Design of Offshore Structures
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Module - 6
Lecture - 5
Design against Accidental Loads 5

So, let us continue today, the remainder of the design against to blast loading. I think yesterday, we were looking at the requirement.

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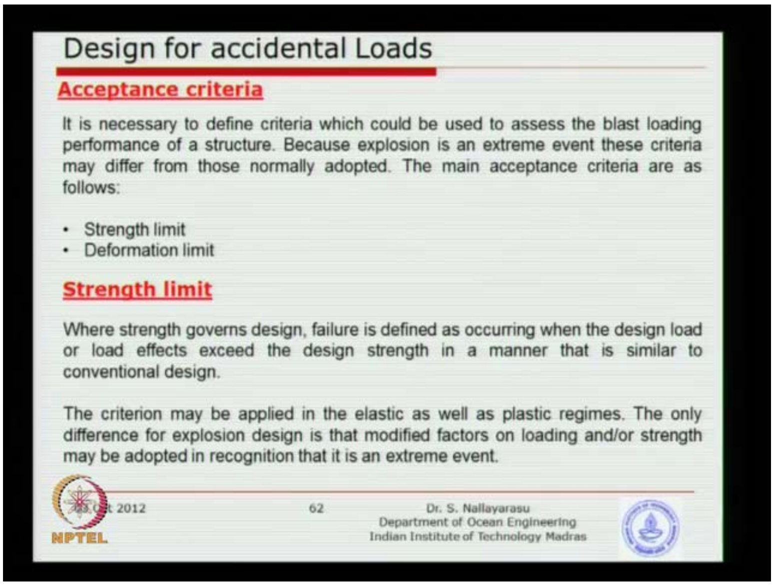

Basically, how you evaluate and what are the design criteria. And if you look at it, the basically, the acceptance criteria is based on the serviceability requirements and the strength requirements. And the this strength requirements, as usual if you are looking at allowable stress design or the other forms of the design, where you use the plastic capacity. But most of the time for blast loading, we still use the allowable stress method. Only when very rear cases, we go into basically plastic design methods. And the deformation limit is something that we need to limit it indirectly.

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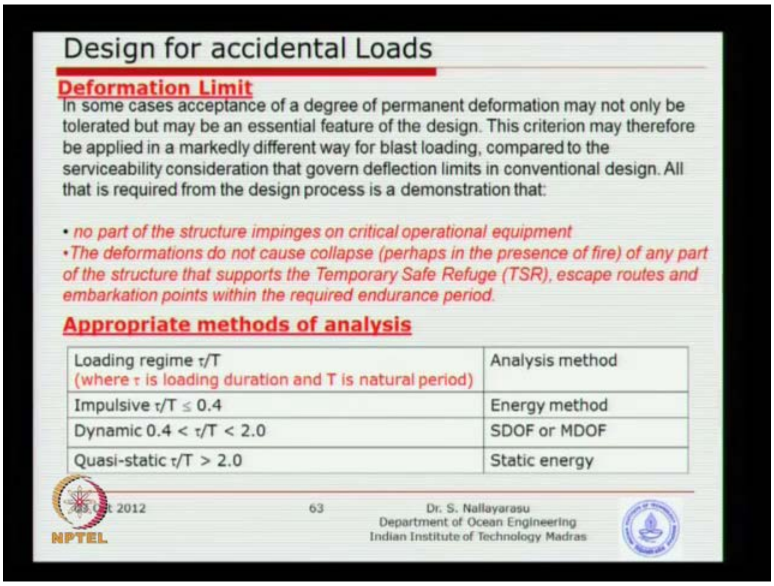

So, basically the deformation limit is depending on the location of the equipment's and the facilities and also the disconnection of the structure, with the main structure. Basically, what do you do not want the last displacement to make the plastic hinge formation at the 2 ends. For example, if you take a simply supported beam, you allow the beam to bend substantially larger deformation, then the ends will form a plastic hinge, by which it will just fracture. So basically, no part of the structure should impulse the critical operations, on the equipment on the other side. And the deformation should not collapse or make the structure to collapse because the hinge formation, either 2 numbers or 3 numbers are depending on the bending movement.

So basically, the idea behind why we do not want the structure to collapse, because we need to give sufficient time for the people to run away, to a place which is safe enough, for them to be evacuated. That is, sometimes we call it temporary safe refills, is just a technical notation given in the codes and guidance. Its t s r is nothing but, some place is designated to be a safe place, for them to stay there for a slightly longer time - waiting time, so that you know basically either they can get evacuated, by helicopter or boat or other means. So, every platform normally will have a temporary safe refuge, at a particular designated location.

You suppose to assemble, in case of in case of an emergency like fire or other forms of accidents. And along the route, you know basically when they are running around, towards that particular location, the escape path must be designed in such a way that, you know, the collapse does not happened. The idea is, so you have to identify the elements, which are required to be satisfying this condition and design those elements accordingly. So, if you look at the design load, I think yesterday also we are looking at the pulse loading. The duration of pulse, is basically tau and the natural period of the structure that you are looking at.

For example, when you are looking at a escape path, you have several beams supporting the escape path. Each beam should be looked at as a individual element, it is a local design. It is not a global design we are looking at. And basically, the natural period is local to that particular beam, not like the complete structure. And the design method are also called the analysis method, depends on the behaviour of the structure, whether its dynamic or static or even highly displacement based structure.

Basically, if you look at the loading ratio, the duration verses the period of the structure is very very small, then you may have to use the energy method, which we normally we use it for some class of problem like drop objects, we look at the impact energy and the energy observed by the structure. As long as the load is very short duration, short pulse and just have a impact and typically, we calculate impact energy by means of the weight times a height, m g h we can calculate.

And the energy observed by the system, can be easily calculated by the work done, you know. So, as long as the energy observed by the structure is larger, this system is not going got fail by, you know basically brutal nature. So, that is one of the method which is conventionally used, for most of the, you know the impact type of problems. And if the loading is between 0.4 to 2, that means the duration to the period of the structure, is slightly longer duration. You could actually use a dynamic analysis method, where you look at the response of the structure using a simplified, either single degree freedom system or multiple degree of freedom system.

I do not know, whether we have taken classes in dynamics, basically single degree of freedom is this, moves in one direction. For example, each particle in a structure can have a 6 degree of freedom, in a basically 3 translation 3 rotations. In this particular case, what is our interest is, the lateral motion of the structure or the displacement of the structure. Typically if we take a wall, you know the horizontal displacement is what we are very much worried about. Basically, you do not want to have the structure go on hit or impact against any other equipment and dislocates. So, basically that, so most of the time, we try to use a single degree of freedom system. If it is only assists a simple wall or a beam, you do not look at anything else, other than just the lateral displacement. And many times is very very simple, you know quite easy to do hand calculation. If it becomes multi degree of freedom, of course, then you may use a assistance from computer, computer software's and then the loading is substantially longer duration, then you can go for a simple static energy method. Static energy which is equal to a stiffness method, basically a simple analysis can be performed.

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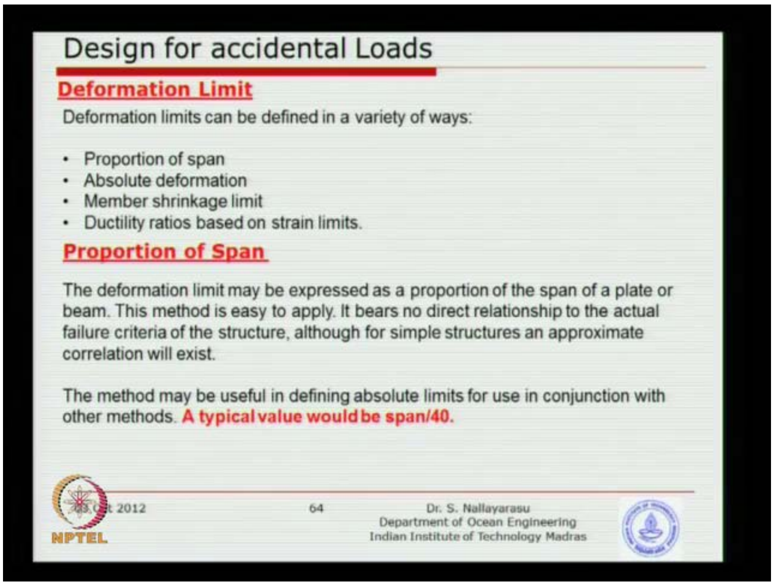

Deformation limit in many cases, we directly or indirectly, we have several ideas have limiting without doing design. You know for example, the I think most of you are civil engineers. You might have studied in concrete design, we tried to limit this is span to depth ratio, you know for making sure that the deformation is within limits, you do not even need to do calculations. For example, simply supported span to depth ratio is limited to say, 20 cant linear 10, 12. Something guidance, which you follow most probably, you will not have a problem with a deflection. In this particular case, basically a typical values span by 40. You know, because of the impact loading, so in just almost a factor of f t f, true. So basically, the proportion by span, the larger the span, then you will have a larger amount allowable.

