Elements of Ocean Engineering
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Lecture - 39
Structural Analysis of Jacket Platforms (Contd.)

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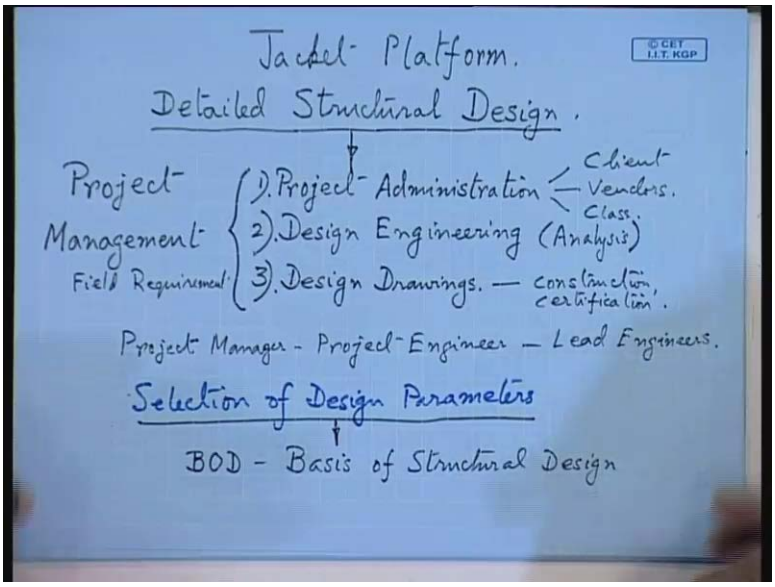

So, welcome to detailed structural design. So, we were discussing jacket platforms. Now you find that this offshore structural design is more rigorous than your ships. In the detailed structural design we have under project management. So, all is unlike ships you know they are not project, but here actually you have to do according to site. So, it is built at site. So, project management is required. Under project management you have a project administrator, then design engineering and design drawings. So, these are the three crucial items of project management.

So, if you are in an offshore field you will be put under a project manager. So, project manager, then the hierarchy is your project engineer, and then you have lead engineer. So, that is how this system goes. So, most of you if you want to go to the level of project manager you should have some managerial capabilities. So, now here besides the project administration actually you have to handle lot of people out here. So, one of your measured is the client, then you have vendors, then you have all the people from the

class or regulatory requirements. So, you have to very efficient in this financial type of work.

Now other part is your designing engineering. So, this basically consists of analysis. Now this is also very crucial because from the loading aspect. So, I was talking about all this because the final structural design will depend on the load characteristics, then your flow requirements and all these things you have to know, otherwise Then and the last one is your design drawings which is prepared. This is prepared for construction and also for certification, construction and certification requirements. So, the activity is quite large in the oil field, we will see. So, after this you have prepared all this, then you have to select design parameters, selection of design parameters.

Now in ships how do you start? You start at the design spiral from the owner's requirement, then you find out, you make the detailed withdrawal to go to your lifespan GA and make all the structural drawings and all that sort of thing. But here actually I talked a lot about what is called the field development aspects or field requirement; your platform is part of the oilfield. So, there are field requirements specific field requirements, you to have to start performing that. So, after that you have to go into these three types of categories of work. So, anyway now the selection of design parameters however you have selection of the pile diameter sizes and all these things.

So, you have to prepare what is called a document. A design document is prepared which is called BOD or basis for design, basis of rather you write structural design. Now this document has to be prepared, there is a sort of a contractual document. Now the client will always want to know have you have proceeded; that is why I told you nowadays for structural analysis and all these ships also you require fundamental analysis and not the LRS or ABS or DNV. We will require the fundamental calculations to be forward two times. Sometimes they do not specify a particular thickness, say, thickness of a column or thickness of a pipe or thickness of shell plate. It is not specified, but they will be happy if you can convince them how you have arrived at the plate thickness, okay.

So, whenever you go to offshore or particularly in the offshore field you will find there are number of all these structural engineering programs STAAD, ANSYS and SACS and all these things, but you see the client is also a very knowledgeable person; you cannot fool everyone. So, you will ask for the BOD document on the basis of design; on what

basis we have selected a particular, say, structural program. And what is the foundation or what is the basis of your pile size, on what basis you have taken, okay.

