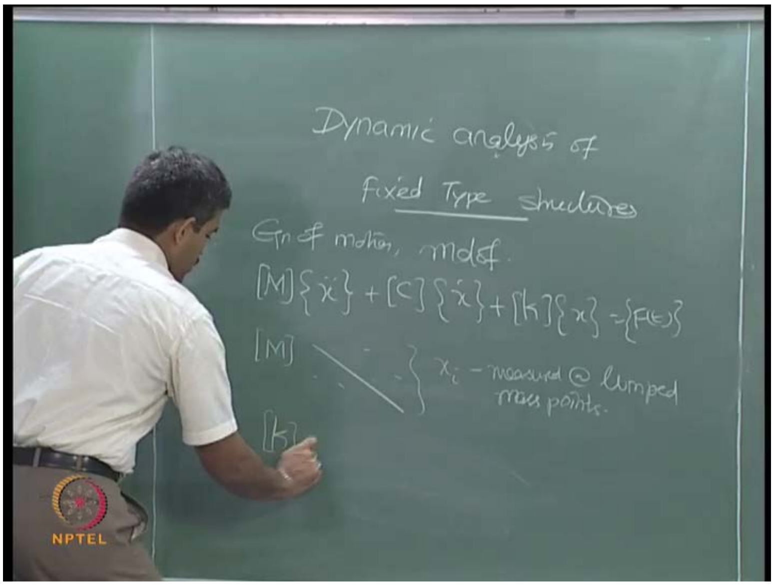
Dynamics of Ocean Structures
Dr. Srinivasan Chandrasekaran
Department of Ocean Engineering
Indian Institute of Technology, Madras

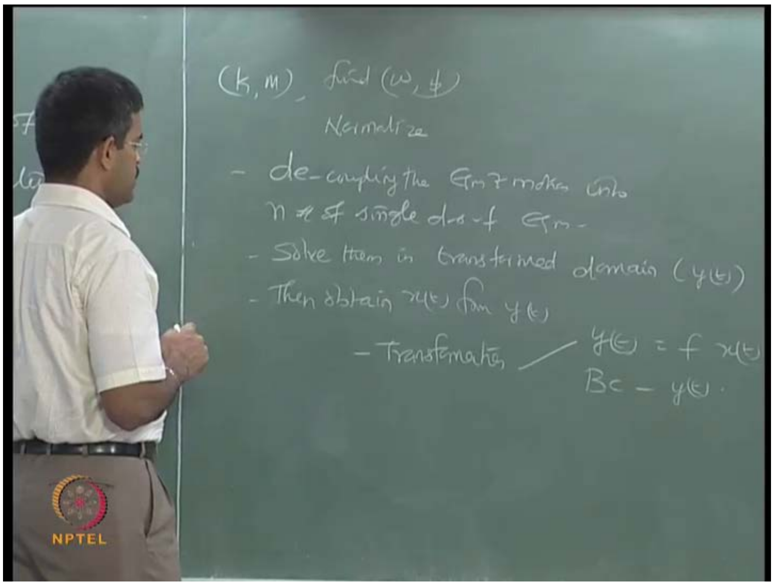
Module - 2
Dynamic analysis of offshore jacket platforms
Lecture - 3

(Refer Slide Time: 00:15)



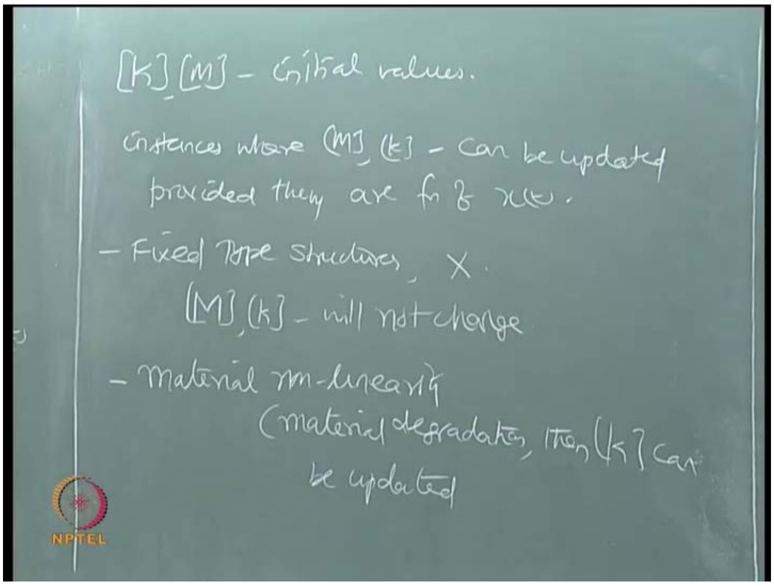
In this lecture, in module 2, we will talk about the dynamic analysis of fixed type structures. So, as we all understand, the classical equation of motion for any multi degree freedom system model is given by. It is a classical equation of motion, where mass matrix generally is diagonal of the limits are not present, provided the degrees of freedom are measured at the lumped mass points and k can be derived from the first principle.

(Refer Slide Time: 01:40)



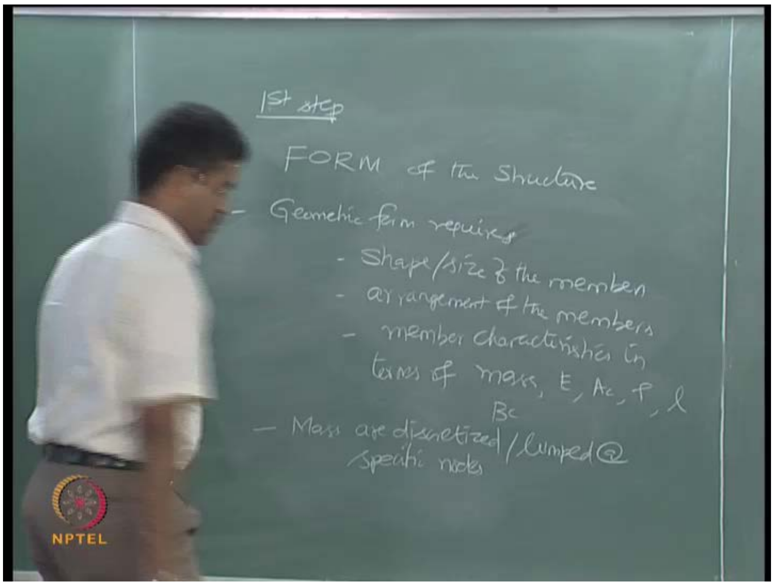
If I know omega, if I know k and m, I can find omega and p. I can normalize it to make advantage of decoupling the equations of motion into n number of single degree equations. Of course, solve them in transformed domain, which will not be x of t, but, y of t and then, obtain x of t from y of t. When you do transformation, you have to also transform the responses as function of x of t as well as the relative boundary conditions also to be transformed in the y domain to solve the problem in y domain.

(Refer Slide Time: 03:02)



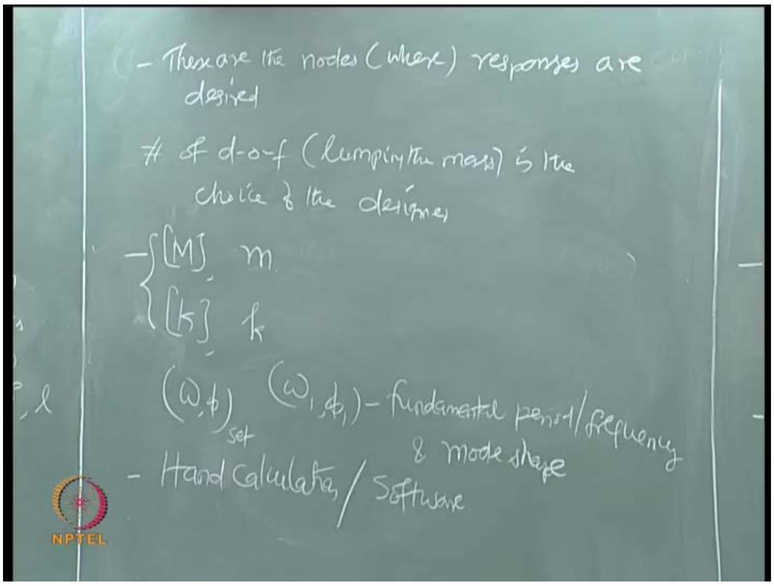
So, based on the initial values of k and m, why as initial values because, there can be instances where, m and k can be updated, provided they are function of responses. But, in fixed type structures, this problem will not occur. So, there will be initial values of k and m, which will not change. However, if you consider material non-linearity to account for material degradation, then k can be updated.

(Refer Slide Time: 04:40)



So, what would be the first step to do dynamic analysis is, I must have the geometric form of the structures. What does it mean? The geometric form requires, one shape and size of the members; the arrangement of the members; then of course, the member characteristics in terms of their mass, there young’s modules, area, cross section, density, and of course, the length and boundary conditions. So, based on this, we make a very important assumption that, the mass are discretized and lumped at specific nodes.