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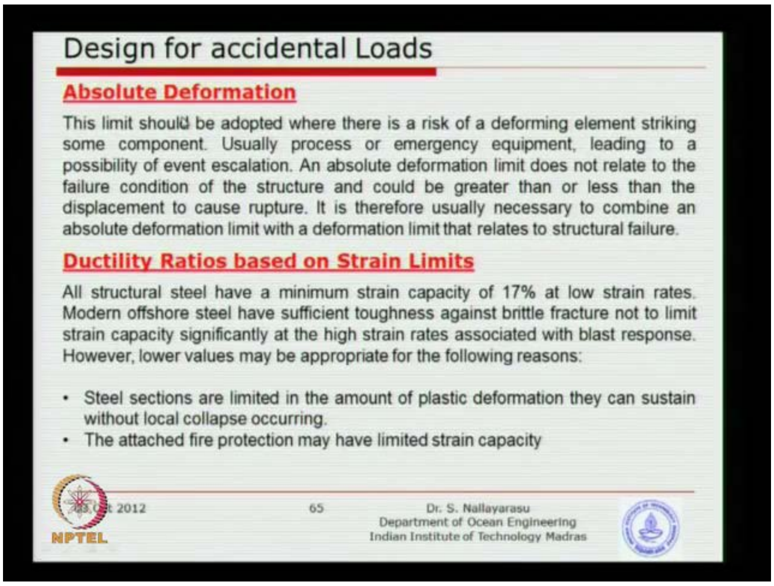

Absolute deformation is something that, we need to also set because of, you know the spacing between the structure or the wall to the equipment in the vicinity. Typically about a meter in practise, normally we give a meter space. Because if it is less than a metre space; for example, you do not have a access to equipment on the other side. So normally, we give about 1 meter 1.2 meter. So, once you fix up this, the absolute deformation, then probably working out are that calculating the straight limit is easy easier. Because you take a beam, you allow 1 meter to deflect, then automatically you can calculate that, what could be the potential strain induce down the beam, at the ends or elsewhere. So that, basically the strain limits is indirectly coming from the deformation limits.

Now, how much strain any system can take, depends on the type of material. For example, you take a glass, you take a rubber and the steel material. You can easily see, that the glass will not even take a fraction of a percentage. So just break because the material is brutal in nature, compared to steel. And the same thing goes to rubber, its quite elastic, it can take a large amount of strain, as much as 20,30 percent. Whereas, steel can take at, specially the ductile steel can take 17 percent at low strain rates, not very fast, slow increase. So you can see here, the ductility ratio is defined in terms of the elastic verses elasto plastic, basically to see that after elastic deformation how much strain the system can take, so that failure will is not immediate, it can actually go for a slow and ductile failure.

So the ductility ratio is one of the area where, lot of research have been done. In fact, we have already got some idea about elastic modulus verses plastic modulus. I think in few classes back, we were looking at for different sections, different boundary conditions. So, one of the thing is ductility ratio is not only effected by the material selected, also affected by the geometry and also the boundary conditions and the type of loading. I think all of them, we have had a look at early run, we just have to re look at it, in terms of ductility ratio.

Basically, the steel sections can sustain the plastic deformation, provided they do not have other forms of failure. For example, you take that eye section verses the tubular system, the predominant different is buckling. Eye sections have a buckling, whereas tubular's have a local buckling because of the d by t ratio. So, as long as they both of them does not happen, both of them will reach the maximum plastic capacity. But again, depends on the span. So basically, we need to look at the span, the section property and type of loading and the boundary conditions.

All of them put together, though you have a very good ductile steel and calculate back what is the ductility ratio, the ratio of deformation at elastic to the plastic, that the maximum deformation that beam can take. Because, we are looking at, mostly the beam type of element for design in offshore structures. One of the limitation, basically though the beam can take, many times that is what happen. You know, for example you design a residential building.

You have architectural finishes, the structure actually can take slightly higher or increase the deformation deflections by. Why we want to limit to lower value? We do not want to see a crack appearing on a structure, which prohibit the uses to be little bit scary. You know basically, they do not want to go there, because you can see this cracks visible. So the structural deformation actually, will reflect on the architectural finishes, whereas I think offshores structure is we are not worried too much. But what is our worry is, the fire protection coating, what is applied on to the structural elements will start cracking. Once you have a crack, the effectiveness will be gone, because the temperature will be directly attacking to the steel structure. So, that is one of the worry, where you know you may limit the strain to a limited value rather than going to the maximum strain value.

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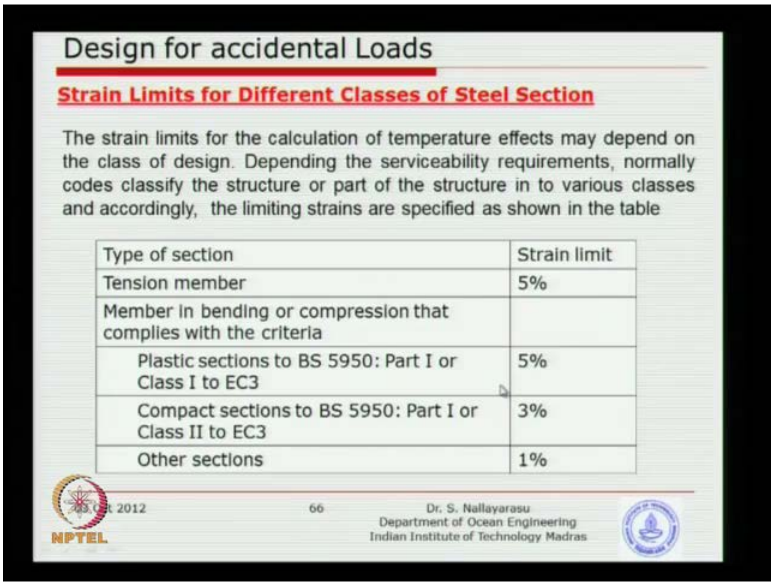

A typical strain limits given by some of the codes, which I have just try to summarise, you know basically, tension member you can go for 5 percent instead of 17 percent, though we say we can go for 17 percent up to. And basically, the other members in compression bending, you know I have just taken one typical example from B S or E C codes. You can go for 5 percent, 3 percent and other open sections to 1 percent, compared to we allow 0.2 percent, for elastic or allowable based design, which all our linear stress strain diagram is at 0.2 percent strain. So you could see here, from 0.2 percent, we are trying to go to 1 percent, 2 percent and 5 percent.

So, we use the same equations, allowable stress equations and calculate back what could be the possible deformation or deflection of a beam. If I use 5 percent strain limit, you will see that it will be very large. But when the deflection is large, by that means itself, all your theory is not correct because the first assumption, we make in the elastic beam bending theory is the deflection is small, so the deflected configuration is same as the original beam. That is the first assumption you make and that will be violated. So that is why, whenever you are going for this large strain problem, you have to look for a, the updated.

So basically, every time you apply a load, you divide the load into several sub steps. Each time you apply a load, find out the deflected configuration, re calculate the stiffness based on the deflected system and then apply the additional load and just keep on going.

So basically, that is where the this, the idea have to work out. So most of the large strain problem, we have to go for a non-linear analysis, geometric non-linear analysis. The other one basically, thee important problem is shrinkage of the beam. You take a simple beam, rectangular cross section, you apply a central point load, when the beam bends, what happens?