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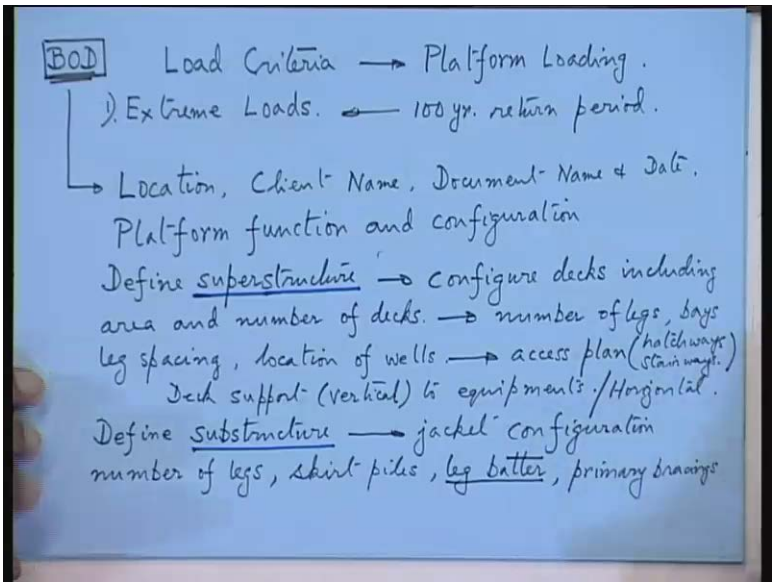

So, that you have to explain to him, and the point that you have to convince the most important is the load criteria. This will talk about; you have to convince him of what type of loading we have taken on the platform. So, platform loading is this is very crucial; in civil engineering normally they call live load and dead load, okay. So, this I think we have talked about. The other point that we have to convince is about extreme loads. See your client is you are in talking terms with, say, one of the oil companies that is your Mobil or Exxon or whatever it is. Now they have their own engineers and specialist. So, you are just talking at that level.

So, here actually lot of knowledge is required on extreme loads coming from the waves, storms, etcetera. Normally the analysis is done based on it already hundred year return period of storm or extreme load. So, when you go to offshore actually the ships you have analyzed based on a simple LED linear victory and you have used what is called the trochoidal wave. I do not know whether you have done this, the horizontal bending structural analysis. Well, here actually the same thing is not that simple you know. So, first of all the jacket platform does not look like a ship; it is a tower type of platform, and there are horizontal loads acting. So, it is not resting on two wave crests, okay.

So, that is one situation. So, where you have the lot of overturning moment and sliding force will come on the basis of the structures. So, unlike your ships which normally the failure is by bending; they call it bending failure, the horizontal bending they you have done. So, horizontal bending and sheer, but here actually you will find there are lot of other forces are coming onto the platform. So, the problem is much more severe and more so because of this extreme load, because your structure has to survive the extreme load. It is fixed on the seabed; you cannot move the structure away from the seabed, and you are investing say thousand of cores onto the oilfield. So, this is one of the regions which we have to clearly specify in BOD; that is called the basis of structural design.

Now here actually you have to convince the owner or the client of how you have taken the load configurations. Now here actually in BOD you breakup into this; first you specify your and all this thing is the general data that is required, and these are site-specific. So, location is going to be specified, location, client number, etcetera all these will come under first page, or rather you write client name and then document name and date. So, this keeps on changing name, and so you start with this. Now after this you go to platform functions and configurations. So, this is very important, because the design actually is based on the functional requirement of the platform. So, it is platform function and configuration.

Configuration means I have told you how many decks you are going to give to the client; what is the area requirement, okay. So, you will ask about this. So, first thing is in jacket platforms or in any offshore structure the first thing is there are two things which we have defined superstructure. So, I told you these are all the dead design type of platforms or deck loading type you know. Now what is the structure above the deck that is called a superstructure.

Now here you have to decide you total about deck configurations. You have to configure actually amendment or configure decks. You start with this; actually most of you, you are not taking training in all the offshore companies; then you will have some idea about the configured decks. Then this including area and number of decks, and this is actually similar to your GA of a ship.

So, I told you this is very important because of the load that is going to be the self weight that is coming on to the. First it will come on to the support frame, and then you have to

take the whole load down onto the jacket. So, this is one of the prime areas. Now here actually number of decks, then deck also has number of support legs. So, these are called number of legs, etcetera, and these are to be decided. I am not going in to details, number of legs, bays, etcetera. In civil engineering they call the levels as base, leg spacing. This depends on the floor area, leg spacing. Then the other most prime location of waves. So, this is actually not a novice job.