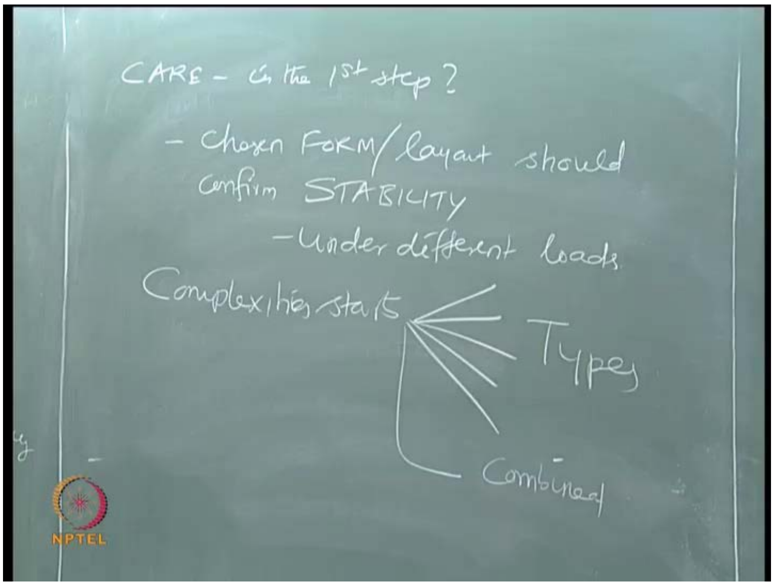
(Refer Slide Time: 06:42)



So, these are the nodes where I want my responses are desired. What does it mean is, the number of degrees of freedom, where you are lumping the mass is the choice of the design. So, you can work out as an idealized single degree freedom system also and you can work out as multi degree freedom system also. In the first step, when we have the form selected and chosen and when I have got the shape and size of the all the members in their arrangement, ultimately what I will get will be the mass matrix or the mass value, if it is a single degree idealized. The stiffness matrix or the stiffness value, if it is single degree idealized and of course, once I have this, I get omega and phi as a set for all degrees of freedom or at least omega 1 and phi 1 as fundamental period or frequency and node shape. This is what I will get in the first step.

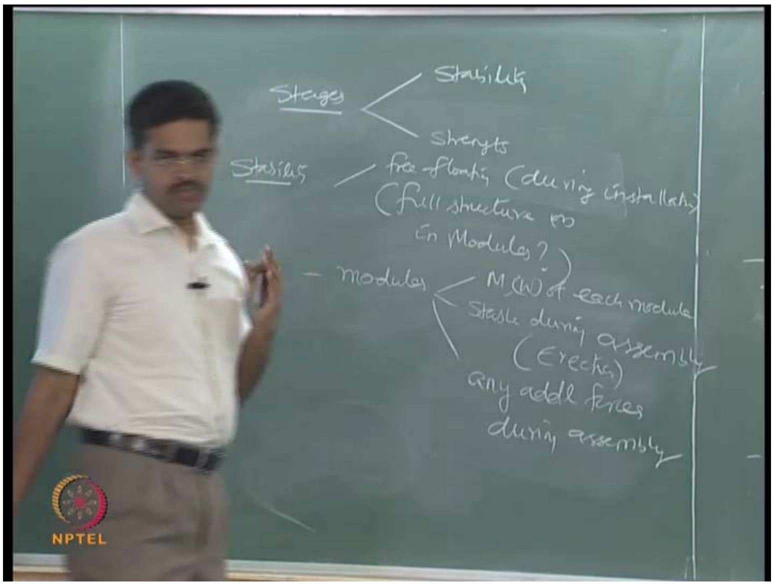
Obviously, one can do this first step by hand calculation. One can do this by hand calculation or using software. You may wonder that the first step is very simple and I have to only assume a form and arrangement, so why do you actually use software and I can use the single degree idealized. The software is required because of the following reasons.

(Refer Slide Time: 09:04)



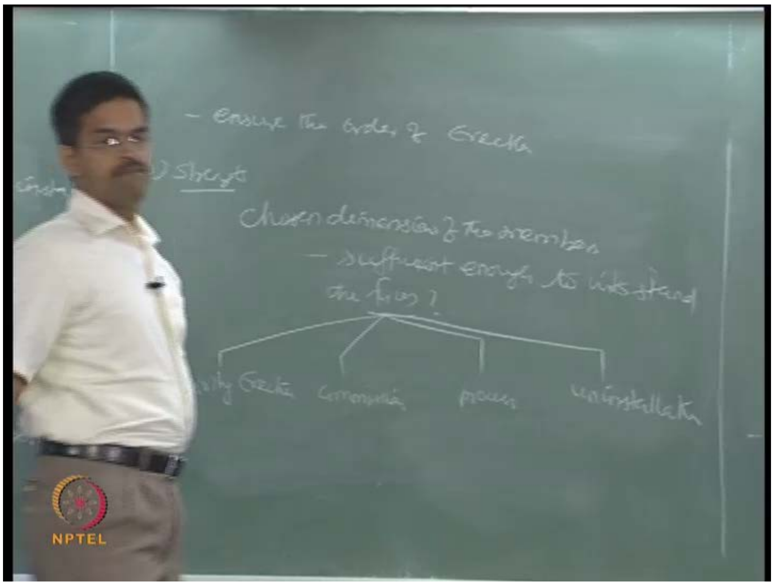
What care you must take in the first step and what should be your care that you have to take in the first step, if you want to do a dynamic analysis. One, the chosen form and layout; what do you mean by layout? It is not the layout of the platform in the given sea state. It is a geometric layout of arrangements of members. So, the layout should confirm stability under different loads. You may wonder that, if you can check stability by hand calculation again, why do I have to do a mathematical modeling for this or programming for this to check it for different loads.

(Refer Slide Time: 10:47)



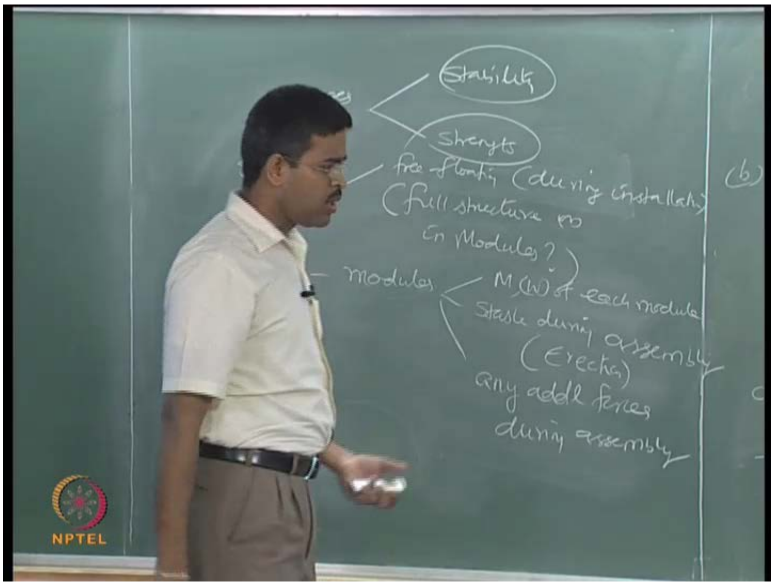
Now, the combination or the complexity starts when there are many types of loads and they are also combined. So, as the first step in dynamic analysis, one is interested to see, whether the chosen form can be stable. At what stages? What are those stages where I must ensure the stability of this platform? So, what are the stages at which I must confirm my stability and of course, strength. I will come to slightly later. The stages where I confirm stability are the following. One, when I do free floating, that is during installation; what does it mean? I am going to do the installation for the full structure or in modules. If I am going to do it in modules, then what is the mass or weight of each module? Are they stable during assembly? That is erection. Or, will they attack any additional forces during assembly? So, I must check this.

(Refer Slide Time: 12:15)



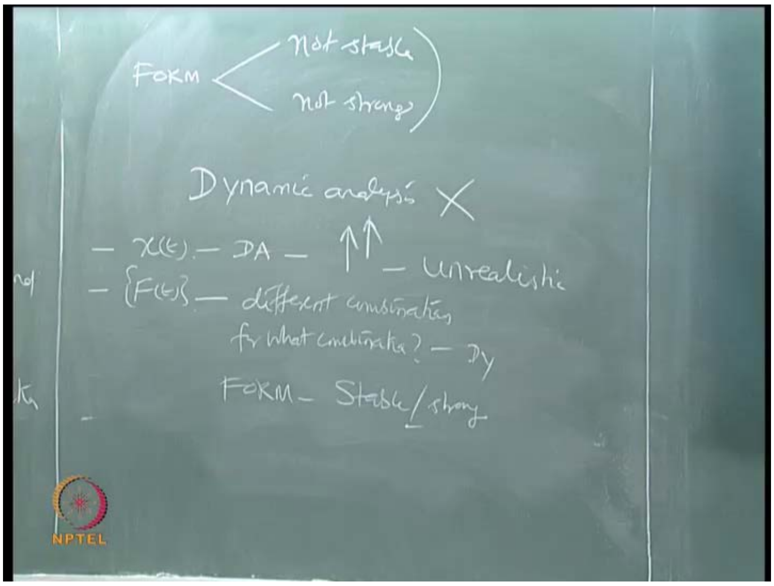
So, by the way of checking this, I must ensure the order of erection, which will be the first module mode of, which will be the second module and why. The second part must ensure the strength. It means, the chosen dimensions of the members should be sufficient enough to withstand the forces. Now, what are these forces? These forces can come during erection, during commissioning, during process, and during uninstallation.