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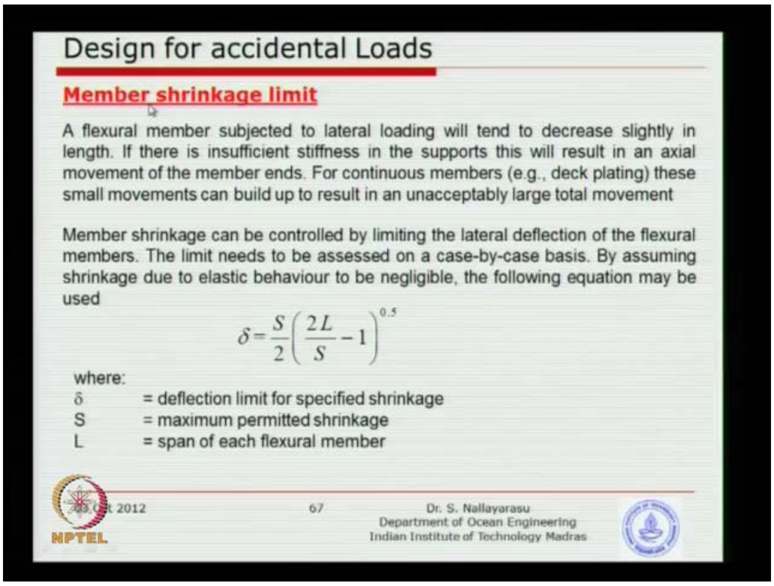

The bottom surface experiences tension. The top surface experiences compression. As long as the deflection of the beam centre is smaller, these extension and reduction in the length of the beam surfaces could be very small, the difference, the compression and the tension. Whereas, if the deformation is so large, that you will see that the shrinkage at the top is going to be substantially larger and they longest in at the bottom is going to be very big. And that basically have to be worked out, the shrinkage limits, sometimes instead of specifying directly the deflection, you will be given a shrinkage limit of particular material. Because I have got architect architectural finishes, I may have other coatings. At that particular shrinkage limit, the material disintegrates.

For example, you have a intermission coating on top of the steel beam, when you bend the beam to 5 percent strain, you will see that none of the coating excites there, so all gone, so you will have to get the shrinkage limits from the material manufacturer, that it can take only, say 1 percent. Then you have to calculate back, what could be the potential deflection that you can allow for the beam and what backwards. So all this is basically to not just look at the mechanic side of the problem, also the serviceability and offer ability of the system in question. So, member shrinkage is one thing that we need to work out.

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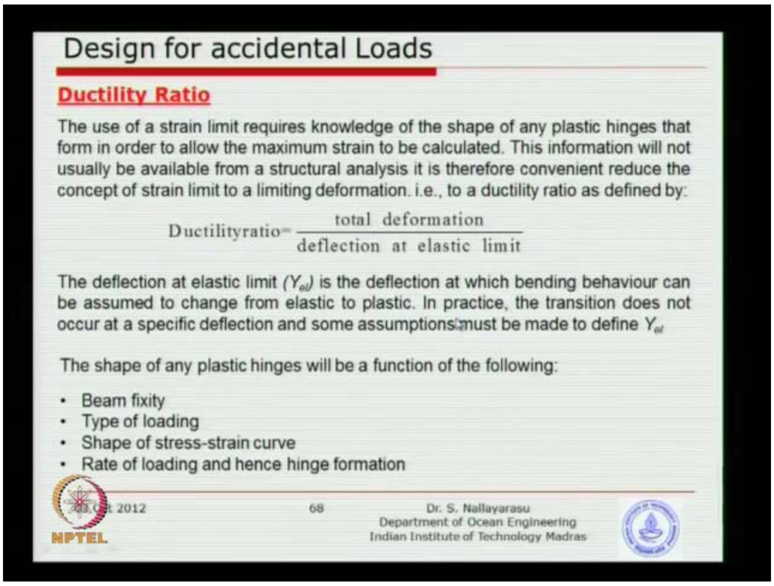

So basically, the ductility ratio is the total deformation at failure or just close to failure at ultimate load, to a deflection at elastic limit which is at 0.2 percent, which will give you an idea, how much deformation a beam or a plate or a system can take prior to failure. So, that gives you the range, as long as if they are equal, for example ductility ratio is 1, not a good idea. Because as soon as it reaches the yield, the beam is going to fail and that will never be called ductile failure. It will be called brutal failure, which is what we do not want to happen.

And you have to select system material and loading systems and basically your cross sections, such that ductile failure. Always every design of structure, whether it is onshore, offshore everybody is looking for a ductile failure of the system, not the brutal failure. So, as I mentioned early on, it depends on so many factors. The fixity, not only beam, it could be plates also. And you have type of loading and the shape of stress strain curve, whether it is just elastic and perfectly plastic. No, good is it not? Because it is basically by linear and once it reaches and large deformation will be immediate and that is exactly, we were talking about.

I think several classes back, the difference between yield strength and the ultimate strength, the larger and larger is good. If you have smaller and smaller, there is no redundancy in the stress strength of. And the rate of loading, basically whether it is quick pulse loading or sustains loading for a longer duration and the hinge formation, basically the plastic hinge. I think we have cuts, little information about simple beam system, to calculate the plastic movement capacity. I think, we will insist revise again one more time. If you look at the, some of the text books or code guidance, you will get this derived formulas.

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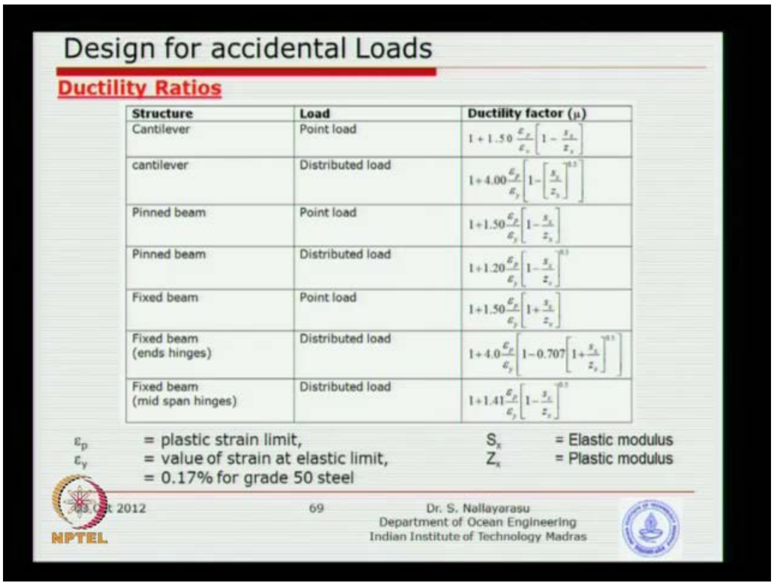

We could also derive, based on what we have learned on the beam fixity and the stress strain curves. This is a summary of equations, that is to give you an idea for ductility ratio or ductility factor, which is just sometimes do not get confuse with symbol mu. In this particular one, they have given mu. Normally, we use mu for poison sections, so just do not worry about it. Basically, for a different beams, from cantilever and supported beams on both and simply supports, fix beam with different types of loading, you know the summary of the equation to calculate, the ductility ratio, always must be greater than definitely 1.

If it is 1, that means the system is very week in carrying in any load. Basically it will fail, once it reaches the ill strength. So you see here, epsilon p is the plastic strain and epsilon y is the, you know basically, I think it should be 17 percent. Basically the elastic limit and 0.17 instead of 0.2 for grade 50 steel for elastic limit and s x and z x is the elastic and plastic modulus, which I think most of the sections, we have already derived sometimes back. You know, i sections, circular sections. I think, we have derived both, so you should be able to substitute this, you can get the value. And you will see that depending on the type of cross section, depending on the ratios, you will get the different values. In fact, summary of such, has been taken from one of the euro code, for grade 50 steel.