So, a person who is nowhere experienced into this then you can do the region GLA out, and if you want to start you have to start from your basic design; you have to take a basic platform. Now location of waves; after this you prepare, now decks have to be serviced you know. So, you have to prepare proper access; this is called an access plan. The ships also you have in the GA that is you have segregated all the holes, compartments, areas etcetera. Now all these areas have to be accessed. So, you have to prepare how you go or enter into the holes, how you entered the decks, what are the machinery it requires. Some of the missionaries you will find is going above one or two decks like your heat compensating device, drains equipment and all that.

So, they will go to number of tiers of decks unlike in ships where it is stored in a whole, but here actually the support to the drill string or your grim will come from number of decks. So, decks are also acting as supports to your conductor pipe, your drill colors and all these equipments support. See decks actually give support to equipment also vertically; decks support vertical, and you will not find this in ships vertical to equipments. So, here actually if you take the disposition of the equipments vertically then you have to provide support at that deck level. So, those things you have to crater, and you have to tell your client that this is what we have done.

Then of course, the access plan; access plan means you have to provide hatchways, then stairways, how you do them, okay. Now this you have to confer to certain rules because of the fire. Normally in ships you have to prepare an access plan they called based on your LSA life saving appliances or FFA requirement such that a particular portion of the ship has caught fire, you have to quickly evacuate that person from another extreme end. So, same thing the access plan has to be prepared. So, decks support vertical equipment or you can go horizontal. So, this is a very crucial layer. So, this is called the superstructure design.

Now after this you define. Now this is actually in your nutshell; if you go around your offshore you will find all these detailed design they do, and after this define substructure. So, this is a typical offshore engineering work; this is called as a sub structure; that is the structure which is below the deck or supporting a deck. Now substructure actually consists basically of a jacket; jacket essentially defines what? Jacket is a cover for your piles. Whenever I say you we are your jacket; jacket means a cloth which covers your body. So, this jacket actually is a cover for your pile. So, jacket configuration how you design.

Now here actually these all part of your BOD, remember that, or basis of designs which you are actually convincing the client at the stitch; the client is being convincing. Now here actually you have to tell him the detail about superstructure; you have already told about how your decks and all these things you have done. Then you come to the structure, basically jacket configuration. That way we have to tell him about number of legs. Legs are essentially your columns. Then if you have skirt piles, skirt piles are short piles which are fixed to the perimeter of the columns through which they have derived short piles that is called skirt piles; leg batter that is the slant of the leg.

Now why the columns are given a batter? That is to increase the base area to resist the overtopping moment; your deck may be this much, small but your base area will be larger than this; wherever your base is going to be it is going to be large. So, obviously the pile has to be fixed at the corner of the base and also the corner of deck. So, it is going to be slanted, because this dimension is less than your base dimension. So, that is called leg batter or a batter pile. So, piles normally the building piles are all vertical like this, but offshore if you go there is a rake or slant.

Now here actually how you drape piles on the rake? Vertical piles are easy; you just put the pile hammer on top and keep on driving where here actually the force you have to do around the slant; that is more critical, more critical because of leg feeling. So, legs are given as batter and then you find out what is called primary bracings. Bracings are support that you give to the legs in the jacket. Then after this is coming onto the substructure, then spacing of well connectors or rather spacing of well connector pipes; this will come under the substructure, then pump casings. All these things you have to decide.

