Design of Offshore Structures
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Module - 6
Lecture - 4
Design Against Accidental Loads 4

So, today we are just going to continue the design against temperature.

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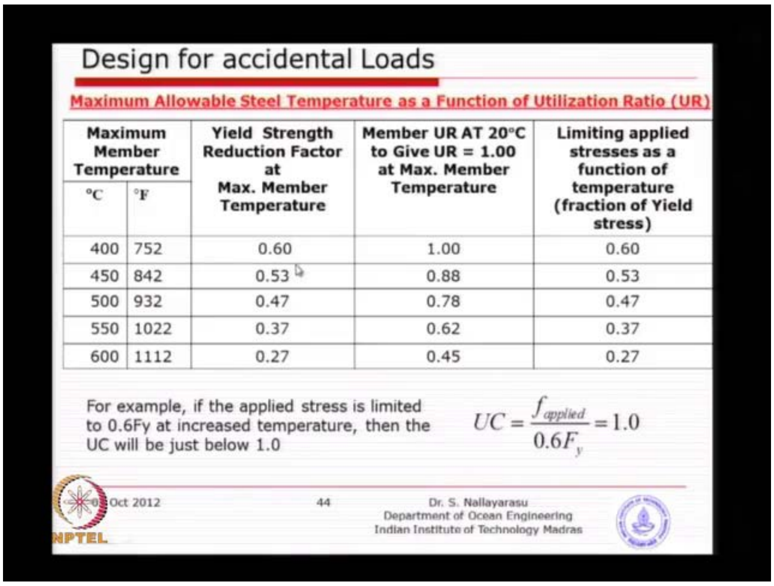

So, you see this table, you can see here the yield strength reduction factor, which I think presented earlier also in terms of, you go back to this for 0.2 percent, you know stream you can see the reduction is 0.6 for 400 degrees. So, you use the summarize, summary of the reduction factors for various temperatures for 0.2 percent. So, you can see here from 0.6 it goes down point 0.7 when the temperature reaches 600 degrees. So, how do we approach the design problem? So, basically we want to keep the stresses under control. So, you look at this, the second column, the unity check ratio, I think most of your are familiar with unity check ratio, I think what we were looking at is the applied stress divided by allowable stress.

So, applied does not depend on the temperature, it is basically the loads and the geometry. Allowable stress depends on the allowable stress factor, which is percentage of yield and yield strength itself is going to reduce by certain percentage, which you see from the column number one. So, basically at 20 degrees, if there if is no temperature change then, unity check is 1, it is normal design, but when you have 400 degrees increased, the yield reduced by 60 percent. And basically, as long as you keep your applied stress level at 60 percent, you know you correspondingly reduce your applied stress to 60 percent then, the unit check will remain same. Because, ultimately we want to maintain the unit check less than 1 so that, the structure they demand versus capacity satisfied, structure dose not so, failure case.

So, that is the ultimate aim of the design. So, as long as you keep the temperature higher, keep the applied stress is lower. So, it is just a linear interpolation I would say or just a proportioning of the increased temperature, reduction in the steel yield stresses. And correspondingly you reduced the applied stress levels by reducing the load or the alternatively you cannot reduced the load because, that is what your indented purpose have design. So, what we normally do is, we increase a section capacity such that the applied stress levels are only brought to the level of 60 percent of the, that is for the 400 degrees, just a typical example.

So, if you want to have any other factor so, just proportionate the reduction in yield is equal to reduction in the applied stress level. So, just a crude way of doing it, if you understand this I think then it is very easy. Basically what we are trying to maintain is, the unity check to be maintained, as if the original unit check when the stress levels are maintained at 20 degrees, just normal you know the operating conditions. So, that is what is demonstrated in this particular table because, most of the design methods for temperature, it is going to be this way except, in some specialized cases we may go beyond the yield.