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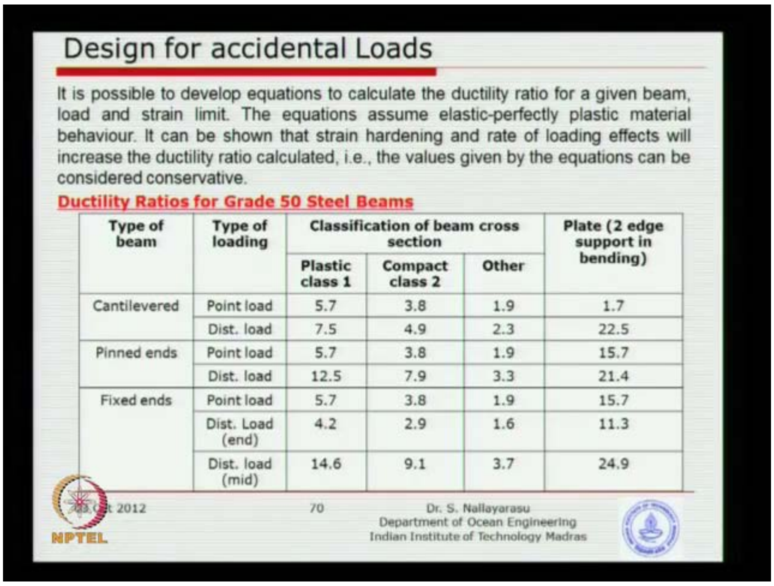

You will see that the numbers, rising from as low as 1.6 up to, you know 12.5 is the large number for most of the beams. You can see here, especially the class 1 and class 2. Class 1, class 2 is basically a, you know the classification whether its compact or plastic sections. I think one of the class, we will try to go into this classification of open sections, which I think we have done so far. And also for plates, you know most of the times, we use plates for, you know the fire and blast walls. So basically, you see depending on the boundary conditions, you can have larger number. You see here the fixed ends for the plates. All 4 edges are fixed, you have a very large ductility ratio. So this gives you an idea, how much redundancy the system has got, prior to complete failure.

Now idealization, unfortunately you have not taken the dynamic course yet or you some of you have taken previously? Not yet. So basically, the single degree of freedom is nothing but, the that the dynamic response of beam or a column or a plate systems against external loading. And basically, a single degree of freedom is one particular displacement is modelled for analysis. For example, if you take a beam, transversely loaded, perpendicular to the axis of the beam and when we look at the vertical displacement, so it is only single degree of freedom. If you are looking at a horizontal displacement, actual deformation, then it becomes 3 degree of freedom. And as together, if you looking at the rotations, x rotation, y rotation and z rotation and then it becomes 6 degree of freedom. So basically, single degree of freedom is one particular axis of deformation is included in the calculation. Most of our beam calculations, if you look at it, we are only worried about the vertical deformation, basically is a single degree of freedom. It is just a notation in dynamics.

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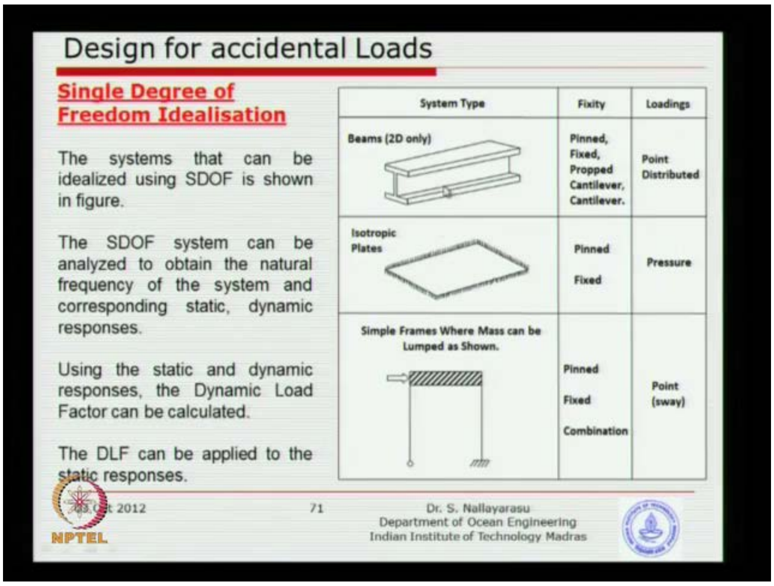

So basically, you can model all this systems. For example, you take a beam, 2 dimensional beam and some boundary conditions are given at ends. You have a transverse load perpendicular to the beam axis, at the top flanks and the bottom flanks and you can model this as a simple vibrating problem, perpendicular to the axis. So, most of the text books will have formulas to find out the, you know the displacements and the movements and can be used very easily. In next, I have got summarised table for both dynamic and static and probably right now, you may not be able to, you know basically memorise it, because you need to take the course, so that you will be able to use it appropriately.

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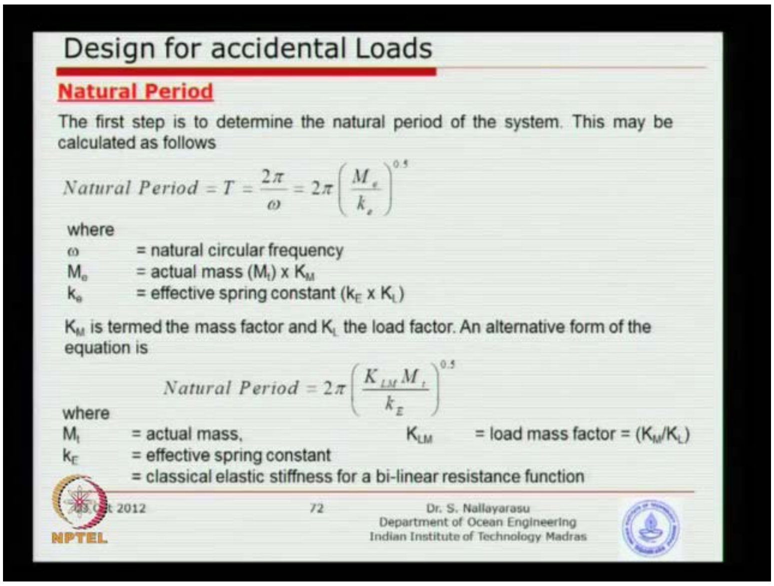

Somewhere here, you know I have just given only 3.

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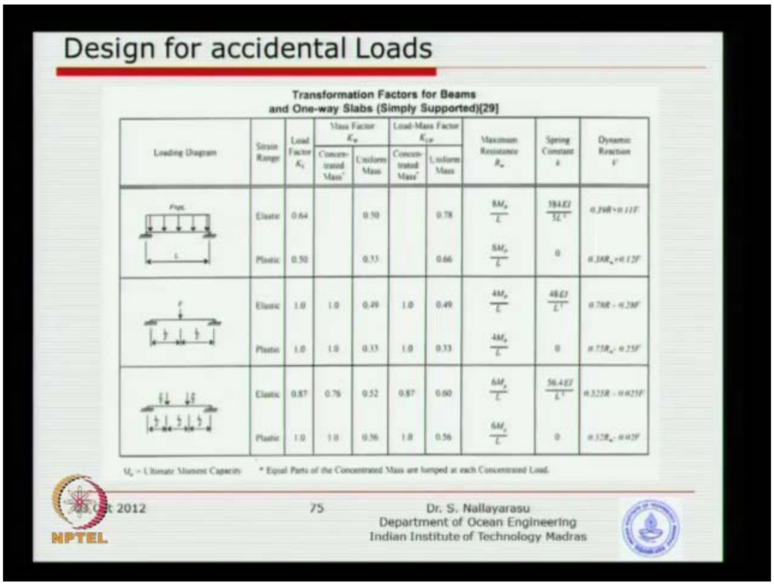

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If you look at this particular code book, you will have several more. Probably, I think 3 or 4 pages, just to give you an idea what really happens. But in fact, we in fact derived some of this formula in one of the classes. I think in the previous class, for point load and the distribute a load, we derived the maximum rotational capacity.