(Refer Slide Time: 13:38)



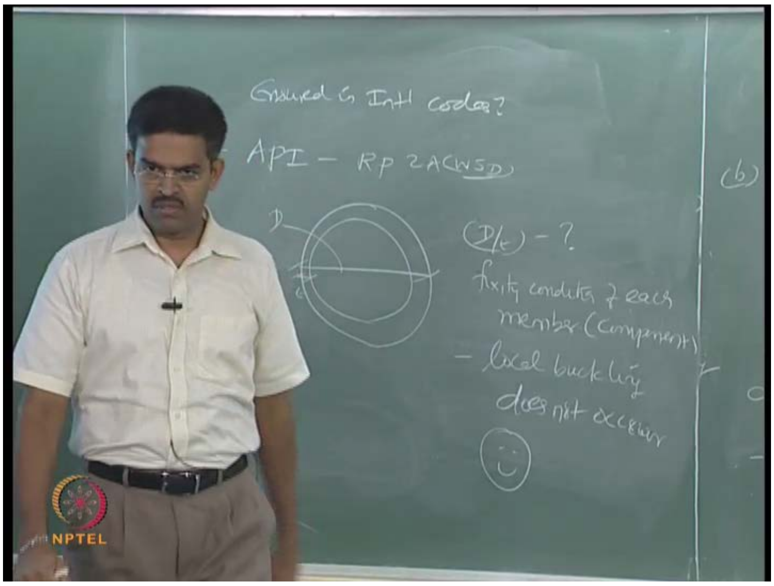
Now, there are various complexity involved even in the first stage of checking itself, that I must ensure that the system what you have chosen should be stable and should be strong. Now, one may ask a question subsequently that, I am not designing the structure. I am doing only a dynamic analysis. Why should I check the strength and stability in the beginning? That is a very relevant and very intelligent question that, why I should do this strength and stability checking in beginning because, my focus is not the design of the system. My focus is dynamic analysis.

(Refer Slide Time: 14:08)



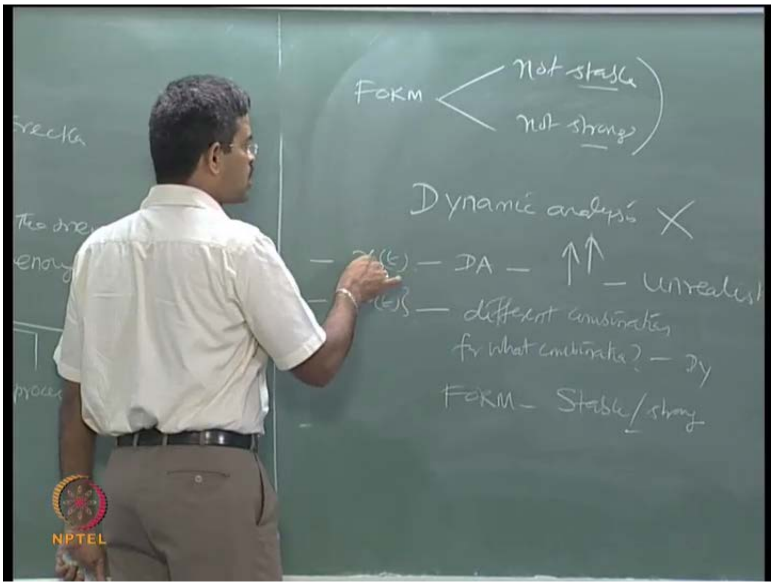
Most importantly, if your form chosen is not stable and not strong, there is no meaning in doing dynamic analysis. I will tell you what is that. It should not be done. There are many reasons for this. The foremost reason is, the responses what you get from dynamic analysis will either become verify or will be become unrealistic and dynamic analysis involves f of t into it and then f of t can be different combinations. Now, for what combination you must do dynamic analysis? You must do a dynamic analysis only for those combinations where, your form is proved to be stable and strong.

(Refer Slide Time: 15:35)



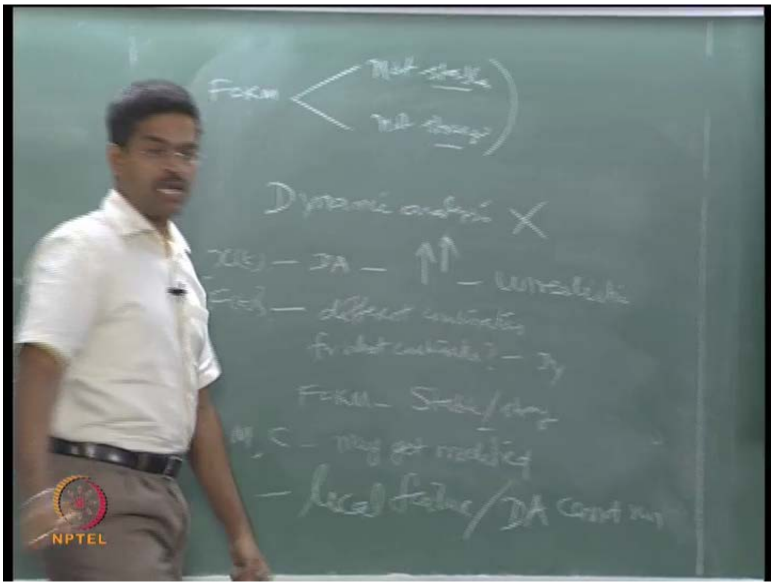
Very interestingly, how this has been checked and exercised in international codes? I can give you a very simple and a very elementary example, how this process has been ensured in international codes. Take for example, API. To be very specific, RP 2A WSD, to be very specific. It is a design code. I am talking about dynamic analysis as a preluring for the design code. Now, the design code clearly says, if you take a circular member of an external diameter d and thickness t, which has a ratio of d by t, which is of interest for you, for a given fixity condition of each member, which I now called as component of the platform, you must see that local buckling does not occur. You must check this. If the local buckling occurs, you cannot do a dynamic analysis first.

(Refer Slide Time: 17:03)



So, it is very important that my chosen form in simple terms should sustain or it should prove that it is stable and it is strong.

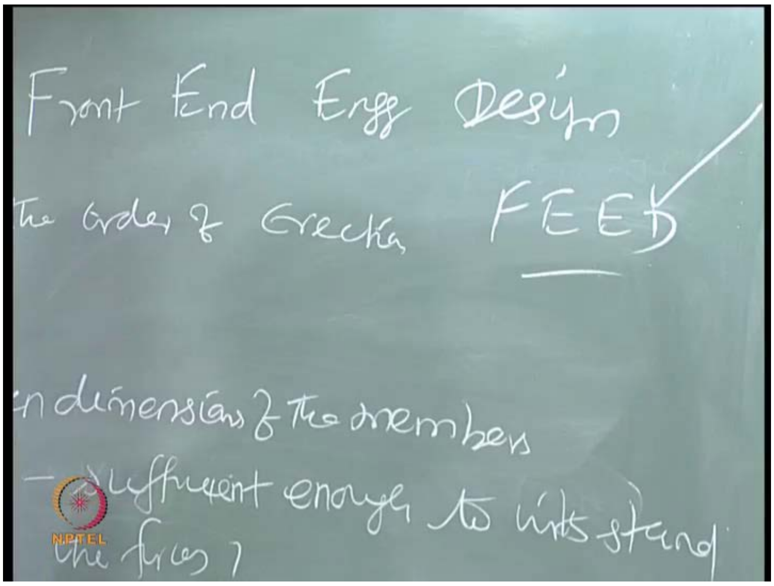
(Refer Slide Time: 17:28)



If it is not stable and strong, the responses what I will get as an outcome of a dynamic analysis, to be very specific, they will be unrealistic. Therefore, there is no value for this output from the dynamic analysis. Most importantly, your structural characteristics may get modified during the analysis itself, if your form is not strong and stable, because it will initiate what is called a local failure. Your dynamic analysis cannot run. It will give a runtime error. You will not be able to run the program at all. Ok?

So, in nutshell, if you have a form, which is already chosen by you, which is now the geometric layout of all the components or the members in the given form, you must have the dimension, cross section properties, and characteristics of all the members in elevation plan, which you must first generate in the software. Then, to that form, apply different combination of loads as recommended by any international code and see that this chosen form is sustaining or withstanding the combination of these forces. Once that is done, the following will be the dynamic analysis.

(Refer Slide Time: 19:00)

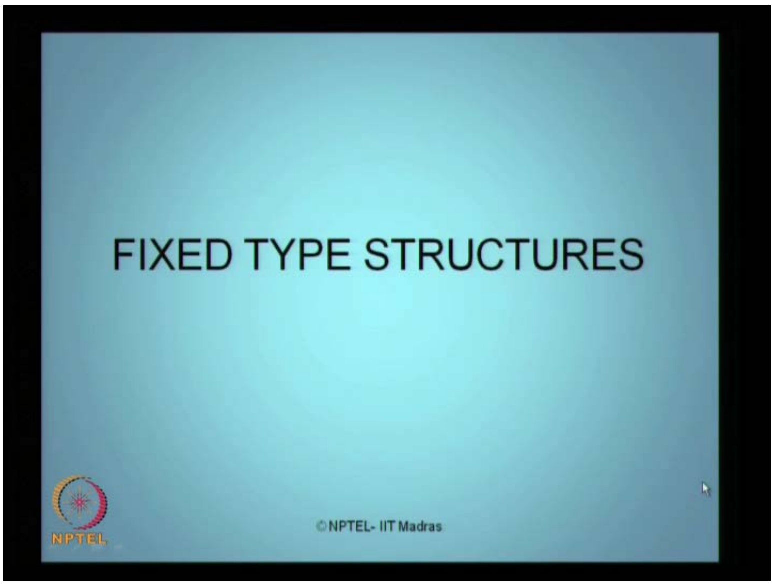


It is very simple that we must agree, that essentially a preliminary check; the whole process what we just now saw, is generally called as front end engineering design. It is called shortly as FEED. The whole process what we discussed now is FEED. So, a dynamic analysis is to be carried out only after there is a FEED clearance. If the FEED clearance is not there, dynamic analysis is not done. It means, dynamic analysis is always a second stage of analysis in any given system. It is not done at the first stage. So, the first stage, preluding dynamic analysis will be a quasi static or a static analysis, which will prove that the chosen form sustains all the recommendations as installed or given by FEED.