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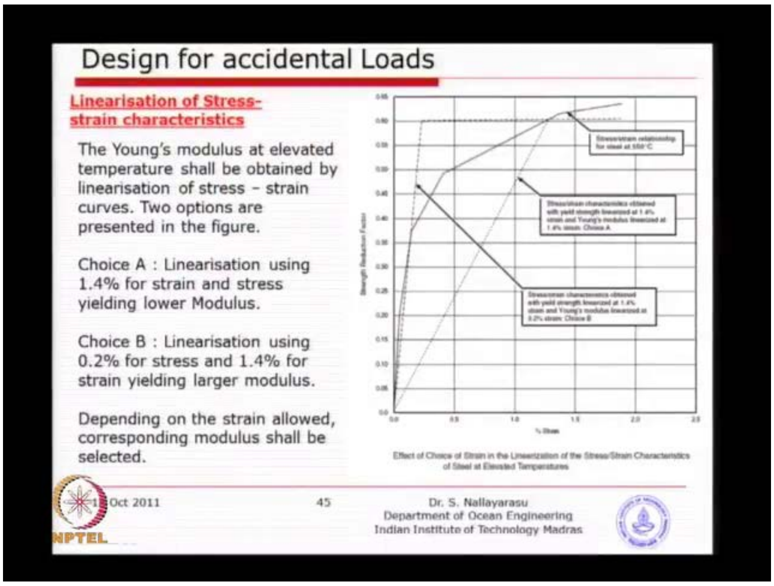

So, if you look at this diagram one important think what we are just now discussed without realizing the changes happening to the stress strain curve, we simply reduce the stress levels to the same as the reduction in the yield, which is not very good. Because we do not look at the stress strain curve because, the slop of the stress strain curve is very important, how the behavior is. You see this curve is the solid line, this solid line is the change of you know the stress corresponding to strain at various points, along the increasing strain levels. So, basically from if you look at this first point is about 0.2 percent and then, 0.4 percent and then so on its keep on increasing up to say 1.8 percent or 1.7 percent.

Now you see, it is continuously changing, it does not fallow a typical you know linear elastic and then perfectly plastic. It is just basically a continuous non-linear profile. Now we need modulus of elasticity value for design purposes. Basically when do analysis you need stiffness, for calculating stiffness you need surely the model is a elasticity value. So, which value will you take? If you have very nice typical linear elastic one line bilinear stress strain diagram, then it is very easy because, you will take the initial slope because, most of your design is going to be within the 0.2 percent.

You see here if of course, this first one 0.2, but you even before there was, there was slight clink there, even point may be 0.5 percent there. So, it is continuously changing and basically we need to find out what will be the best assumption and approximation we can make. As the discussed about yesterday, we can take a initial modulus, an average between this point which is 0.06 and basically 0.2 and pass through a data line, which take us to a typically strength reduction factor of 0.6. Basically here and this and make bilinear graph and take that as your yield strength, 60 percent of the yield and corresponding to strain value of 0.2 or slightly higher. So, you take that slope as the modulus of velocity used in your analysis, that is a first approximation.

So, we take 0.2 percent as the approximation to find out what is the approximate model is the velocity value. The second approximation could be potentially using the same 0.6 or the corresponding yield value, just take a straight line joining origin and the point of intersection with the 60 percent reduction. And you will see a reduced modulus of velocity whether the slop is reducing.

So, you can see here there is substantial difference, when you use a model is a velocity using the first option b, you will see that the stiffness is more compared to the second one, stiffness will be less. Now, how do you approximate depends on the person who is doing the work basically, this is where the principle needs to be applied, you have to be conservative, but non conservative.

So, if you use the choice one or option b, they call it choice b it is not good because, you are taking higher stiffness in your system analysis compared to the second one. And most of the time both of them are not correct because, if you are having a value of your stress at this plot may be that point correct, but what about in between? In between you have continuously changing values of the ratio of stress and strain and if you take only one value as a representative because, you are doing a linear static analysis. Because you are trying to do a simplified structural analysis, that is why you are doing this, but what of you do non-linear linear analysis?

Then you do not need to assumed like this, every time you can divide the hole graph into say 10 sub segments, every time you can take the different values of modulus value, whenever the strains are increasing So, for lower strain you will take the values somewhere here, as the strain value increasing, as you have a long large deformation problem then, you can continuously change your the tension modules, which you should calculate from this graph. So, that is where the necessity of the second order or so called a non-linear analysis structures is required, whenever the strain values are larger than 0.2 percent and then higher.