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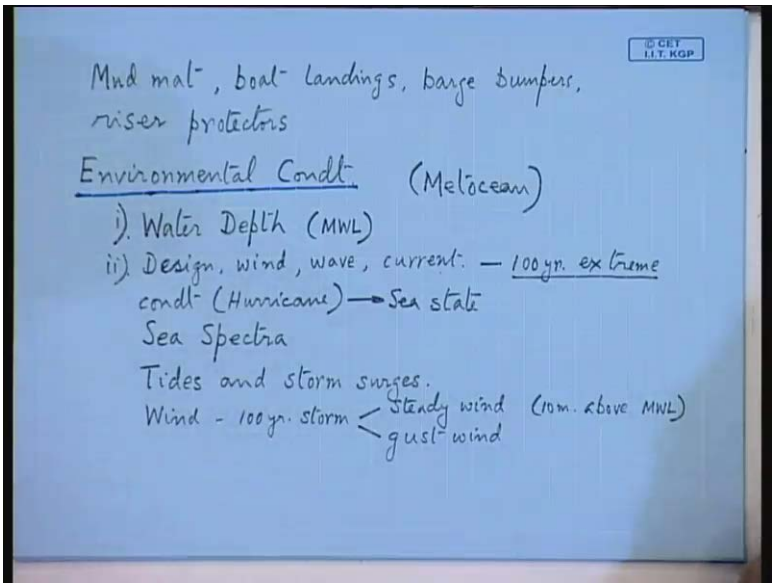

Then the last one is in the substructure this is called mud mat. So, mud mat actually gives the bearing area to the jacket, follow the piles. Your piles are not giving you the base area, is it not? Now whenever you do pile design there are two types of forces that will come. One is called suppose you are driving a pile or else call this skin friction that is coming on the perimeter of the pile, and the other is the base force. Pile is actually supported by skin friction coming from the soil and your end force that is coming at the tip of the file from the soil. So, similarly this is your jacket. Now jacket suppose you do not give them mud matt then the jacket is actually on piles.

Whenever you design a jacket platform you will find that the column piles that is actually supporting your deck, okay. Now in case of extreme loads where there were large amount of overturning movement, now the pile does not have a large base area or an end area. Your end area is quite small as you compare with the surface area or the skin area. So, that you are not getting the bearing support, okay. Now you have to increase the bearing support also to desist the topping moment. So, that is the jacket footprint; at the corners you will find huge plates; that has been given like this. At the centre of course you have to keep it open, right, because you have a marine raiser, you have that vile template and all these piping have to come.

So, obviously, the mud matt is not rectangular, but at the corners you give heavy plates. So, that actually resists the whole jacket from going down to the soil, because the soil

has to do the bearing function. So, the mud matt will come under substructure, and then the other smaller items are boat landings. This boat landing will come on the jacket, it will not come on the deck, barge bumpers, and the other is riser protectors. Now your jacket platform is a fixed structure, okay. So, the rises that are coming from the seabed and right onto the deck, but in between how you are going to this fix the riser; one will be fixed on the seabed, another fix it on the bed. In between also you have to give fixity, is it not; otherwise, it is going to bend like this.

So, you have to clamp at some levels, because the jacket is a tower, say, hundred meters or forty meters, seventy meters high. So, these are called riser protector's that have to come there. So, these are the things we have the superstructure and substructure will come under the BOD. Next is environmental condition. So, your client is going to ask you about this that we have designed a jacket for what type of environmental conditions? Now in ships how do you design ships? Ships are normally designed; that is your cargo or oil tanker, of course it goes under a specific sea state; that sea state will come under your load-line calculations, ships normally and you do it the hull girder bending calculation based on the load profile, that is the wave profile, okay, but similar things if we offshore this is more rigorous.

So, here what are the environmental conditions that are specified? Now the first one I told you which goes into the structural design is water depth. So, water depth is the major criteria which define the size of the platform; obviously, the platform size will increase with increasing water depth, is it not. Now you cannot increase the platform size longitudinally; if you increase along the length along the height also you have to increase along the width, because your overturning movement will be larger. Now if you want to resist overturning moment the first thing is you increase the base area, is it not; it will prevent toppling. So, that is water depth; actually this you normally design from mean water level MWL.

Now after this you design wind, the air has to be very specific. Design wind, wave and current. Now normally this is we specify hundred-year extreme conditions. So, in short they call it hurricane. Now the hurricane condition I think it is BFO-7; this is governed by sea state. So, your client will ask you about what sea state you have found the basis of designed, sea state seven or sea state six. So, this is given; normally you do for sea state

seven. So, hundred-year extreme storm conditions, very crucial. Then from this what you get? Normally these sea states are normally specified in sea spectra.

So, I talked about all these spectra at the beginning of the class, what spectra you have taken? JONSWAP, Pierson-Moskowitz, Bretschneider and why you have taken. And normally you will find at a particular location along this spectra are applicable. So, those data you have to get from the oceanographer. So, this actually comes under met ocean engineering. So, you have to confer or you have to coordinate with the met ocean engineer. So, he is going to give you all these data. Spectra cannot be one single peak; it may be double peak also.