One may wonder, apart from checking the given form's stability and strength, what does more FEED give me? FEED also gives you what other dynamic loads which will come on the deck during erection, during commissioning or during impact loading caused with the barges on the vessels. If you do not look at the FEED, you will have no idea what would be the f of t. f of t is not only the wave and the wind load and the current load and the seismic load, which are created by the nature, there are man-made loads, which are also counted to f of t. For example, helicopter; for example, buoyancy tanks; for example, turbans and generators; for example, the drilling derricks under operations. So, all these should give you a fair idea at what frequency, at what loading, at what mass of the mass, the structure is operating. So, dynamic analysis is not a simple first step of analysis in even a fixed jacket structure or fixed structure like this, where I must first establish the FEED clearance for a given point. Now, one may wonder, sir, if I am proposing a new platform of funny form geometry or a form, then I may look for a very detailed FEED. But, I have been looking forward for any existing dynamic analysis, for a proven form, already which is in situ or which is placed in position, somewhere in the sea state. Still do we have to do a FEED for that? The answer is yes, because you will have to model each and every element in the dynamic analysis because, my dynamic analysis will also include the component level failure and global level failure, in terms of x of t.

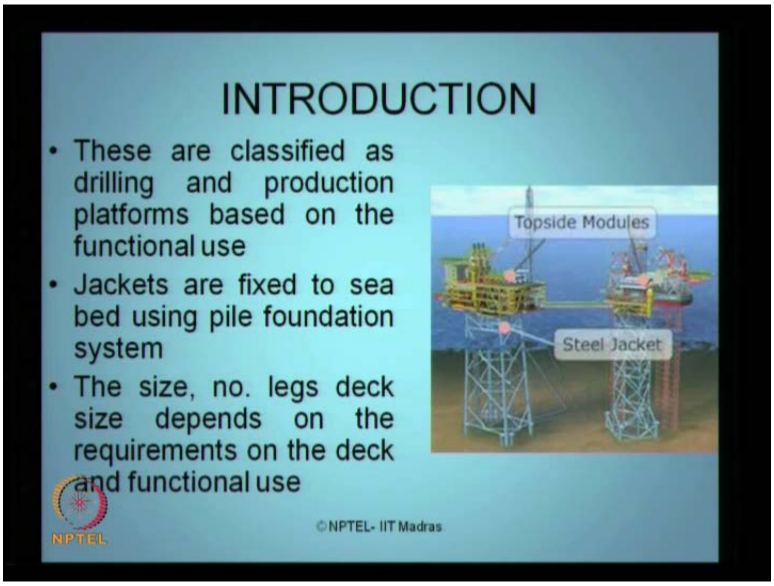
So, I have to anyway model this. So, in this lecture, we will talk about how we will prepare the model for dynamic analysis. Then, in the next class, we will take up an example and do the analysis by hand for a single or double degree freedom system model in simple terms and then, we will demonstrate this for higher end platform, using software results directly and not as the step used in the software. Is that clear? So, you must understand the necessity of why we are talking about preparing a model for dynamic analysis. That is very important and why do we use a software because, we have got unrealistic and very wild combinations of different kinds of loads, which are all highly uncertain in its combinations and its magnitude and occurrence of time periods. So, we cannot do this calculation by hand, because, one, it may cause error and two, it may be tiresome and cumbersome for doing this and above all, for doing a dynamic analysis of multi degree freedom system, you all agree that, if you have a six degree freedom system, it will be comfortable for me to solve that using programming rather than solving it by hand.

(Refer Slide Time: 23:07)



So, anyway for doing a dynamic analysis, you prefer to land up in using a package or a software or a program or a analytical model, which you will program yourself and to prepare the model for that, I must have the compete detail of the model first, which has crossed these two stages of clearance, which I simply say as FEED clearance in the given platform design. Is that clear? So, in that argument, let us quickly look at the fixed type structures today.

(Refer Slide Time: 23:13)

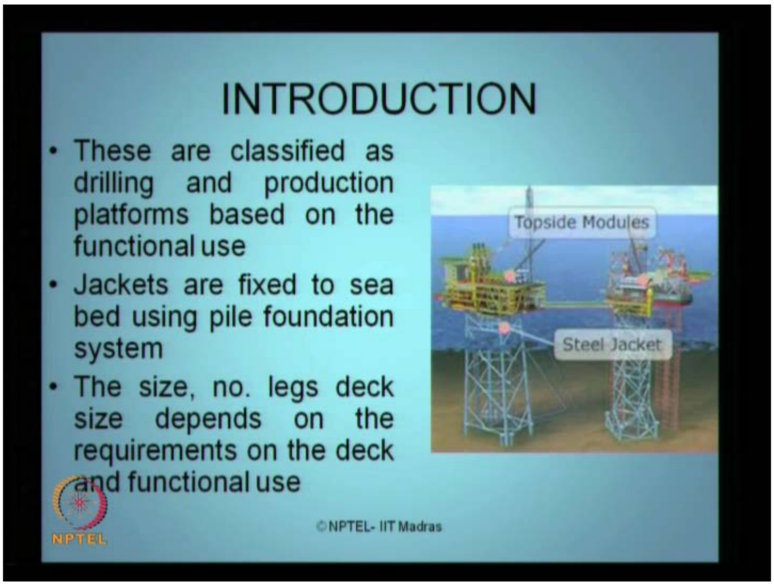


So, this example of a jacket structure, which has got topside modules and the steel jacket lattice braces at the bottom. So, these are actually classified as drilling and production platform based on their functional use. Something can be only production and somewhere drilling can also happen. Usually fixed based structures do have both the operations in place. Of course, jackets are used to the sea bed or fixed to the sea bed using piles, because below the subsoil here, you will see piles, which are connected or which are driven into the subsea or subsea bed for holding these legs in position. Of course, the size, the number of legs, the deck size, all depends on the functional requirements of the deck and the functional use. So, though we say, the form is geometry driven, but, the size and arrangement is all functional driven. Ok?

So, it is a very interesting combination of architectural design where, functional and form, both are combined to arrive at a platform design. So, functional design in the sense, what should be the size of the deck for operational requirements and how many tiers of decks should it have? 3, 5 or 2? What should be the deck clearance from head to head and why you should have it? Where do you place the mast of the deck? Where do you place the crane? All these are functional requirements. Where do you want to place the storage chambers? In the first deck or in the third deck and why? In which geometric centre in the layout? Exactly the c g or actually eccentric corner or where do you want to place? All these are functional requirements because, they are all deciding what will be the length of the pipe, what will be the layout of the pipe, what will be your offloading and unloading arrangements for the platform etcetera. These are all functional requirements. But, depending upon these functional requirements, what should be the deck thickness, what should be the deck arrangement and layout, how many number of legs will support the deck and how do will be supported in the foundation using piles and what would be those diameters, what would be the effective length of every member, what would be the boundary condition imparted, and what would be the design of the joints, all these are form based designs.

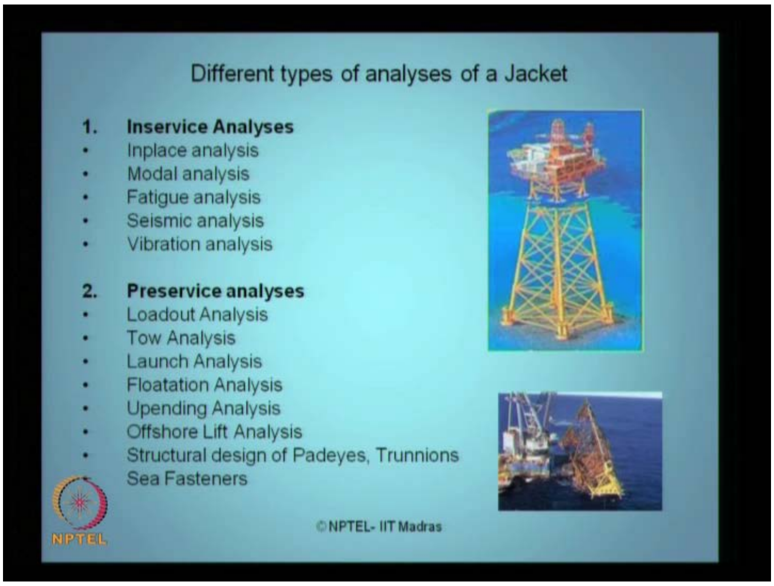
So, this is a very interesting combination where, functional use also demands and directs the design plus form based used direction design because, for this platform, form based design may not be innovative and thought provoking. When we move this platform to deeper water, you will see that form based design will dominate the whole functionality of the platform. Because, for compensation on the functional based design, for example, we say, we do not want production at all and we want only drilling. I can have platforms of that order. I can also have platforms, where there is no drilling, only storage and off loading is possible at the source. So, I can compromise on functional part of the problem, but, not on the form, because I want to take it to deeper water. You understand the combinations?

(Refer Slide Time: 23:13)



It is very important that in case of offshore structures, this combination, the integral and unique value of combining them together, whereas, possibly I think, offshore structures are one amongst the unique combination, where common function both are combined together to arrive at the structural system. No other system has this kind of uniqueness.