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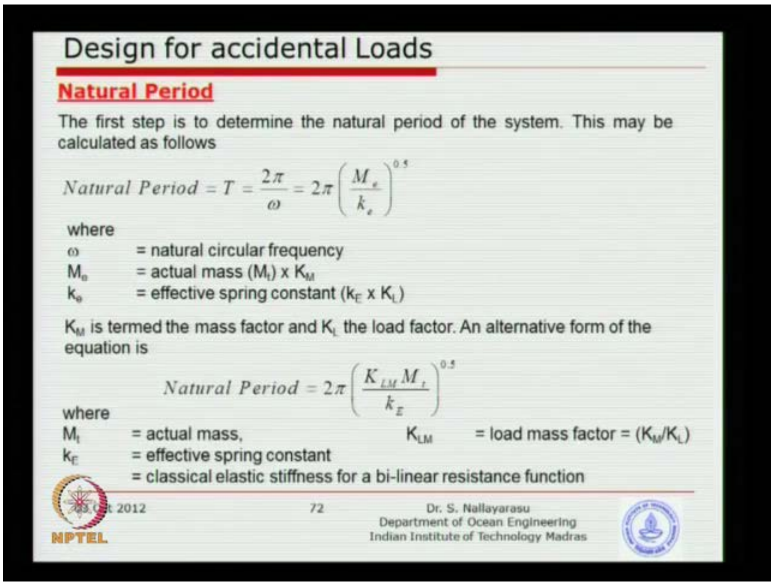

I think the last time, so similarly for other forms of loading, the summary is given. The reason why we want to do is, basically what we want to find out, what is the dynamics of the system place a role on this. You know, basically when the load is dynamic, dynamic response is to be looked the response with respect to varying load. In this particular case is not a 100 percent varying load. It is actually a short pulse and stuffs, compare to a wave load where it is varying continuously. So the response could be slightly different. For that to happen, we need to understand and calculate a natural period of the system, which is a very simple stiffness and mass equation.

If you look at this, I think even it you might have studied in your basic physics, square root of m by k, you know simple idea. As long as you know the mass of the system, where it is a distributed mass or a lamped mass at the top, you can calculate the period, which I have just rewrite in a slightly different from, does not matter. Basically the idea is, you need to the mass of the system and the stiffness. When you are solving a starting problem, you do not look at the mass, you just look at the stiffness, that is what the most of the bending movement formulations based on, you know the initial effect is negligible. That is what the assumption, we make when you try to derive your simple beam bending theory.

You know acceleration is so small, you can ignore it and basically, assume that the inertial force is not contributing to the total displacement of the system. That is what makes you the problem so simple, that you just only solve for stiffness and displacement. So in here, what we are looking at is, the contribution of the inertial effect, to the total deformation is not ignorable or not too small, then you find out what is the vibration frequency and what is the loading frequency and compare it. And that is exactly the idea behind. So if you have a distributed mass and you want to distribute to a particular degree of freedom.

For example, you take the beam, the matches all along the length of the beam. It is not one particular point, then you need to designate to the lamped mass to either at the top or at the bottom. So, you depending on the mass factors, the distribution factors, you can summit up as a characteristics mass. Sometimes, we call it effective mass and remember most of our offshore problems, we need to take into account the added mass. Because this, especially the sub structure, super structure you do not need to really worry because is above water.

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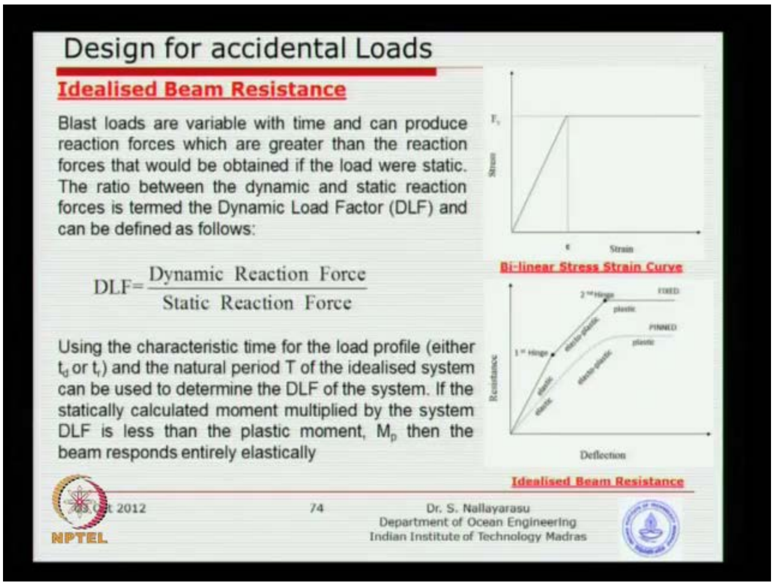

The typical stress strain curves, which for idealization is a by linear curve. So it is basically, you see here a single line with the perfectly elastic and plastic, basically is not a good idea to have it, but for modelling several times we use this. Because if we have a non-linear, something like this, then you need to go for a non-linear analysis. To simplify, many times we make a by linear stress strain diagram and try to calculate simplified solution, of course by hand, not by computer programme. If you have a computer programme to do, then you do not need to assume such type of stress strain curve. You always can go for a non-linear graph like this. So the dynamic load factor, I think indirectly, if you study dynamic which we call it dynamic amplification factor, but in this particular aspect, we call it dynamic load factor. Basically the increased reaction of the system to a applied load. So how do we find out is, basically the ratio of the dynamic respond or dynamic reaction to a static reaction.

Basically, if you take a simple beam, apply a centre point load you will have half at both ends. When you apply the same w, as a impulse, as a short duration impact load, then the increase the reaction, you could easily find out from the formulas that we can derived and that gives you the ratio called dynamic load factor. The reason why you want find out, we want to solve this complete fire and blast world design in a simplified manner, instead of going for a non-linear analysis, you do the static response, you find out what is a d l f separately, apply on top of it.

So basically, quicker design method is a short cut, but of course, saves the purpose for which we want to design the fire wall. That is what you will see from, you know the table here, the derived statics reactions and the dynamic reactions. So basically, the ratio will give you the d l f, which we could derive, but I think this is part of your dynamic course, which will take considerable amount of time, that is why I am not deriving in this class.

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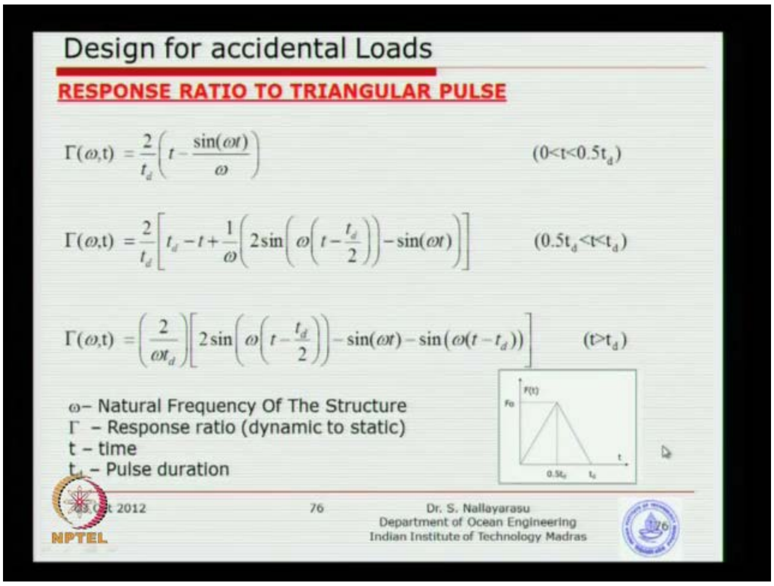

The next one is a simple dynamic response, which I just wanted to highlight, before we summarise, basically the response of a simple beam system to a triangular pulse loading, just a basically idealised pulse loading like this, with symmetric rise time and the fall time. Basically just a nice, you know a simple loading to be analysed quickly by hand. So, you could find most of these equations in any dynamics book, starting from your dynamic equation, supply this loading and find out the response. The response contains 3 parts, especially you see here is between the time of pulse, basically between 0 to 0.5, that means on the rise time and on the fall time and after the load is over.

So, you will see the response will be definitely different compare to, if you have this triangular pulse keep on coming back and again, then there will be a stress strain response. You call it transits response and the steady straight response. When you are doing your calculations, you will do exactly this. If you have a continuously applied load, then the study stress strain response will start from few cycles later.

But continue for a longer duration because the load is continue to be there. In this particular case, if you see here, the policy supplied and that there is no more loading. So you will have a increase response first and then go for a reduced the response after wards and then it will tie die down, because there is no more loading coming there. So basically, this 3 component responses can be computed and I just graphically shown here, that is what the idea. So the response is peek, typically reaches is a normalise response.