So, whenever you have a material characteristics not bilinear, I will show you another bilinear graph, I think you have before also straight line and then just a perfectly plastic and that type of problem you do not need to worry. Whereas here, you see here multi segments of linear proposition here and continuously changing from starting itself, which will be a typical behavior for steel under increased temperature. I think is what we saw or so, yesterday at several graphs in one particular picture for steel at 20 degrees, 400 degrees, 500 degrees you will see that is no more a bilinear graphs. So, that is one thing very important that you need to remember, it is not only yield strength reduces, but also two things happen, there is a reduction in the modulus and also the modulus is not a constant value trough out the range of deformation.

It is going to be changing, which needs to be accounted for, if you are using higher strain value, if you are using 0.2 percent strain, I think you do not need to very because, the anywhere difference between this and this probably a very small difference. But you decide to go for a large deformation because, you want to absorb more energy, you want to allow more strain, more strain means you will go somewhere here.

Then, the strain value is needs to be appropriately taken to calculate the model is a velocity, that is where the difference and it all depends the choice of analysis with it. If you still use the conventional allowable stress method, none of this what we discussed here can be incorporated because, the method itself uses only a single rings modulus value, which either you will use the initial or you will use the final.

So, it depends which method. So, if you go to non-linear second order analysis then, all this can be in corrupted appropriately and that why when you are designing is, basically critical components in the system. For example, thermal nuclear reactor you do not do a simple static analysis like what we are trying to do, you have to do non-linear analysis to stimulate the, the, the temperature behavior of the structure and make sure that all the possible, you know the response are taken into account. Whereas, when we are designing a simple structures like you know, the protective barrier you go, try to go conservatively and try to do a static design, as long the pickup right values.

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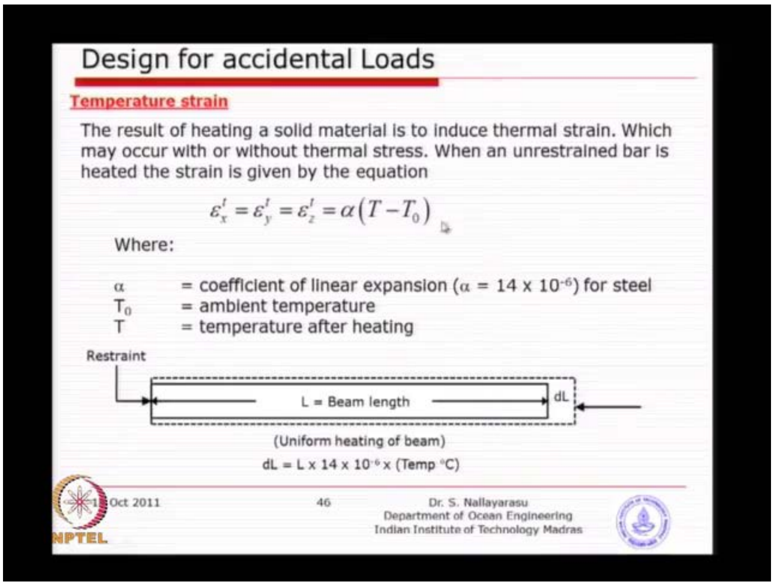

A typical elongation of a beam not restrained in any directions. So, then when you temperature increases from t, t naught to t, you see the delta t happening and basically you can find out the thermal strain in any direction as long is not restrained. So, it is just going to expand this way, expand longitudinally and it the transfers direction. So, you could easily calculate, but what if, what happens if you just try to restrain in one direction, along the end, see you have put one restrain on this understand on this, that the beam is trying to expand in any direction where ever, the degree of return is free. And that is what will happen, when you try to do, look at beam you just hold it on both ends and it is trying to unable to go in the actual direction.

And also unable to rotate at the end because, you might have fixed, but if you have allowed to rotate and that is will happen, you know when you will allow the ends to rotate because, simply supported the boundary conditions and just trying to. So, you can see here one important thing is, when the beam is bending one of the surface is going to get a compressive force, the other surface is going to get the tensile force.