Why you have chosen particular spectra will come here. Then you have tides, tides and storm surges, tidal height, storm surge height. So, that will dictate your structure size, and there are two types of wind, wind hundred years storm. Now you base it on two aspects; one is called the steady wind, and the other is called gust wind. It is a sudden increase in the wind velocity. So, this is normally calculated ten meters above mean water level. So, this you have to figure out from the met ocean engineer, okay. Now after you have done the environmental conditions then you go to foundation designs.

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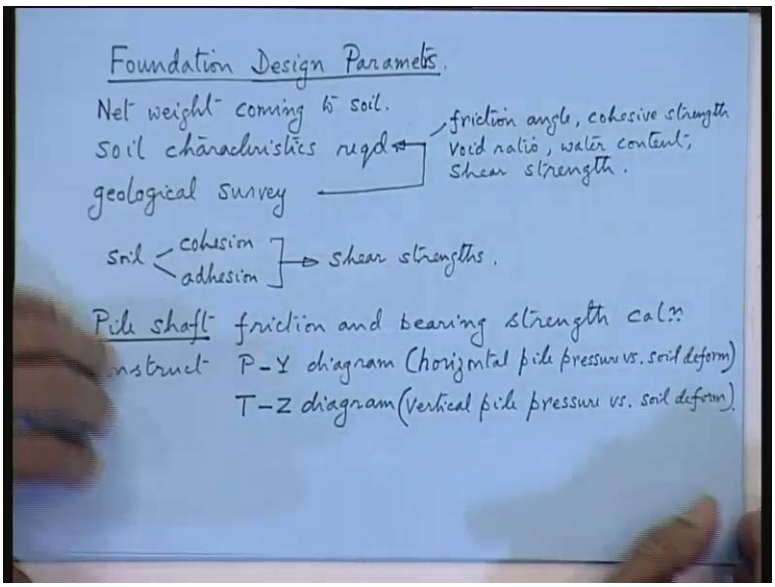

Now here actually this is distinctively designed from your ships, because ships are not sitting on the seabed, is it not, because ships have more parameters. Ships are actually founded on water; foundation design is basically you have to do the net weight that is

weight minus buoyancy, net weight coming to soil. Now here soil characteristics required. Now here actually before the jacket is fixed onto the seabed you should have made a geotechnical survey, or a geological survey is done to find these soil characteristics. Now some of the soil characteristics are this fiction angle cohesive strength.

Now soil has two provision; one is the soil basically you will find, I am not going into details, soil basically has two provisions. One is called cohesive strength or rather you write cohesion and the other is adhesion. You find this will be a part in sheer strength. Normally soil sheer is calculated based on these two strengths, the cohesion and adhesion characteristics of the soil, friction angle. So, all these have to be found out. Then you have to find out void ratio; that is the empty space given in the soil. Then water content, then sheer strength. So, these are your foundation parameters. Now next pile shaft friction and bearing; friction means skin fiction, friction and bearing strength calculations.

So, this is best provided by a P-Y diagram. So, construct P-Y diagram. So, a lot of input is required, the other is a T-Z diagram. So, these two diagrams are referred to the pile shaft. Now this is the horizontal, P-Y is horizontal pile pressure versus soil deformation. Now the P-Y diagram is important, because it is latterly loaded pile. Your piles are mostly these are latterly loaded, and the other T-Z diagram is vertical pile shaft, horizontal and vertical pile pressure versus soil deformation. So, these two diagrams have to be provided to the client. So, these will come under the foundation design. Now load design is very thorough and some of the idea I have already given you.