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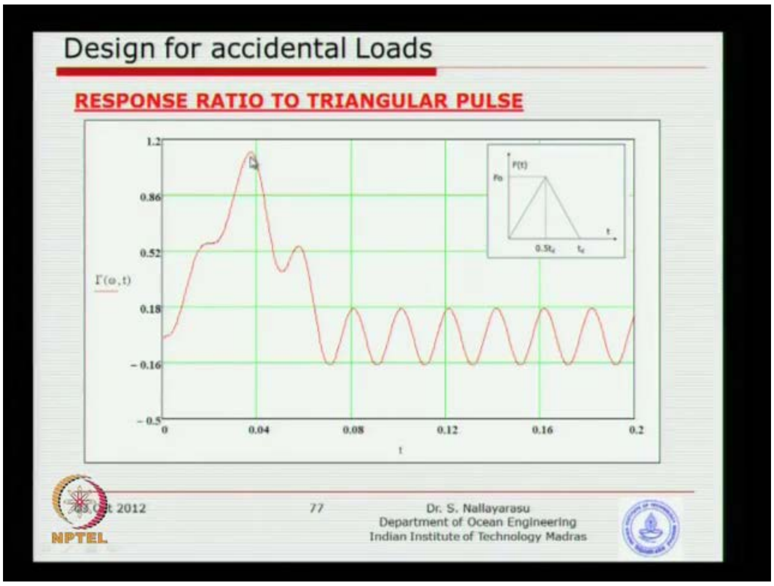

Basically, see the maximum response within the limits of your, the applied load and then go for a sustained, also called a steady state response. Then it will die down afterwards, as long as, there is a dumpling in a system.

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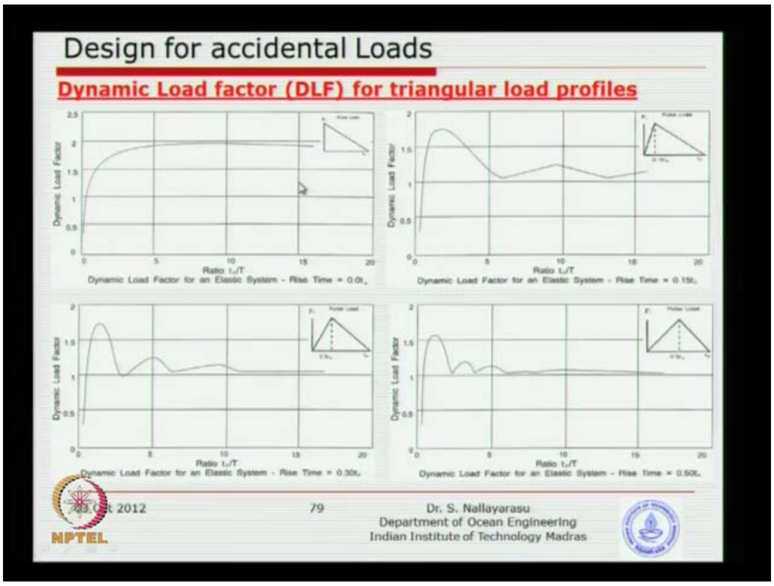

Now, I just summarised 4 of the cases, plotted the basically the dynamic response factor. We call it, in a basically the dynamic load factor, in which we just now calculate the dynamic reaction verses the static reaction. You say one at the same. So in here, you see here for 4 forms of loading, 0 rise time, smaller rise time, slightly increase rise time, 0.3, here 0.1 and its 0.5. You see the ratio of factor, as much as 2 here and reduces to 1.5, 1.6 and then 1.5. So, you could see here most of the simple beams, you will you have a increased deformation factor, basically almost 2. As long as you are able to predict this particular response to your class of problems, then you can multiply whatever the static displacement you are calculating because we have assumed a by linear elastic perfectly plastic system. This is only a simplification we are making for our hand calculations, most of the design practise. Now a days is based on this, of course this is not mandatory. If you have your time and effort, you can actually go for a non-linear stress strain analysis.

But, most of the design practise, we make this because its quicker and seal the purpose. So that is why, we need to derive such dynamic factors. So load is applied dynamic, we know indirectly the dynamic factorise say x and you calculate your simple beam static displacement, static bending movement, static stresses, multiply that with this factors. So, that is the idea behind. Many times we do this, even for big jackets. So basically, the idea of calculating the dynamic load factor or dynamic factor, is to account for the system dynamic and not going into non-linear analysis, simple static analysis will cover the response of the system. So, how do we design the fire wall, is basically several steps, all of them have been discussed.

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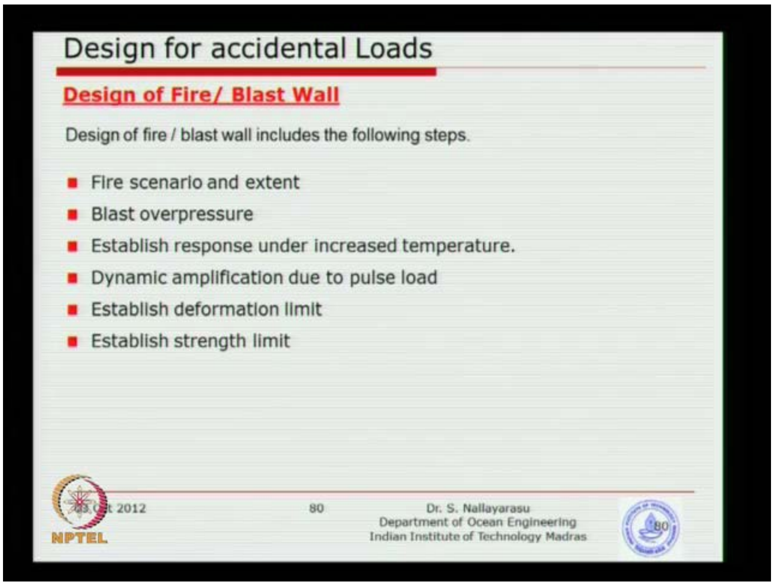

First one is the fire scenario, I think we have already discussed whether it is a full fire or jet fire and fire ignited blast or blast generated fire, all that have to be described, so that you can find out the extend and the area of the loading. And the over pressure scenario, basically depending on your procreative of the structure and the wall configurations and the ventilation and establish the response under increased the temperature, so which I think very simple idea.

We have a stress strain characteristics, under increased the temperature for steel and the reduction factor for yield, reduction factor for modulus of elasticity as a velocity and approximate methods also we have discussed. So, we need to establish the applicable yield strength, applicable module as a velocity and keep it one side. You have establish the design pressure, which will come from specially study. Most of the time computer software's are not that good. References from various, you know the proton tabs testing are some recommendation from other guides will be used.

Many times, people use the risk verses the value. Because based on history, if you want to take lower risk you design for a higher blast pressure. So, there are several guide books, which give use design 1 bar, 2 bar. But in the recent times, quite a number of 3 dimensional modelling software, I think are available and could model complete platform and make a ignited blast and can calculate and software's able to simulate such over pressure values. But again, it depends highly on how the model is done correctly because the real scenario verses the computer model, prediction could be quite approximate. So, this blast over pressure will be recommended for design by the discuss has been group. They will assign you the value, that you can use.

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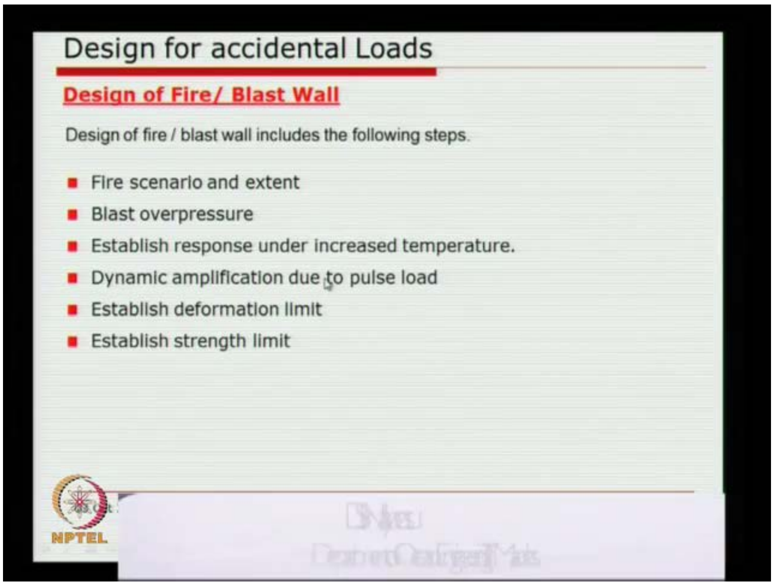

For structure engineer, the most important is the third point, to asses and establish the characteristics of material falls, you will be point and the modulus then find out the dynamic amplification, dynamic load factor which, you need to have a basic understanding of system dynamic. If it is a simple beam, I think what we describe is ok. But, if it is multi degree of freedom and basically you have complete frame to be designed, then probably by hand calculation will not be able to do properly. But for class room exercise, I think most of the problem, we are going to solve is either a beam or a simple rectangular plate.

