas processing plants. Sometimes we convert the natural gas into other forms for transportation, so this is this whole activity is downstream. Normally, we are not bothered because it is conventional petrol chemical industry and on land software engineers are not at all required to go there.

Coming to oil and gas field development you could see onshore which was actually happening for several decades. Many parts of the globe many countries were having onshore field in meaning is you find oil on oil and gas in the land not land means below ground. So, basically for 30 to 40 years the exploration has been happening in some of the countries. Nowadays, they feel that the reserves have reduced and basically moving to offshore. But, if you if you look at India we never had a very large hydrocarbon reserve on land very few places and that also have exhausted. Most of our oil reserves are in ocean, if you go to west coast mostly we find shallow water reserves and that too almost exploited for last 40 to 50 years from 1960s.

So basic idea is in India we are also trying to move into deep water means beyond few hundred meters. So, the technology is required money is required I think more than the technology the amount of money required to spend. When you saw the shallow water development I showed one picture previously 500 million it could become 5 billion. So, typically that is where the range of multiplication happening 500 million for shallow water versus 5 billion for a simple deep water project. So, if you imagine the cost of the KG Basin development is 12 billion US dollars, so you could imagine. But, after doing this not enough gas you might have read in newspaper.

So, that is the idea behind deep water development more than technology because technology is available nowadays. To reach 3000 meters whereas the investment required is too high very seldom people take that kind of risk. For example, you saw that graphical view of the cash flow versus production. For 10 years you start pumping in 10 billion US dollars you never know whether you are going to get back is not it. That is

where the high risk business, but of course success rate is also very very small 1 in 10. So, if you put 10 projects maybe 1 project will be success, so that is the kind of business. Sometimes you will find lot of projects are coming up sometimes very few projects depending on.

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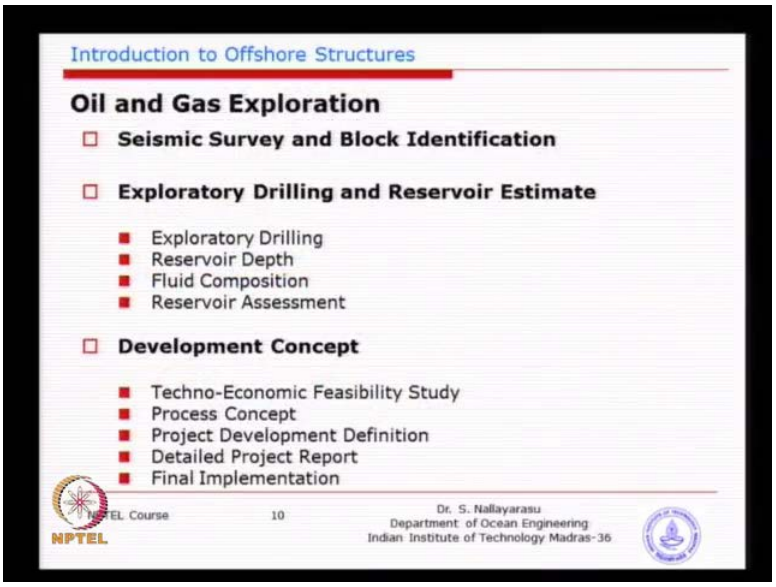

So, what is happening on these particular exploratory activities we have a survey. We have exploratory drilling and then the last stage will be design and development, which is a conventional activity like any other projects on land. So, the first two is basically a little bit of worrying nature because the surveying will be larger area. It is not like you go to one place and start survey you have to survey a larger area few hundred kilometres.

So, imagine you go to ocean you take a hundred by hundred kilometres space given to you this particular company for exploration. So, they have to do the survey in that kind of stretch once you do the survey. Survey means various kinds you find out what is the water depth you find out what is the ground conditions and penetrate the ground conditions by remote sensing methods to find the layers of soil rock and below weather.

We have any natural hydrocarbon reserves depositions happened several 1000 years. So, how do we do it there are various techniques remote sensing techniques to find out. You send a signal of particular kind it could be seismic signal it could be ultrasonic or it could be acoustic signals which will reach and reflect back. And based on the strength of the signal received there are diagnostic methods by which you can decide whether it is oil or

rock or other kinds of material. So, such techniques are well common and in fact it is also used in land based techniques for surveying you know remote sensing techniques.