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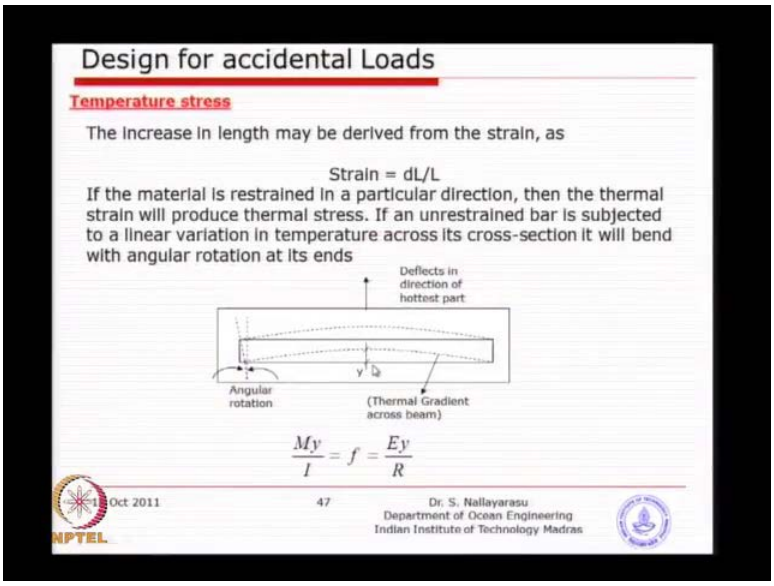

So, this shrinkage is also a problem, depending on type of cross section you know if the shrinks is to large, buckling may initiate. And that is way most of the failures due to fire happens because of this, large deformation unable to take. And then suddenly, though there is no actual load, you know the problem is because of the shrinkage length of the member, unable to go further down, just try to deckle locally and fail. So, that is many of the cases the failure due to fire is because of this phenomena called shrinkage length.

There are several methods described by API for a design so, what we have looked at is the critical parameter is the reduction factor, modulus of elasticity reduction corresponding to the temperature. And in here, we got about typically the first two methods are same, almost same I would say, except there is little difference in accommodating in the temperature.

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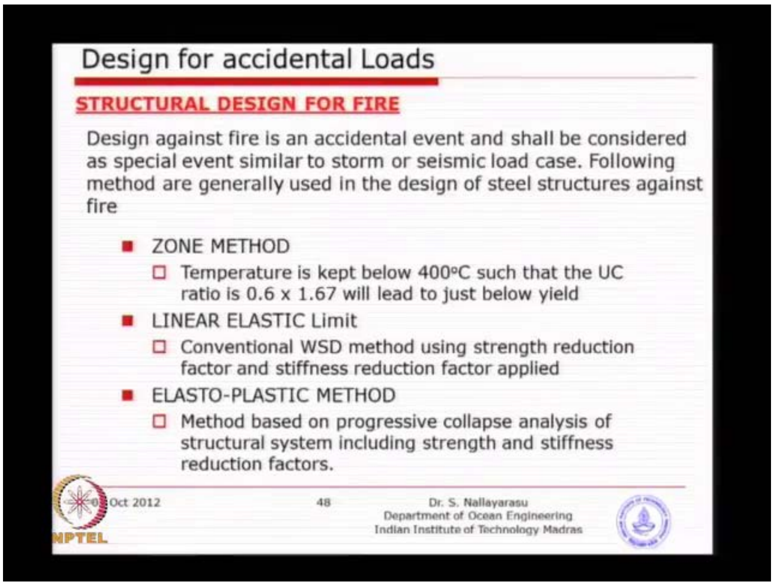

The first one is very simple, keep the temperature below 400 degrees means, is as long as you have the temperature below 400 degrees, you do not need to do any design, as long as you keep the unity check ratio corresponding to the yield strength reduction.

So, basically that is the table that is going to be used, the linear elastic limit as the normally do, most of design in the last several years is basically just replace the yield strength by, the actual reduction factor. So, you if have 0.6 or 5, you replace trough out and replace the modulus of elasticity corresponding to either the tangent or the initial modulus. And this is what practiced by almost all designers in the, in the see for so, many years because, it is quite easy know, just replace modulus value replace the. But only one important thing is the linearization has to done properly, like this all one different choice b, choice a.