So you can establish d l f and establish deformation limit, I think which we have sufficient information now. 1 metre, half a metre, 500, 600 mm, then you can proceed and establish strength limit. Basically, whether you want to design by allowance stress method or you want to design for plastic deformation capacity. So, once you do this, I think the procedure is very simple. As normal, you do a simple beam design; for example, we decide to do a allowable stress design you do not need to go anywhere, simply follow the steps, what we have done so far.

Only 2 things you need to do, change the material characteristics, increase the loading factor. Isn't it and the allowable stress needs to be increased by x amount. In this case, we will say 50 percent, 60 percent. The codes allow as much as to 70 percent you know like, when you design a structure for earth quake, you increase a load the stress levels to

70 percent of the conventional or normal stress levels. So, this are the 3 things, you will, there is no other difference because of the presence of the temperature, the material charters changes. Because of the presence of the blast loading, the load is dynamic, so you incorporate the dynamic factor and because of the deformation is large, you may have to consider increased the strain and that increased strain, you will go back and calculate and find out what could be the potential reduction in yield and modulus. So basically, that is the simple idea and we will just see few of them.

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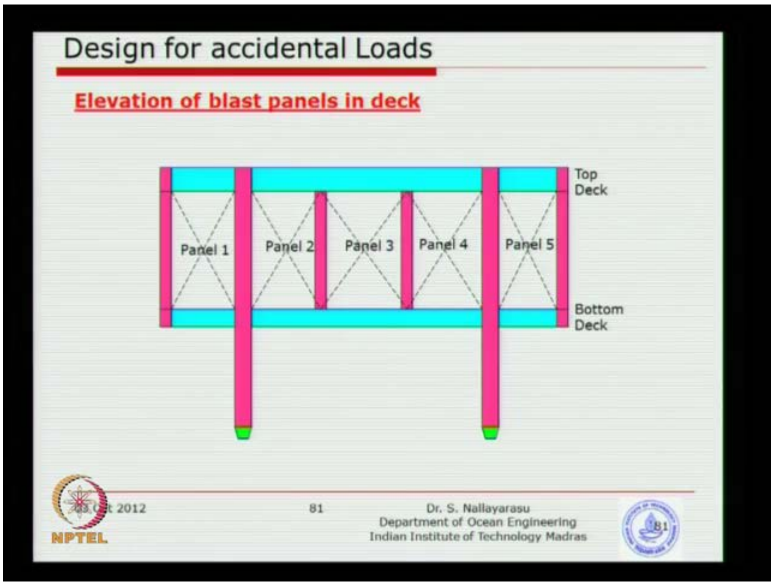

A typical structure, normally a fire wall is like this. This is one of the frame in a, in a offshore platform. I think the offshore platforms, on the super structure have several frames, like you have one wall here, you may see some of the columns which are hidden there. So the pink colour is typically a column and the blue colour is the floor beam. So, we have a fire wall, say safe side and safe side and this kind of panels, as I mentioned yesterday I think, are designed for a specific blast pressure.

And in a basically once the over pressure exceeds, they actually wanted to have the panel break away, because they do not want to create such a large pressure, that they will fail the main structure, which is potentially dangerous. So you see a situation, we want to safe guard, of course yes, as soon as the pressure reaches that point, you do not want to destroy the structure because structural integrity in question. Because if the columns fail, what will happen? Even the temporary refuse are, escape roots actually will collapse, making a whole platform to be unusable. And that is exactly the design idea, but not everyone practise this way. So, this is also dangerous because the safe side becomes very quickly unsafe. As long as the temperature rise and the blast pressure increase, is very quick. Suppose, if it happens in a delayed period, then it is okay. Otherwise, you actually will be destroying the safe zone also. So, that be little bit careful at, that is where the risk will come into picture. How much risk you would like to take and how much potentially you want to have a design of the columns? Suppose you design the column for increase the pressure, then this worry is not there. So basically, that is the idea behind, so each of this panel need to be designed either by allowable stress method or by plastic design method.

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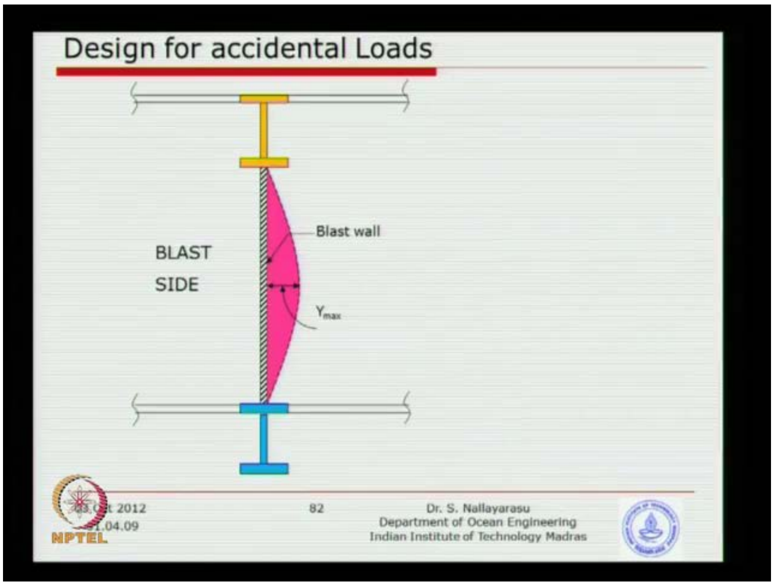

So typically, if you look at a cross section of the wall, is just a barrier and blast side safe side and you can see here the horizontal deformation, you hope to design this connection in such a way that, at that deformation the connection will not dislocate or the connection will not fail. So large rotation will happen is it not? So basically, that is exactly the idea that you need design for. Typically for most of the fire and blast walls, sometimes people still use flat panels, assist a thin plate.

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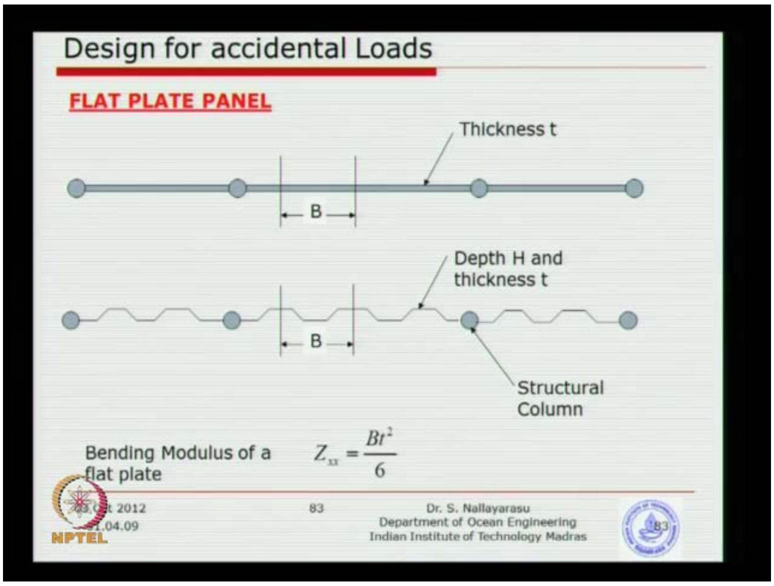

But as you know very well, the thin plate has got not much movement of inertia. So if you do a move because it is bending perpendicular to the thickness know, basically if you calculate the mode of inertia of a thin plate, is not much, is basically B t square by 6. B is the width, effective width which you can consider, whereas if you just make the corrugation like this, simple, same plate, but you bend it in this manner. You increase the movement of inertia substantially, as much as some cases 30, 40 percent.