So, such methods are very suitable because most of the time we cannot even go to the sea bed. So, floating vessels will be carrying all these equipments and can actually sense them once you find a kind of idea that there could be potentially such layers of earths crust containing hydrocarbons. Then you pinpoint the area locate them and focus and do a more closer survey. Whereas, instead of hundred by hundred kilometres area you may select one kilometre by one kilometre and try to pinpoint potentially higher possibility of availability of hydrocarbons. Once you do that probably you are little bit positive yes something is available.

Then you start looking for physical drilling mobilise the drilling rig and then bring out the reservoir fluid. And send to the laboratory test it test means what you are trying to find out whether how much oil how much water simple thing is too much of water only. Little bit of oil maybe you can abandon that area I am not going there. Whereas, because the cost economic business will not work out.

So, this exploratory drilling and estimate of reservoir fluid how much is available you could have oil, but only small quantity. So, how do we estimate this is actually a bigger subject we have in fact our department we have introduced petroleum engineering. Where reservoir simulation there is a full course called reservoir engineering this is not the same land based reservoir it is underground void space in the earth crust, where it is filled with some kind of hydrocarbon fluids. So, we do have methods to estimate what could be the possible volume once you determine that. Then probably we can go little further to see that yes we can invest further and spend more time more money in developing the particular locality.

So, in that we have several ideas depending on what whether it is oil or gas or mixture. You find out what processing required identify the equipments identify the structures what type of structure is required. And then prepare a report make sure that your concept will work and that is where a bigger role played by structural engineers. Depending on what is the type of oil and gas available you play a major role because that is what is going to drive the total cost of the project. Whether it is a fixed platform or a floating structure or some other type of structure you will have to determine depending on what is

the water depth where is the locality? What is this environmental conditions. And then you finalise your design and then make a estimate of the cost.

Then we will determine whether based on that whether the locality identified is feasible or not feasible. Because the other people have already worked out what is the amount of oil available you have already worked out your structural concept. Then put it both things together see whether the techno economic feasibility is positive, if that is yes then you will proceed further.

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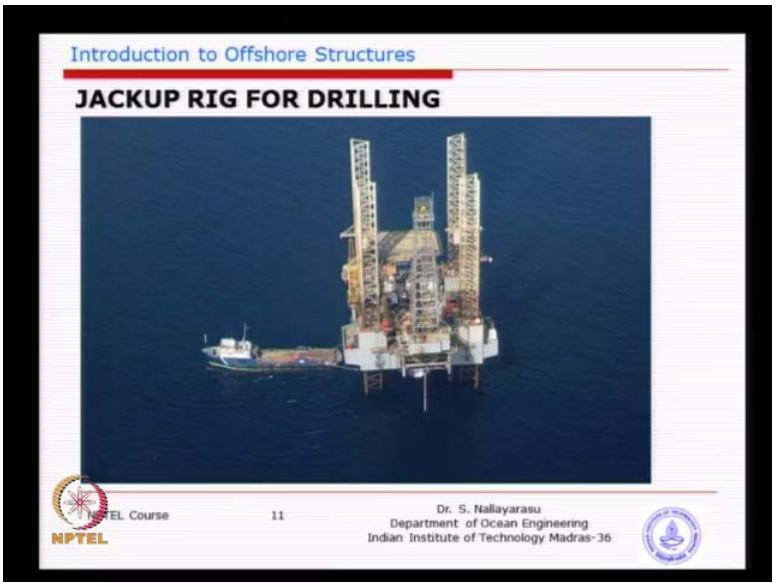

So, typical Jackup Rig probably I think we will spend some time in one of the days what is so called the Jackup Rig. And what is the great idea behind for drilling purposes basically this you see four of skeletal frames sticking together. You see you see that in picture is the legs of the Jackup where it will be positioned at particular location for drilling purposes. And you see here there is a boat in the vicinity basically from one point to other point or one location to other locations. This tug boats will pull these drilling rigs because these rigs does not have propeller. So, they have to be taken from one place to other by pulling, but of course has sufficient sea going buoyancy. So, it can float.