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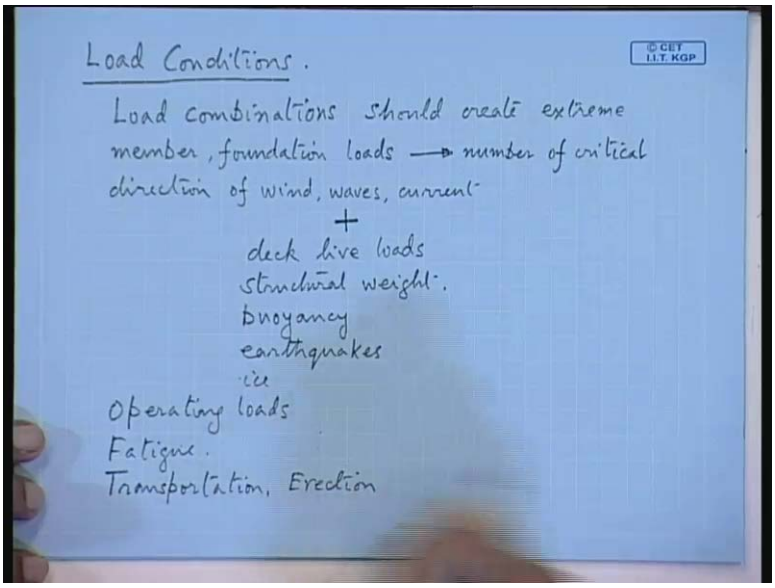

So, load conditions are first is load combinations how you combine the loads. So, normally whenever you are doing a structural design. So, you educate your client on number of load conditions; ships I think you have already done this your stability calculation. That is your GZ calculations have been done. Now you will find your GZ calculations are drown for different load. One is the arrival condition of the ship at fort and another is the departure condition. I do not know whether you have been thought about all these. So, like this you have to specify the number of load combinations for the jacket. So, load combinations should create extreme member foundation loads.

So, we are bothered about the extreme loads. You have to find out which type of condition will give you the extreme loads whether you combined waves and current in one direction or in opposed direction. Normally you may not get a particular time all the loads acting in one direction, but you have to design for that kind of eventuality; you cannot escape. Now this is done from number of critical directions of wind, waves, current. Find out the worst case scenario. Now this is so far as the environmental loads. They other is we have to superimpose plus what live loads, deck loads. Live loads are mainly coming from the dynamic loads or the vibratory loads. Then you have structural weight, then buoyancy, then earthquakes.

So, these are the types of loads will come; ice if you have normally in our case you would not have ice. So, these have to be given to the surveyors. So, after this will come

operating loads. That is you are driving your drill string below the seabed. So, that means you have to have some kind of a hammer at the crown. So, these are called operating loads. So, you are given governed by operating conditions, then fatigue, then you have transportation loads, transportation in direction. So, these have to be given in your BOD.

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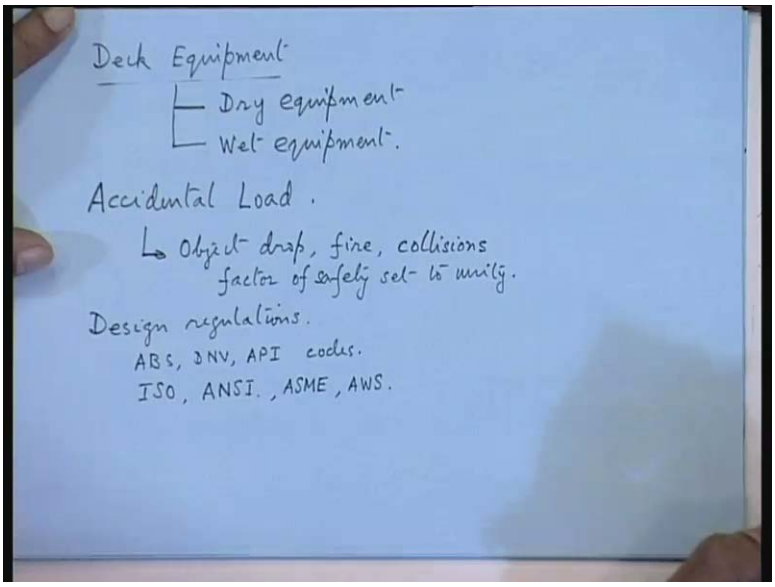

Deck equipments, so before you jump into an analysis this is more required, because nowadays nobody does all the structural analysis by hand you know, the computer programs are available. But this is important because it is the type of data you are giving to your program; that is why if you go wrong on the data size then you will get all the weird dimensions will come, okay. So, that is why he has elaborated out here all the loads. So, deck equipment is one load. Now here actually the equipments normally you characterize into two categories. One is called the dry that is without in the oil or water, and the other is the wet equipment and dry equipment load. Now dry equipment and wet equipment.