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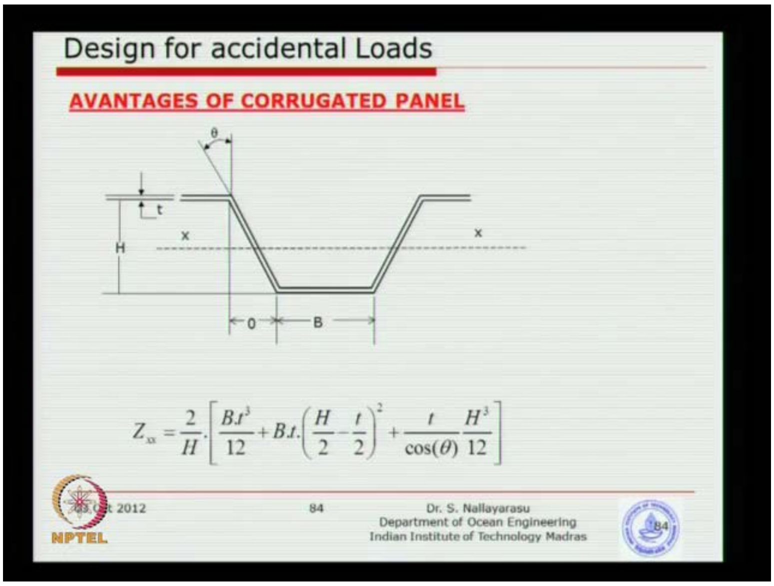

So you could see here, when you just make the same plate bend in this ratio and this profiled plate, you will see that good increase of modulus of velocity and many times we use this practical applications.

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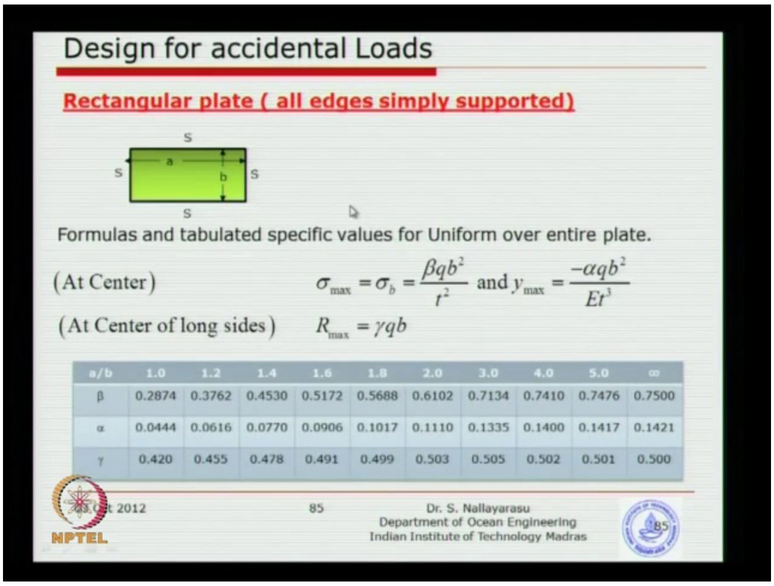

Typical flat plates, I have just given you a simple table, which you can use it for calculation of stresses. I think if you have taken plated structures codes, you will derive this. In fact, if you look at this formula, for example, you go back to this particular formula is basically, will by down to simple beam bending, when you have the ratio of a t o b. a is your length of the plate, b is your width of the plate. When there length become substantially larger, what will happen? Basically, it becomes a beam. It is just a one way action and when the plate is a to a equal to b, it becomes the 2 way action.

So, that basically is one way slab verses, those who studies civil engineering, concrete design. 1 way verses 2 way load distribution. So, if you just look at the long plate, you substitute the 0.75, will ultimately will come down to your w l square by w l square by 8, something like this. You know basically, for other a by b ratios, you have been given basic bending stress parameters, which is I think is beta and deflection parameter, which is alpha.

So you can select and given the loading the blast pressure is given to you. I think, when you solve the problem, the pressure is q. This q is here, over blast pressure and t is the thickness of the plate and simply substitute, you will get the bending stress and you will also get the deflections. So quite a simple and straight forward, the only reason why I gave this, you know the cable is just to make not only the beams, you also can solve plates with the boundary conditions, simply supported. And similarly, you can go to plate fixed at all the 4 sides. You can also find the formula similar, is exactly same when the plate length becomes longer, it becomes one way action.

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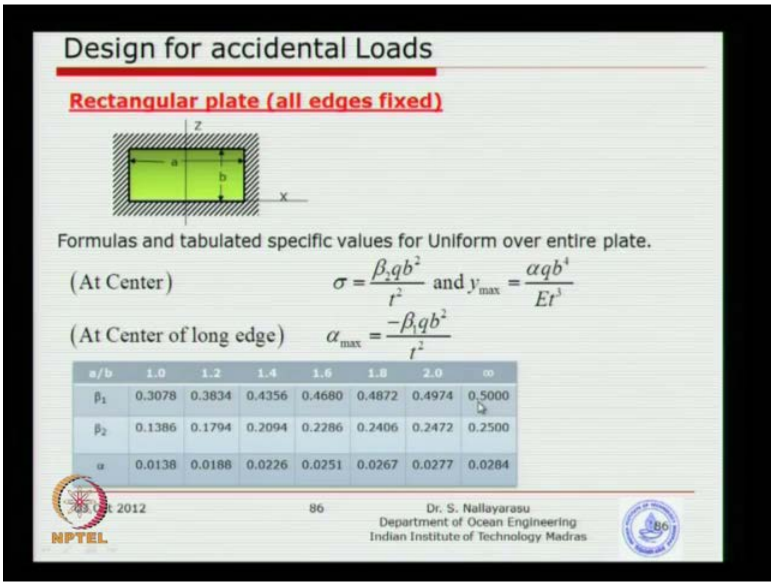

And basically, will reach 0.5 and there are 2 coefficients beta 1 and beta 2. Basically, you know the stress at the centre and stresses along the long edge. So and the deflection coefficient is alpha, basically at the, all of them will convert to a simple beam equation once the a becomes too large. So for solution purpose for problem solving, the table will be given in the examination point. Suppose, if this question is coming, the table will be given, but these formulas you need to remember. Is basically, simple m by z, you know if you go back here, is nothing but bending movement divided by x n modulus. x n modulus is p t square by 6. So, just substitute backwards. And sometimes we have a stiffen plate like this, you know basically like a floor like this. You have a stiffened, the plate stiffened with the several stiffness.

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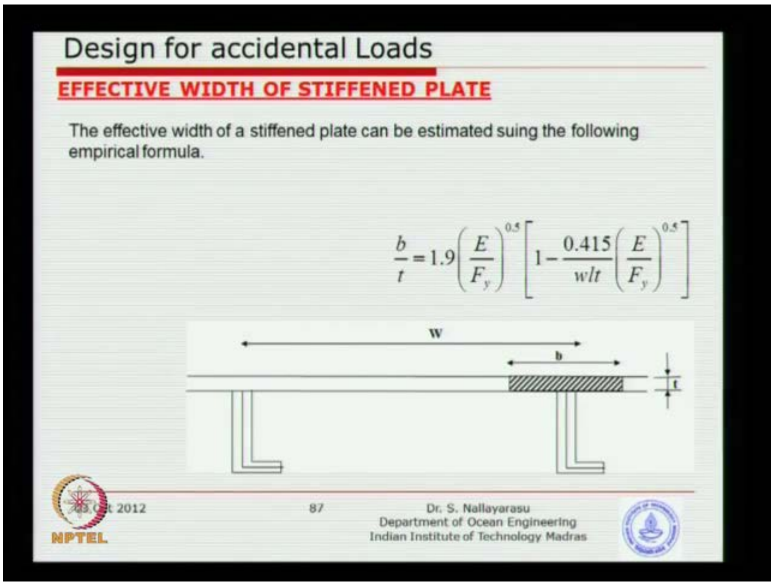

Very similar to swift construction, so you may actually take effective flange from there, the floor plate for take it as a beam action, so that you can use that in the calculation of bending stress on the stiffen the section. So empirical formula.