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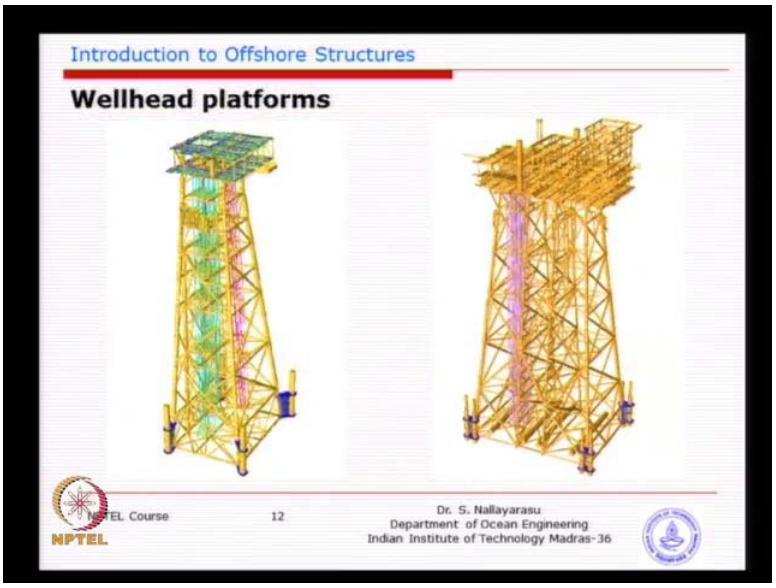

A typical offshore structure you see here we will have to introduce later on what is the purpose of this and how do we build this as we go along the coast we will see that later on. But, you can see here this is the super structure it is a computer simulation it is not a real picture and a skeletal frame 3 dimensional frame structure fixed to the ground by means of some sort of foundation. So, you got three components super structure sub structure and foundation, so all three needs to be designed appropriately for the functional loads coming from all your drilling or from processing this is the process platform. And then for the environmental loads arising from wind wave and sea currents.

So, that is where I think most of you are going through this hydrodynamics course you will see that wave theory hydrodynamics wave loads wind loads I think you must have already learnt in your graduate degree. So, you will see that these loads are going to be governed in the design here in comparison to land based structures most of the time the loads are predominantly gravity loads weight of the structures is not it.

Whereas, in here you see here the gravity loads are going to be small magnitude compared to the environmental loads. And the direction is exactly 90 degrees the horizontal loads will cause huge bending compared to the loads arising from the super structure. So, you see the shifting ideas from a land based structure to a offshore structure the behaviour of the structure will change and that is how you are going to find difficulty in designing.

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Another platform structure is where you see a larger area see here in this previous picture it is a small area. So, depending on the locality the requirement of the super structure or so called the top side facilities may vary. And depending on that you see them the sub structure also becoming bigger which is basically similar like any facility you build on land larger the facility required your structure system also becoming larger.

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Typical reality of you can see a drilling platform here you can see a process platform here basically built for that function. And on the right side you see here both of them are

combined, so you could see that potentially the water depth plays a major role of course. This is a very safe process this is also safe provided you have a built in safety, such that in case of an accident fire and gas basically you will have sufficient safety mechanism built in. Does not mean that this is unsafe this is very safe, so situation arises that this water depth this is higher than this 150 meter water depth building two more jackets may not be working out in that location economically not feasible. Whereas, here water depth was less than that, so not a big problem.

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So, where do we call see here a group of platforms for function wise one could be a living platform. You see here on the left far left here is a platform for purpose built living facility to operate all of these equipments. Here you need people it is not going to be everything is remote control. So, basically the idea behind is you segregate that away from the facility that has got hydrocarbon number one high risk of fire high risk of blast sometimes.

And the facilities are segregated this is the drilling platform, so you can see that sometimes we do segregate this way to avoid chain reaction of accidents. You know basically and this is the most safest place because this is very much away from the hydrocarbon facility. So, you will see that if you go around any offshore field many times we will see that colony of structures few of them group them together. So, that one by one will do us different function.

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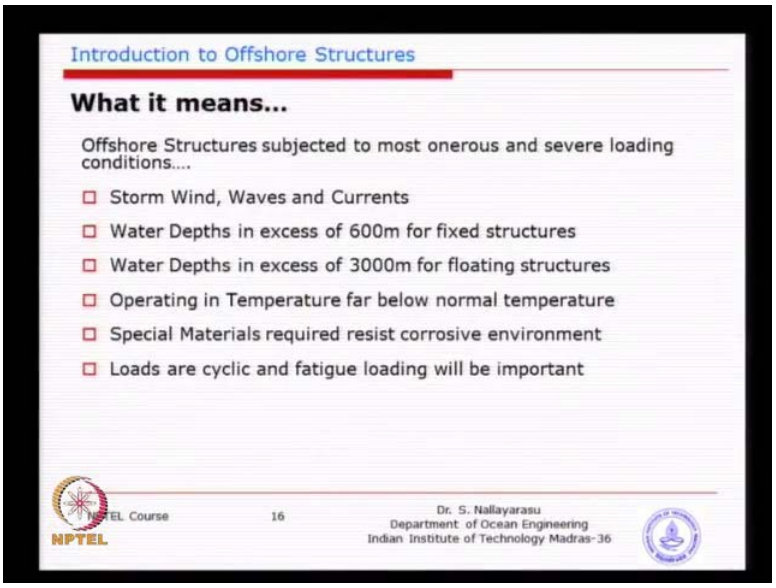