Then after this is design accidental load. Now accident can happen because of object drop, fire, then collisions. So, all these loads have to be basically impact and you have studied in vibration what was that impulse load, impulse and impact loads will come out here. So, those are accident loads. Normally they are designed with a factor of safety, factor of safety set to unity; factor of safety I think is defined by your extreme load by

designs load, and I think that is your working steps by. So, this is unity; that means you design for this load, but you do not exceed greater than this load.

Now after this you have to say the designed regulations. Now we have to tell the client which regulation you have followed. See normally you will find ABS, DNV, then API codes. So, that means the structure that you have designed will conform to which code, either to one of these codes. And normally I think the surveyors from all these classes will come. So, if you design for API, ABS should also survey your platform. So, which codes? There are also other codes that is called ISO, international standard organization, ANSI; ANSI I do not know what is this ANSI, then you have ASME American society of mechanical engineers, AWS American welding society. So, all these codes have to be followed.

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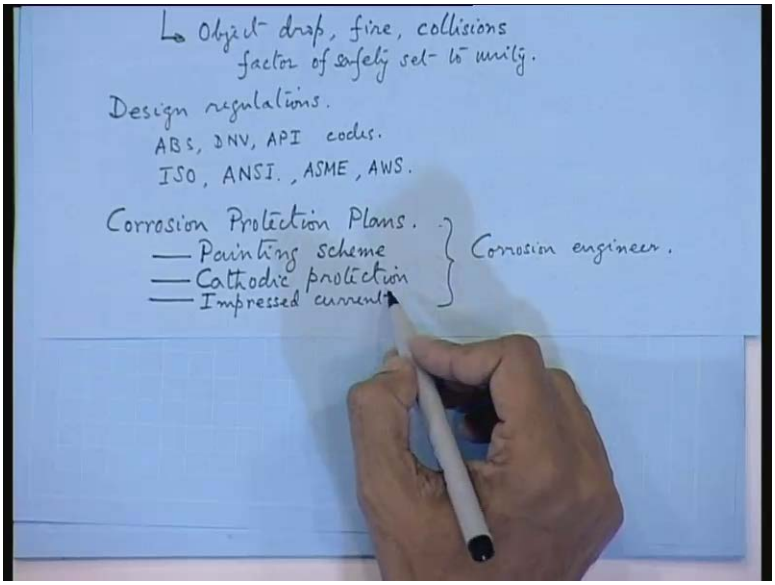

Now after this painting and corrosion plans corrosion protection plans. Now rather you have to specify the corrosion. So, here you have to convince or you have to tell your plan your painting scheme. What paint protection you are giving? Catholic protection by means of sacrificial anodes if you have and sometimes they may give; I do not know anything; I am not a corrosion engineer. So, they call impressed current.

So, this is actually specified by a corrosion engineer, corrosion engineer or what it is called, normally this is done by painting engineer; it is his job. So, these are the protection that you are going to give individual platform, because it is the operating

condition is corrosion environment. Your seawater is mainly a corrosive environment where you have electrolytes from sodium and chlorine that is going to code your structure. So, adequate corrosion protection has to be given to the platform.

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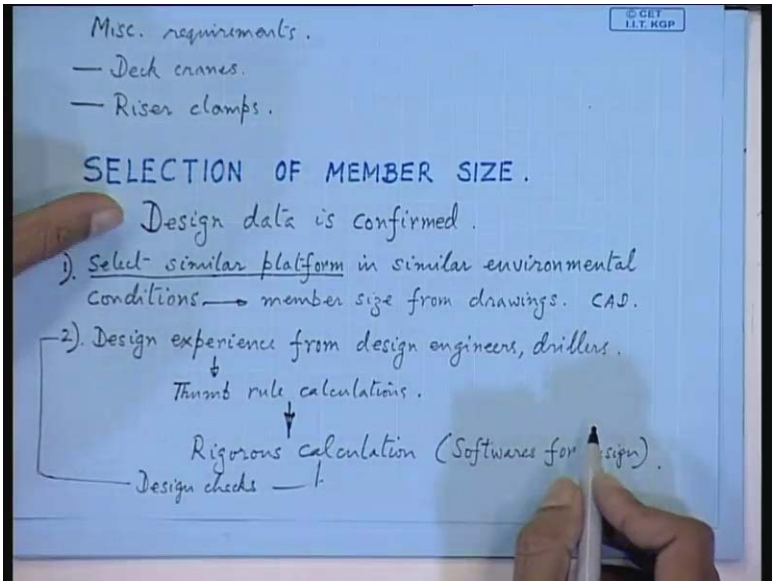