So, if you do linearization conservatively taking as lower side of the modulus properly not a problem, but if you take the choice no, choice a, if you choice b higher modeless value not very good. So, that the only difference. The elastic and the elastic and to plastic method, that is typically a second order analysis, both material and geometry because, it is a large deformation problem and material itself is continuously changing. And which normally not done, except for very specific cases and probably what we are looking at is, the ultimate capacity, not the elastic capacity. So, ultimate capacity at any time the structure dose not collapse.

So, under high temperature so, some of the members were fail, but still the system does not collapse because, you have redundancy in the system. So, that what we are trying to do in the third one and typically, it is not done for conventional design special cases even for jackets they do it, but not for fire, but for ((Refer time: 14:41)). But some cases people have attempt to do fire stimulation, if you lose one of the leg whether the system can still be stable because, during fire you could get such a situation there where, one side of the leg is damaged or collapsed.

So, such analysis is, is basically taking it to account the plastic capacity available that means, beyond yield you might have seen, we have been using a triangles situation for elastic. When you go to plastic, you have a rectangular distribution. So, the distribution across a section and distribution along the length. So, those will be taken into account in this whereas, has the first two methods nothing of that sort, simply a triangles distribution and basically conventional allowable stress design.

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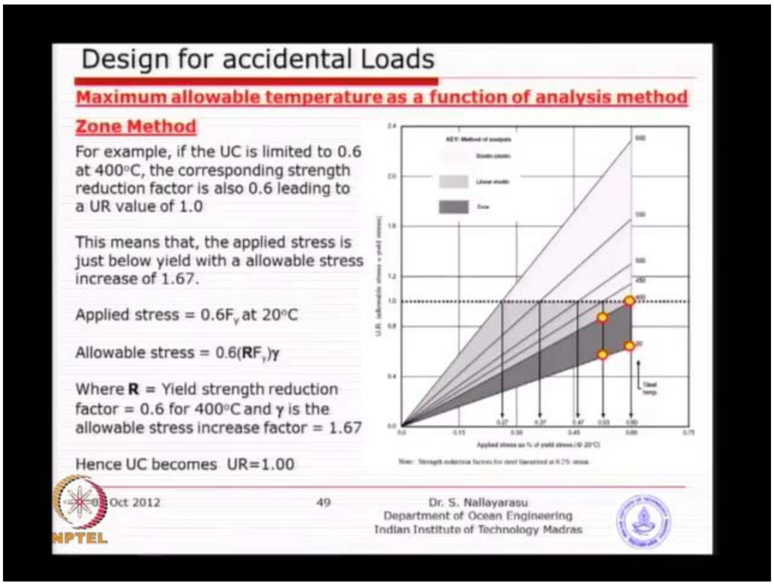

So, let us look at quickly what the zone method, API has given you the tape, figure you see on the right hand side comprising of all three method, the dark color or the bottom, you can see 20 degrees. This is 20 degrees, the design as per operational temperature with no temperature increase. So, you could see here I have just defined the zone method restricting the temperature 400 degrees. So, as long as you have the temperature below 400 degrees, the unity check will be 1 and as long as at 20 degrees, you design the system in such a way that, the unity check is 0.6, 0.6 yeah. So, basically that means the applied stresses are kept low at 20 degrees and at 400 degrees the unity check will become 1.

So, very simple just proportionate, you know basically that is the idea behind the zone method, but only the difference is we are keeping the temperature below 400 degrees. And that is the most projects applied this, this principle because, temperature higher than 400 degrees you know, the reduction factor is so large that, the section size is become too big. So, we will look at alternatives how to bring the temperature below 400 degrees rather than, do not provide any protection, but just allow the temperature to grow as big as in some cases what we normally do is, insulation in many part of the structure, you know basically the thermal coating. Or if the, if the design because of not accurate because, I think it might have seen is structure called flower structure, we were trying fire the excess gas.