So, in summary in this course what we are going to look at is primary purpose of this course is, to design fixed offshore structures. Only because later where in I think some of you might go into this OE 4 we have a special subject called design of floating offshore systems which will come in third semester I think. So, there we will cover the design for floating systems similar. But, of course the idea is slightly behind floating systems are different, but the purpose for which it is designed is same you know.

So, in this particular course we are going to focus high on fixture structures and associated component design. So, offshore structures subjected to high wind high storm wave heights and sea currents water depths almost the structures that has been built in the last three decades 600 meters water depth. Some of the fixed structures have been built in Gulf of Mexico water depth in excess of 3000 meters in case of floating structures. Operating temperature is also a concern as we can see when it becomes low temperature the behaviour of steel becomes different.

So, what will happen it becomes too brittle, so the same structure built in conventional shallow water say less than 100 meters maybe subjected to a temperature of 15 degrees 10 degrees, whereas if you go to 500 meters the temperature goes down as much as 5 degrees. So, at low temperatures steel becomes potentially vulnerable for cracks potentially vulnerable for failures. And you are installing the structure in sea water highly corrosive I think most of you might be familiar with sea water corrosion.

So, when you put a structure like that what you saw in the picture you need to protect them against sea water corrosion. Otherwise after few years you will see that I will show you some pictures later on even the protected structures how badly they corrode. You know maybe tomorrows class I will bring the pictures recent survey taken two weeks back shows that some of the areas even after protection, you see a high corrosion. Some of the structural members are dislocated failed until the last one is basically the loading is cyclic. As you can see from if you have gone to beach you will see the wave action is dynamic is not it.

All of you have gone to the beach no after arriving in IIT Madras here no maybe you can see one of the days you can go there and you can see how dynamic is the see waves. So, you could see one by one is a added effect, so if you if you know how to design a structure on land. So, you add all this 6 factors in addition you will find it quite tough to design and each one area is a specialised area. For example, you take FAT you need to understand what exactly is happening and try to mitigate that problem. Similarly, the low temperature corrosion, so each one is actually a subject itself. You know if you look at if you go to library you will find so much of material related to each of the subject.

What we are going to do in this course is to condense a little bit of introduction and bit of calculations to understand how the problem can be approached. So, further reading further practice at the end of the day is required by everybody. So, that you become familiar with the subject what we are going to learn is probably one percent of each we are not going to cover. We cannot cover in this one 36 40 hour course to a elaborate manner. But, of course we will give you a little basic, so that you can read further on the subject.

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So, you see sometimes the sea conditions are so rough that even water is splashing on to the super structure. These structures were built earlier several decades back, but the sea conditions changes you might have heard this term called global warming is not it. So, what is happening the ice melting sea water level rises, sea condition changes. And there are several other natural phenomena where climate conditions are changing from time to time. And you see a storm in non stormy conditions cyclone in a regular normal period which is not so good.

So, things are changing, so that is why the structures built earlier say 30 40 years back are subjected to different kinds of loading. Because we never expected the waves to be so high because those days the knowledge on sea wave conditions were so limited. So, we just assumed several things, but we can see things are becoming more and more vulnerable.

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And the structures in comparison I think you should realize in when you see the picture the structures are not so small structures are very high. For example, you compare a 100 meter water depth Jackup is as much as 30 40 storey building. But, imagine a 600 meter water depth Jackup, it would be taller any of these buildings. So, the structures are taller slender and limited by its own size and shape and subjected to severe environmental conditions. And loads are placed at the top unlike other building structures where the loads are uniformly distributed. When we go to dynamics you will see that the concentrated loads on the top could make potentially difficult to design.

So, you see that the idea behind needs to be understood and the foundation system for this needs to be installed constructed and installed in offshore conditions. Rather than nice ground conditions like this building you dig around very easy, no need to worry. Whereas, the whole thing is to be run in a several kilometres inside offshore we start building. So, every aspect what we have seen in the previous slide is only the design aspect. But, if you look at the construction aspect you will really get little bit worry because everything is so difficult I think we will stop here.