(Refer Slide Time: 26:24)



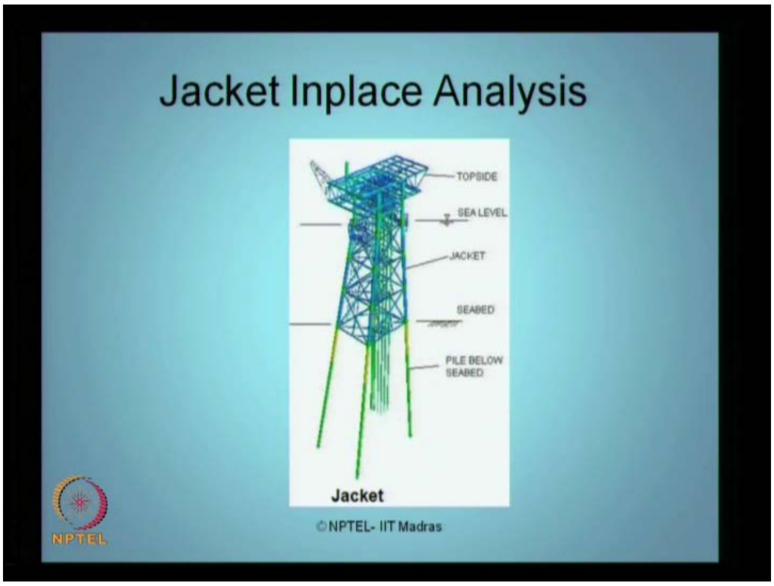
So, we have to know this; so what are the different types of analysis you have to carry out for a jacket, when you want to do a further dynamic analysis down the line. As I said, the necessity for doing this is very important for me, that my chosen form and system should pass the basic functional requirements and the system requirements in terms of its strength and stability. So, I must do different kinds of analysis. What are they? So, I can do what we call inservice analysis, where I do an inplace analysis or where I can do a model analysis. We will talk about this in the coming lectures, what do we mean by a model analysis by taking a simple three degree freedom system model. We will also do a fatigue analysis. Of course, I will not touch upon this in this course, but, fatigue analysis is also done in service analysis. You should do a seismic analysis, where we will touch upon this for compliance system as we post a problem in the last lecture.

We must do a dynamic analysis in inservice. You can also do what we call preservice analysis, before the platform is put to service. You must do what we call loadout analysis, when the platform is to be installed, when the load is out from the platform, what kind of loading will now occur on the platform. You can also do a towing, in case of floatation, in case of erection, in case of commissioning and in case of installation, you do a tow analysis. Of course, this tow does not mean the toe of the leg, of a human being. Tow is something related to operation of the platform, in terms of installation. Launching is again another operation. Of course, these are all constructional aspects. The photograph shows some of them. But, I am not anyway touching upon this. One must have a prerequisite of understanding them. If you do not have, it is not very difficult to learn the literature. You will come to understand, right.

So, launch analysis, as I just now said, flotation. It is a very important analysis. I will take down the line in dynamic analysis in this module where, flotation analysis dominates the form of certain structures we want to take it to deep waters. Ok? How floatation analysis governs the whole phenomena of, let say arriving at the form of a platform, when you want really take the platform at ultra deep waters. So, floatation analysis is very very important, which is nothing but, the free vibration analysis as far as we are concerned in dynamic perspective. So, floating analysis is a preservice analysis. Of course, are pending because, you are towing it and launching it and you are going to erect it and make it straight.

So, during (( )), what will be those kind of forces, which will act on the system and of course, off shore lift analysis because, some components you may lift also as well and of course, structural design of Paydeyes and Trunnions because, these are all the appurtenance and components, which are connecting the members, when you want to put them in modules, because different modules are arranged and then assembled. These are all nothing but the connections. You should do an analysis for that and of course, folding down the whole system in the sea bed using fasteners. These fasteners can be; can you give me any one specific name of a fastener or type of a fastener which is used to holding down the pile to the foundation? Skirt piles. Skirt piles is one of the fastener, which can be used to holding down the pipe, templates etcetera.

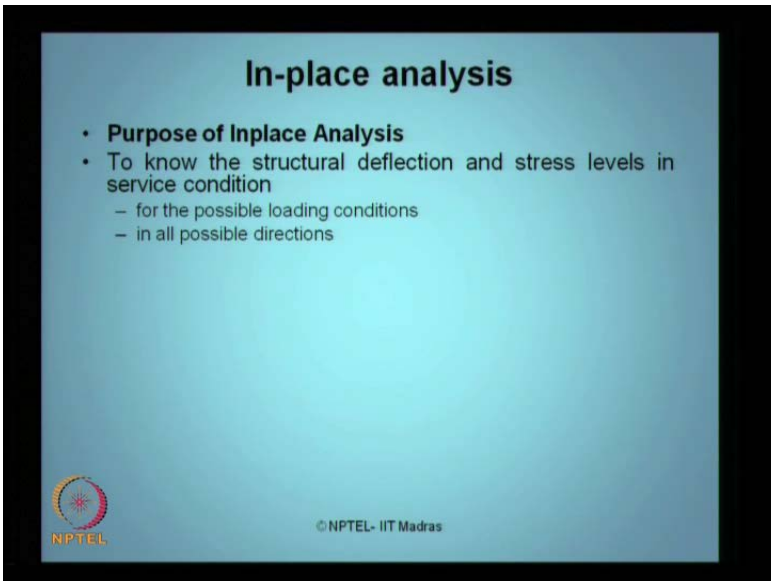
(Refer Slide Time: 29:46)



So, if you look at the inplace analysis, there is a picture which has been drawn or which has been taken as an export from one of the analysis been carried out using a software. You can see all the geometric layout of all the members are mathematically, let say graphically represented, whereas, you can see below the sea bed, there are piles which are extending, the legs of the column and of course, you can also see the drilling raisers in position, which are in different groups of colors, which has been indicated here because, they will also attract or transform forces onto the deck, because of the lateral action from the waves and current. You can see the depth level. There are three levels of decks which have been arranged from the truss system. You can also see an approximate model being developed for the cranes.

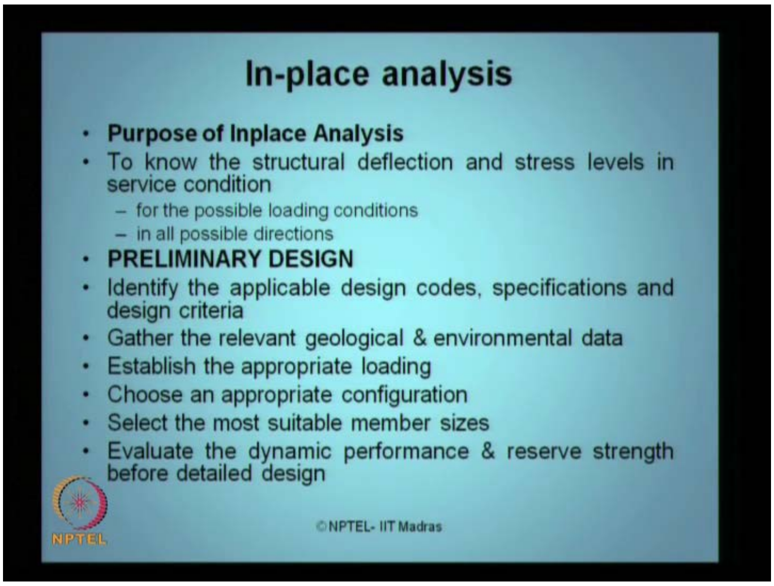
What we see in this assembly is network of lattice or bracings, which we call as a jacket. As technical literature says, it is a jacket and of course, the sea level is been indicated and you will be able to arrive at the comfortable free board, where the deck is placed above the sea level with the required free (( )), which is operational requirement or functional requirement of the platform.

(Refer Slide Time: 31:01)



So, if you talk about inplace analysis, let us see why the purpose of inplace is required. Actually, inplace analysis will help us to know the structural deflection in stress levels in this service condition. So, for all possible loading conditions and combinations, in all possible directions of wave action, you should be able to do this. You may wonder why we are discussing here in dynamic analysis class because, these are all important for me to ascertain that the chosen form that I am taking back to my dynamic analysis has to cross though all the (( )). So, this is what we call as preliminarily investigation and many of the designs, many, about 90 percent of the design in the primitive stage stops at this level itself without completing it. They do not take it. For example, the field success rate for a new type of platform, which is to be installed in, for example, in Gulf of Mexico is about 0.1 percent; FEED successes rate.

(Refer Slide Time: 32:31)



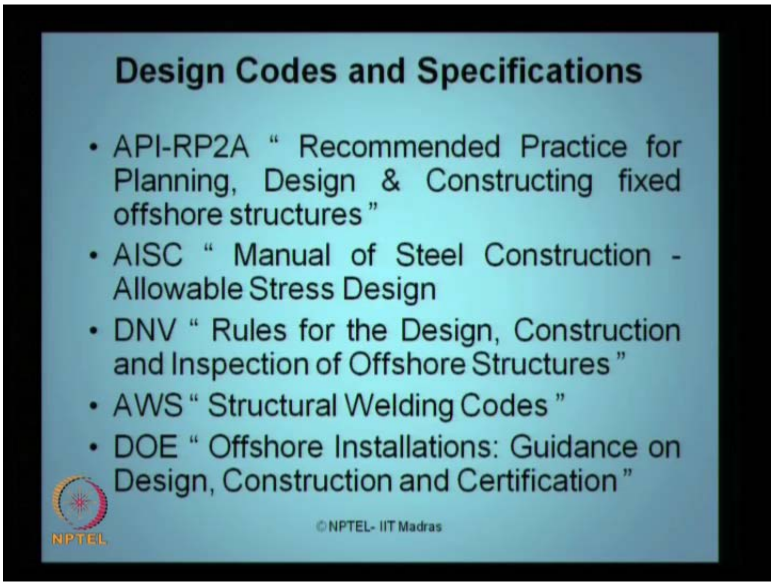
People drop it at this level itself because, at this level itself, you will come to know, whether the platform or geometry chosen by you or imagined by you, can sustain the loads at the specific analysis levels, inplace or inservice levels. So, this is very interesting layout of analysis, which will give an idea like, should I go for a dynamic analysis in detail or not? Is that clear?