Then if you have any particular requirements or miscellaneous requirements; so, these are actually owner specific. So, this will consist mainly of deck cranes. You have to specify crane types, their lifting capacity and all these things and then riser clamps. Now this will come under the BOD. So, these are miscellaneous requirements. Now after you have done this then you go for this selection of member's size, member means structural member. So, at this stage you have designed data where you have calculated from the previous BOD. Design data is fixed is confirmed rather. The design data has to be confirmed, because before you actually plan yourself into member size calculations.

Now how do you go about this? Now the first thing is select similar platform in similar environmental conditions. This is similar to yours their basic ship design approach. Now this is the first. So, that means this forms your guideline. So, you are actually not in the deepwater, okay; I mean this is your start. Now here actually select similar platform in similar involvement role. Now from here you can get an idea of your member size, member size from designed documents or from drawings. Normally most of the companies they offshore companies; they have a well-established design and production office.

So, if you ask also in shipyards. Shipyards normally if you are building a ship then you go into your design office; you ask your previous design files, okay. So, that is your previous, your archiving actually. So, nowadays these are actually all these drawings are done in microfiche archiving or CAD. So, from here you can get all the information, okay. Now this is one area from which you can select, the other is similar platform. Now what else can you do? This is one type from which you can start; number two you can start from designed experience.

So, actually you have to draw upon one and two, because you will not get; if you want to design all the information all the designed data you may not get from your similar platform. Then you have to revert back or rest upon your design experience. Suppose you are driller or normally you have to design experience from design engineers in the company. Drillers, they will tell you lot of things. So, normally is a very experienced personal job. So, these are the two areas in which you can design, design from experience this is a similar project, and normally sometimes they use these two people thumb rule calculations.

So, this is your start; after this you go for rigorous calculations, software's. Now here actually from here you can come back here also design checks. Suppose you find your calculations and what you have to do, the experienced engineers are saying they are quite; you are not converging, you are quite out. Then there is something some wrong in the flow in their data flow in the design. So, these are moved in this, and software's are normally they are bought items or they are designed indigenous by that offshore contractor.

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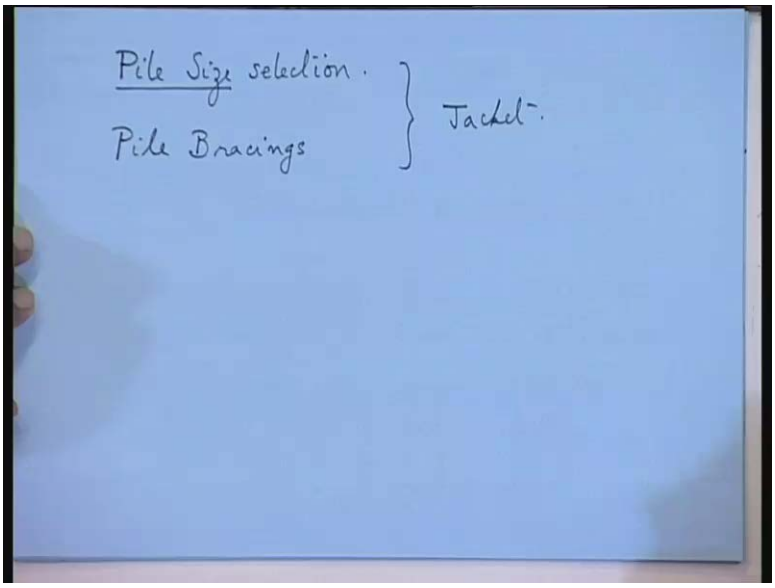

Now after this you have done, the first thing is there are two aspects pile size selection. Pile size selections; you do not have time actually. Now pile size, that means, this will depend on the environmental load, because your major load is being registered by your piles. Actually you select your pile diameter, length and all these things, and those piles are driving through the columns. The piles in turn will support your deck. Now once this pile size is fixed then you can pile bracings, you have two aspects. So, this actually will design your jacket. So, the next class we will talk about this and try to work out a small problem on this pile size. Of course the thing is that if I go deep in to this we cannot cover in one course. This itself is a very huge topic.