At the one of the days I have explained you, there will be a structure two fire the, the gas that is coming out of oil platform, I think first few classes we were discussing. If there is purely oil platform designed for oil protection, but there will be a gas coming together with oil, the quantity is so small that, you do not want to know do production. So, such times you actually fire the gas instead of sending it back to land, if it is a predominantly gas platform and then, you produce because, you got to change the equipments. So, in such type of cases you will see, I think probably I will show you a photograph the, the firing of gas will actually affect the structures in the vicinity, isn’t it?

So, that type of design you can provide a barrier, you actual make a barrier or make the structure so long that the temperature reaching the main structure is within 400 degrees, just a planned activity. So, it is not an accident, it is actually an operational case, but we can restrict. So, most of the time such type of cases we will be assured that the temperature is below 400 and then just come up with the. So, 20 degrees the unity check is basically 0.6 and we know very well that 400 degrees, the yield strength reduction is 0.6. Only one thing is we have forgotten about the modulus of elasticity because, we are looking at the, if you look at 400 degrees.

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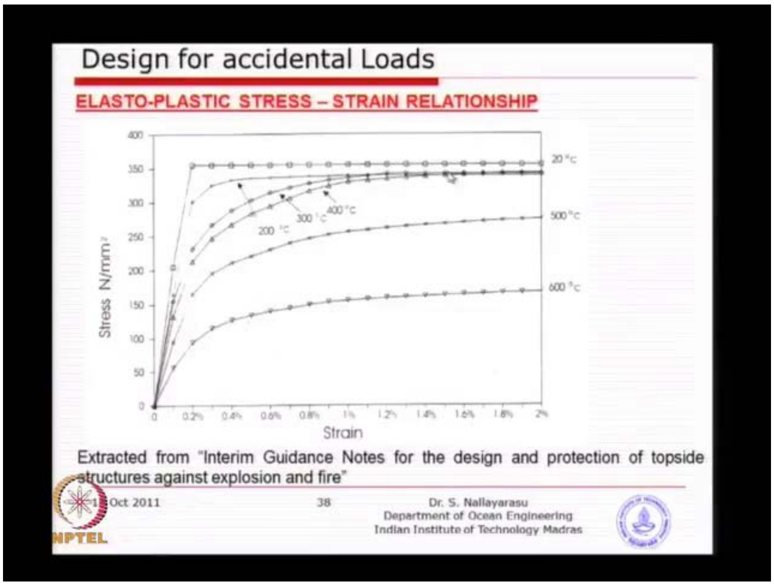

Just let us go back quickly, what happens to 400 degrees somewhere here, 500, 400 is 1, 2, 3 I think this is the one 200, 300, 400. So, if you look at the 400 degrees still it is not linear, if you look at the 20 the degrees, it is just one straight line and a horizontal plastic line. So, basically still there will be considerable change in the modulus of elasticity depending on what reduction factor. For example, for 60 percent you may be taking some where here about 200 something. So, if you join this line and this line you will see at least 20 to 30 percent reduction, 20 percent deduction in the modulus of elasticity value, which is what we are ignoring in the zone method.

So, you got to be little bit careful as long as your temperature is set 200 degrees probably not bad because, the yield instant production from 350 or to probably 300 and the slop between this line and this line is very, very small change. So, that is where you have to be little bit careful. So, the idea behind the zone method is simply designing the structures with the reduced applied stress, corresponding to the yield strength reduction factors for 400 degrees. And there just a typical example, I have the applied stress 0.6 FOI and basically at 20 degrees and we know very well that the allowable stress or the safety factor in allowable stress design 1.67, taking 0.6.

And gamma is also increase factor, which is normally if you remember when you design structures for a seismic condition, we normally increases stresses to 70 percent. I think most of the codes are describing, I think whether is API or IS 1893 during seismic condition, you can increase the stresses to 70 percent. So, similarly you see here the stress increase factor of 1.67, when you substitute all of them you will get a unit disgrace of 1. So, that is the idea behind you keep the stresses below certain level, unity check will be only one thing is the modulus value is not changed and just completely ignored. As long as the change is smaller, then the system behavior will be same. Now if you go to the same zone method at higher strain value, what we discussed just know only 0.2 percent, which is okay, as long as your deformations are smaller.