So, for the possible loading conditions and for all possible wave directions, I must do the inplace analysis. Then, I do what we called as preliminary design. All of the engineers should know what we mean of preliminary design. Design is nothing but, arriving at the member dimension for a given layout of the members and for the given boundary conditions or the support condition of the members and for the given material. Then, I can find out the preliminarily design. So, this is actually to identify the applicability of the design codes and you must select which design code you want to use and what specific material you want to recommend and what will be a governing design criteria. Are you going to design it for a specific criteria which the system should sustain, you must select that in advance.

Then, you have to also gather importantly the relevant geological environmental data, where the structure will be placed in the position and then, depending upon what is the soil depth and what is the strength of the soil at that level and what will be the sea state that which the system is going to be or platform is going to be installed and you will also establish an appropriate loading conditions and combinations. That is very important. We already spoke about in the first module, what are the uncertainness involved in estimating the loads itself and arriving at the combination of these loads. For example, we said, we are looking for wind and wave together and then, one can look for the design wave and not a wind at all the mean speed or you can look for maximum gauss wind speed, but, do not look at the design wave category. Look for the mean wave categories etcetera. We have seen these combinations in the first module itself. So, you should establish what is the appropriate loading at which you want to design or you want to look at the platform inservice or inplace.

So, choose an appropriate configuration now, because you can rearrange the members or you can introduce new members or you can delete or strengthen the members using different kinds of lattice arrangements for the legs. So, choose an appropriate configuration and select the most suitable member sizes. That is very important here because, without all these things, you cannot directly jump into a dynamic analysis, because m will govern all these things as well as k will also govern most of them, the stiffness and the mass. Then, you evaluate the dynamic performance or reserve strength before the detailed design. So, before the detailed design is done, so dynamic analysis plays as an interface between the FEED and the detailed design. Is that clear? The FEED is a preliminary design what we do and then, the detailed design or the detailed, let say the fabrication drawings are prepared and the dynamic analysis is placed in between these two. So, preliminary work is what we say as a FEED.

(Refer Slide Time: 35:10)



So, let us quickly browse though the design codes and specifications very quickly because, this class, this course will not address them in detail. But, just for your reading, for the viewers, at least see that these are the courses which you must possess and read them and try to procure original copies of these courses. API-RP2A, Recommended Practice for Planning, Design and Constructing fixed offshore structures AISC, The Manual of Steel Construction - Allowable Stress Design and DNV, of course, Rules for the Design, Construction and Inspection of Offshore Structures and AWS, which talks about Structural Welding Codes. I am not giving the revision number for viewers because, the draft codes is been released very often and the revision is happening very frequently. There are various changes that have been made in every draft code of every international codes that you see here. Therefore, year of revision and recommended practice is not specifically said at which year, but, you should look for the updated course and the updated draft versions of these codes, if you want to really do the field design before you want to do the dynamic analysis for your given structural form.

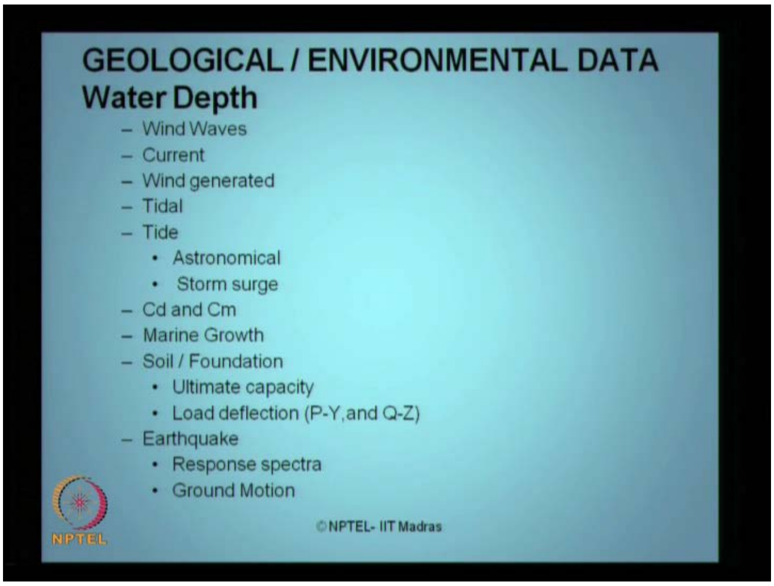
Of course, there is a guidance given for design, construction and certification offshore installation. So, you should do and you should have an access to these. So, these courses will give you a guideline of what are the combinations of forces which you are looking at and what are the intensity of forces in terms of magnitude and occurrence of these forces in the design lifetime of the structure, with the respect of specific sea state, because these are all geographically evaluated. You want to design the structure for Gulf of Mexico or you want to design it for Norway, all different layouts have different kinds of loading combinations and load intensities, which are recommended by this coddle practices. So, you must specifically see at which location geographically and geometrically you want to locate the platform and for that location proposed by you, you must have all these checks been carried out by these and most of these courses do not talk about the dynamic analysis in the first place. They only recommend the dynamic analysis, provided you complete what we said as a FEED.

So, you must understand, interestingly in a land based structural system, which is onshore, you talk about analysis first and then, talk about design. Whereas, in offshore structure, which is critical, we talk about design first and then, we talk about the analysis. It is every interesting and reversal combination which happens in this kind of structural system, where any chosen form which governs my functional production or function layout has got to be fist established in terms of design first. Is that clear? So, I must have. That is why in offshore structural system, the experimental models play a very vital role. Whereas, in onshore structures, the experiments models only substitute the analytical results for validation, whereas in most of the case in the offshore structures, we first go for experimental studies in scale or fortunate enough to do a prototype. That is up to the area of agency or research agency, which carries out and get an idea or feel about, not the dynamic characteristics alone, also get essentially on these two segments of a design.

So, it is very vital that I must do an experimental investigation first on a scale model, for any new innovative form, which I arrive or propose at different sea states. Not for a conventional system. Even for conventional system, people do experimental investigations to ascertain or to verify or to minimize or to maximize or let say to optimize the given structural layout and dimensions for a given sea state or for a chosen see state. So, people still do experimental investigations and unfortunately, in our case, in offshore structures, design and as well as analysis, the validation has become very super critical. They generally do not coincide. The experimental results will show at different quantitative values as far as numerical values are concerned. But qualitatively, one should be able to compare them and get an idea.

I will show you down the line in this module, that there are results where experiments and analytical results do confirm qualitatively behavior but, not quantitative. The reasons are, many reasons as we understand because, there are restrictions and limitations offered on experimental scaling itself, on experimental studies itself and of course, selection of material with respect to that specific scale, where you want to do the model. So, there are many limitations and restraints, which will not allow me to actually confirm my experimental results with that of analytical. But, people really do analytical experimental both not for validation at all, but to ascertain that, I am be able to confirm these two conditions much before I want to take the model to a detail dynamic analysis. So, it is a very interesting reversal happens in offshore structures where, dynamic analysis, post processes the preliminary design.

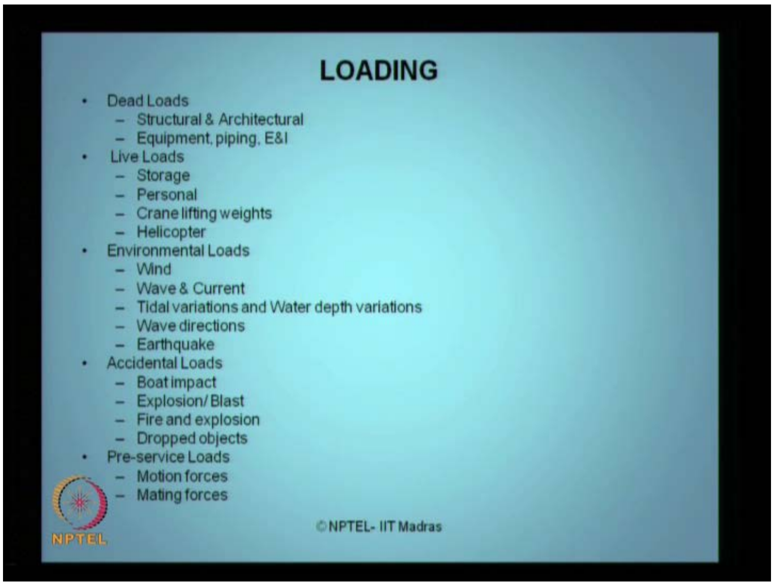
(Refer Slide Time: 40:13)



So, there are some interesting environmental data, geological, which must be understood. I think we discussed this in detail in the first module also. Just for the completion sake for the viewers, let us quickly read this. Wind and waves, current and wind generated, tidal and tide, astronomical, storm surge and of course, you should focus on the coefficients, drag and inertia, Cd and Cm because, they vary and they qualify. There is a Doppler effect that is coming into play and of course, the marine growth will again vary the forces coming on the member and of course, the ultimate capacity for the pile to rest on which the platform will be resting. In case of fixed jacket structures, as we are going to discuss in this module, we will talk about the ultimate capacity and load deflection criteria. Of course, one can look in addition about the earthquake loads, whereas in land based structures, they are optional. In offshore structures, they are mandatory.

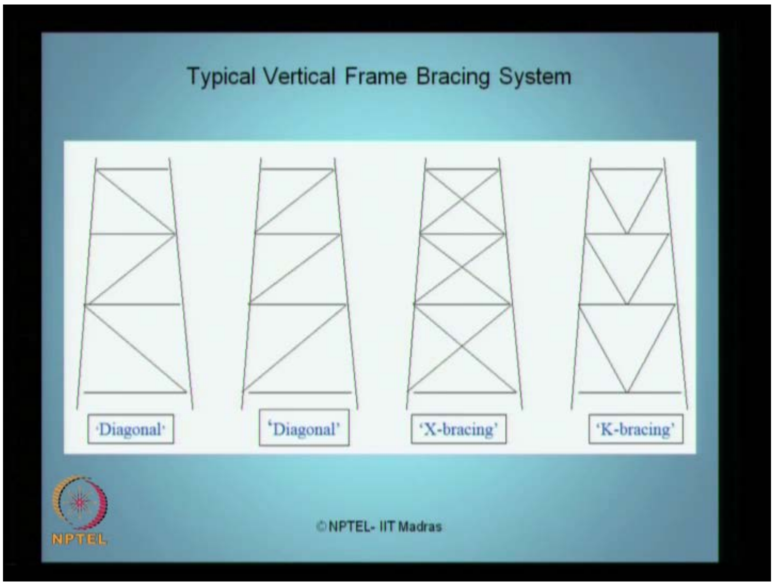
That is a serious deviation we made in analysis of design of offshore structures where, seismic forces are mandatory. You must analyze it for seismic action. Whereas in land based structures, depending upon the d by l ratio or we say h by d ratio, height of the structure with respect to the least lateral dimension in the loading direction, you may or may not do a dynamic analysis including the seismic action, whereas in this case, it is to be done mandatory. So, we have serious deviations as far as offshore structures are concerned from that of the land based structures and onshore structure. So, one serious deviation what we appreciate is, dynamic analysis actually post processes my FEED design, whereas this extent of FEED design is never attempted in onshore structures at all to this extent. People also do their some preliminary design, but, not to this extent what you are looking at offshore structures. It is very important.

(Refer Slide Time: 41:53)



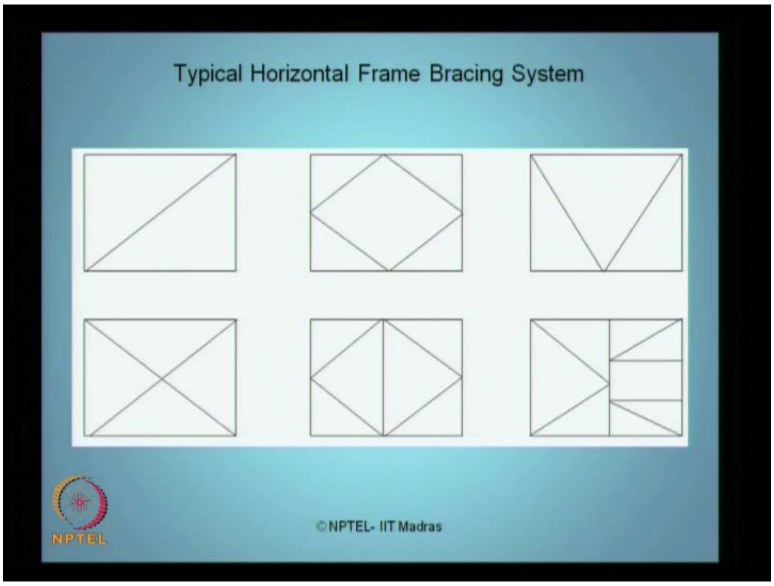
If you look at the loading, again we have different combination of loads and different independent loads. Let say dead loads coming from structural and architectural requirement, let say equipments and piping. We also have live loads coming from storage, personal, crane lifting and helicopters etcetera. We also have environmental loads, wind, waves, current, tidal variation, wave directions and earthquakes and of course, we have accidental loads, which are very important in impact loads. We have talked about impact from boats and barges, explosion and blasts, fire and explosion and dropped objects heavily by the crane during installation or commissioning. We also saw the preservice loads, where there is motion forces, what we called the free flotation analysis and in case of installation, we have talked about mating forces, where we are going to install the structure in position and we have mating forces.

(Refer Slide Time: 42:35)



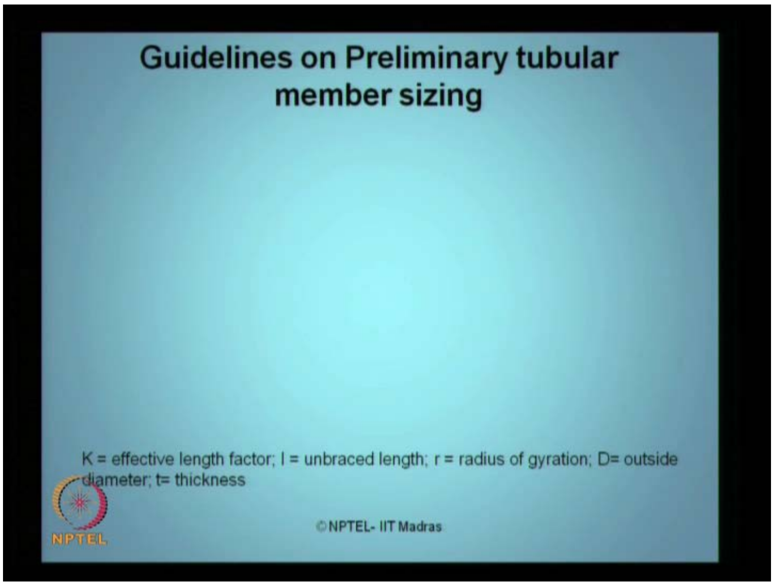
When we look about the stability part of this chosen geometric form for jacket structures, the most important item or component which contributes the stability comes from the bracing system and vertical plane. So, there are different bracing systems advised by the literature what we call diagonal bracing, where the bracings are running in diagonal. You can see here. These are actually the legs. These are the legs. These are not bracings. The bracing what we see here is this as well as this. So, the diagonal bracing that can be either way and there can be mirror reflection of both of them in opposite faces. Then, can be next bracing because, you can see the shape of the bracing. It looks like x and it can have a k bracing, where the shapes looks like k in this form. So, this is my member and this is my bracing. So, it looks like k. It is not v. That is why it is called k bracing.

(Refer Slide Time: 43:27)



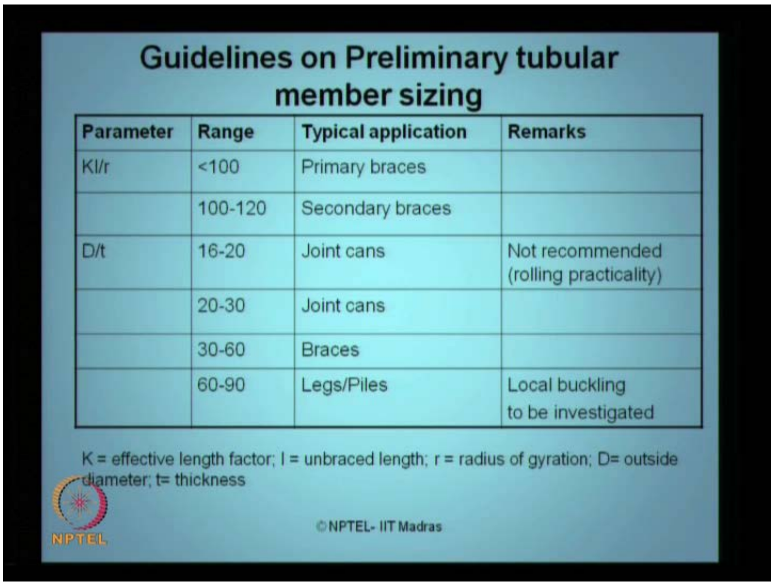
Of course, look at the bracing in plan. There are different horizontal bracings available, diamond, v, etcetera as we see here depending upon. All these are actually arrangements of components of members to ensure that my model or my FEED design is clearing the stability requirements in terms of its validation. So, you can choose any form, so that my stability as a platform, while analysis, while installation and while commissioning preservice and onload, they are stable. They do not get disintegrated.

(Refer Slide Time: 44:03)



Most importantly, I am now looking at the strength point of view. I must have the member dimension and I should have a fair idea. So, idea goes two ways. One, what is the dimension available in the market? If you code the design as per that format, then all the people who are manufacturing fuels will say, from tomorrow onwards, only 5 kilometer tubes will be available because, the more they produce in terms of weight and volume, the more they will get money as quick as possible. So, all structures will have to be necessarily larger in size because, you do not manufacture tubes less than 5 kilometers in diameter. So, I cannot check and choose my form depending upon what is available in the market. If you look at what has been practiced elsewhere, let say, let us look at some structures located in Gulf of Mexico. Let me copy, paste the same structure in the Indian Ocean for example; it cannot suit because, all those requirements of those platforms have been FEED examined for that sea state and for your sea state, they may not even suit at all.

(Refer Slide Time: 45:25)



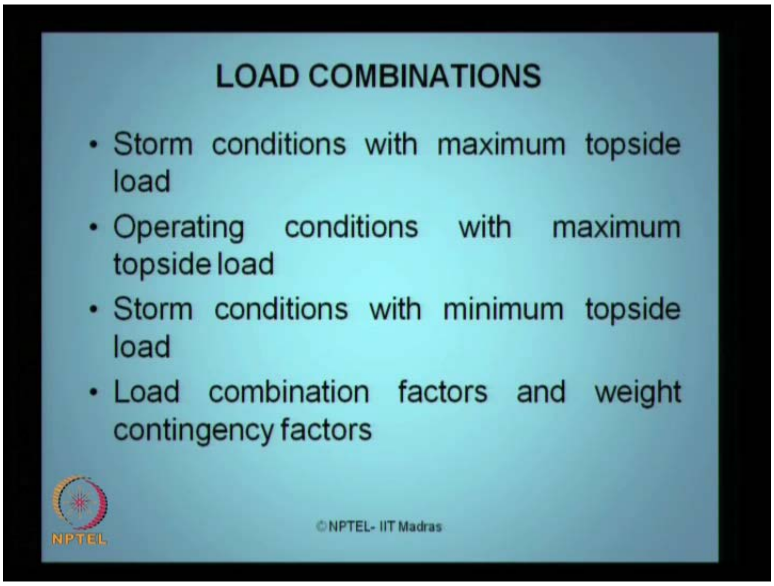
So, it can be foolish idea or engineering coping of existing design exactly on a different sea state. So, I cannot do that as well and I have no idea or no guess what should be the diameter. So, where we will I check it from? How do I choose my diameter? So, guidelines of member sizing is given by international code. For example, again I will come back to same code, API-RP2A will give me some guidelines about what should be the diameter or member sizing. So, very interestingly, summary of the table is given. It is not the table exactly given in API. It is a summary. I have just summarized in simple form.

Look at two important parameters, which is k l by r and d by t, where k stands for effective length factor. It is a factor. I think all engineers will agree that what do you mean by effective length factor, depending upon the boundary condition or restraints imposed on individual component of the member. It is not the global component of the system and of course, effective length is a component variable. It is not a global variable at all. I do not take the platform length from the sea bed to m s l. I am talking about the platform as the component length of the member. So, all these horizontal bracings are going to cut short or increase my component length. So, k is a factor related to that length on its boundary condition or restraints imposed with the joints on the member. So, that is very important. If the value is less than 100 or let say up to 120, you should go for primary bracing and secondary bracing as well, as advised by the code, only to ensure stability. Ok?

Of course, d by t d is the outer diameter of the member. Of course, we have to bother about the outer diameter because, my loading essentially comes from the capital D. It is not talking about the internal diameter, the member at all, unless or otherwise the member is perforated. So, we will also talk down on the line in the module, where if I use a perforated member, what would be the advantages in dynamical analysis. We will talk about that in one of the applications here, in this module on a tension like platform. So here, I am talking about d, which is outer diameter of the member and of course, thickness, because d by t is a very important ratio where, it will govern my local buckling. That is what I am indicating here. If the values exceeding 60 and less than 90, you must check for the local buckling before you proceed further or change the diameter versus thickness ratio to be as limited to 30 or 40 or if you have between 30 and 60, go for essential bracings etcetera.

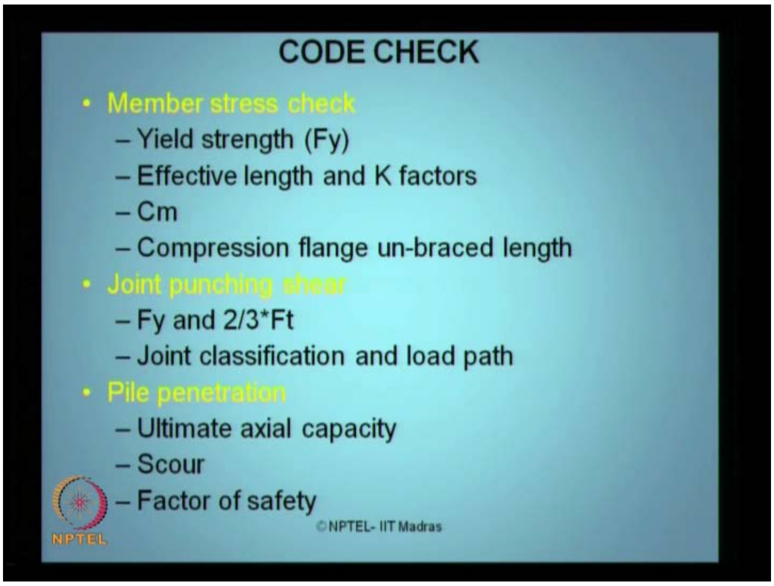
These are all advices and recommendation given based on the practicing professionals on the design of a specific kind of platform. In this case, it is a fixed based structure. One may very strongly agree and accept that this recommendation cannot hold good for any other form, where the fixed based action is not imposed on the structure. Is that clear? So, relevancy of what code you are selecting or what guidance you are looking at also depends on what is the essential form. So, that is what I am repeatedly telling, form selection is predominantly important in offshore structural design and analysis, which is not a governing factor in onshore structural design analysis.

(Refer Slide Time: 48:05)



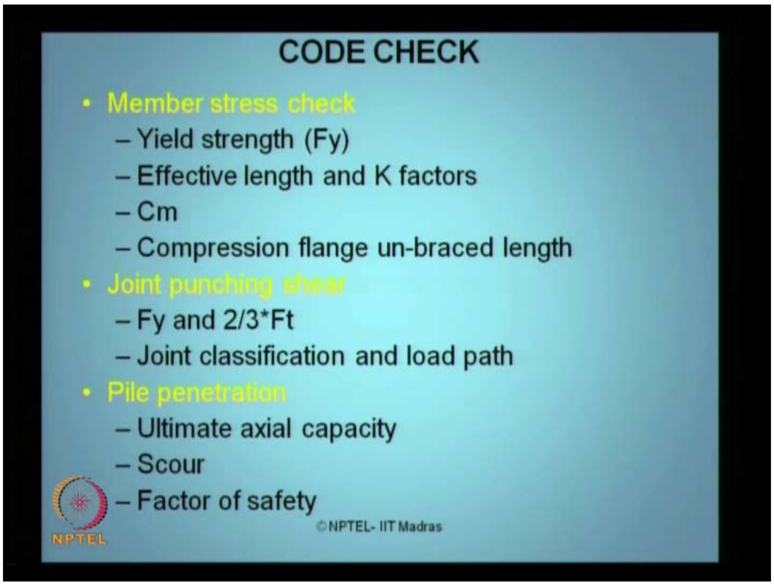
So, we also look at the different load combinations. The storm condition with maximum topside load, that is, one combination and the operation condition has maximum topside load. Of course, the storm conditions with minimum topside load and the load combination factors with the weighted contingency factors are available on the design.

(Refer Slide Time: 48:27)



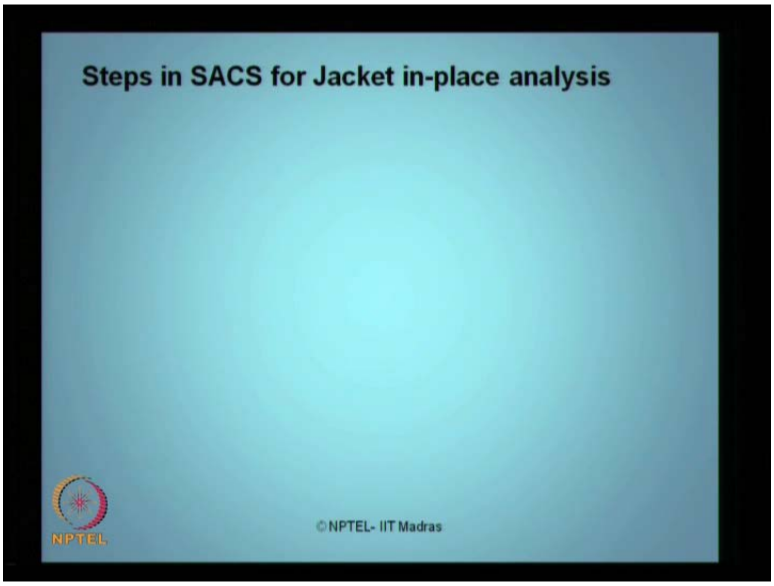
These are the different load combinations that I may look at. Of course, the code check, you can do the code checking for the member stress. You can look at the punching shear on the joint and you can also look at the pile penetration. So, three different segments I can check and I think now you will strongly agree that, the design has been moved on from the stability part to the strength part. On understanding very clearly, if you look at my argument of why and which should follow what, very clearly, the chosen form should first remain stable and then, it should become strong enough. So, it is in the same order as API or any international code recommends for any new form designs.

(Refer Slide Time: 48:27)



So, first we have chosen geometry should be proven to be stable. Then, it should be proven to be strong for the given loading conditions. So, all these are non dynamic analysis. We are not talking about the time history responses at all so far now. We are only trying to establish your form, which can screen and pass my preliminary design state, which I called as front end engineering design. So, this should be cleared first, before I take it forward for a dynamic analysis. So, in that case, if you look at the member check stresses, I must look for the yield strength of the member, effective length factors, Cm and of course, compression flange and unbraced length. That is very important. We are not anyway talking about the design part of it at all, because that is not the focus of this course. We have not touched them. If you look at the joint punching shear, you must look at the joint classification and joint loading part, where you are imposing. If you look at the pile penetration, you must look for the unity check, which I will talk about factor of safety later, slightly in the next slide.

(Refer Slide Time: 50:04)



Now, SACS is very interesting software. It talks about all these kinds of, let say FEED engineering design, before you perform a dynamic analysis. So, we will talk about the steps involved in SACS for jacket inplace analysis, possibly in the next lecture. So, do you have any question here? Any question? Any observation from any of you? Any doubt? Any misunderstanding?