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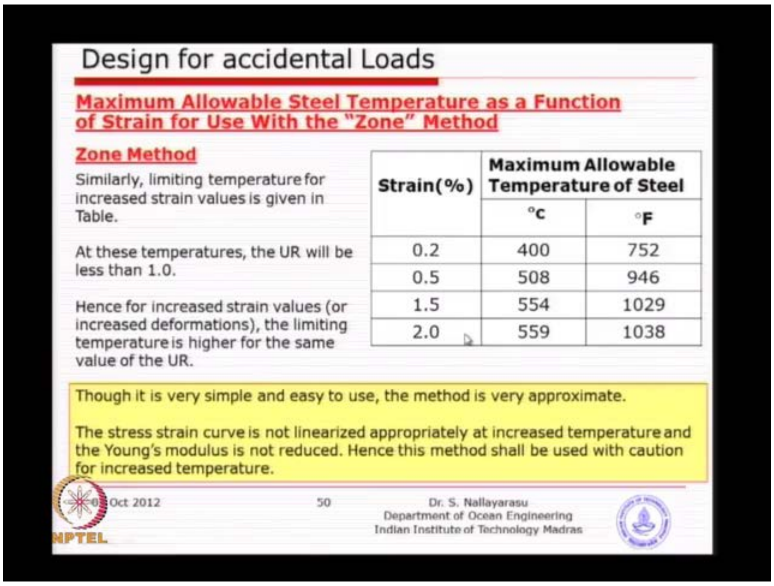

But what happens when the strain values you want to allow larger because, you want to have more deformation and in such cases, the allowable temperature for example, when you restricted the strain to 0.2 percent, 400 degrees you are unity check value is 1. Whereas, when you allow largest deformation the strain value is higher then, you can possibly allow higher temperature. So, that is the another thing. So, the higher the deformation values you would like allow you can have the slightly increased temperature.

Like for example, if you want to allow 2 percent strain then, you can go for higher temperature because, it is going to. So, basically what we try to important note is the, note at the bottom, the modulus value has to be appropriately taken. So, if you not taking then, it will be incorrect system analysis though the components design correctly, but the behavior of the system will not be correct.

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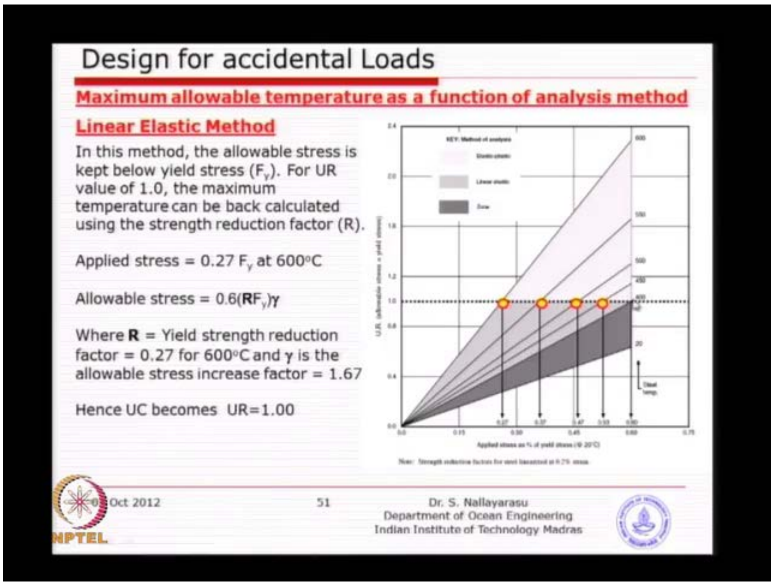

The second one is the linear elastic method, but exactly the same, only thing is the system analysis will be taken into account, the average model is the velocity and we do allow temperatures beyond 400 degrees. So, you can see here this is the 400 degrees line 450, 500, 550 and 600 all of them are drawn in the same graph. So, the typical example it will be the exactly the same design, only that we have for example, unity check value of 1 at 600 basically, your applied stress must be reduced to 27 percent. So, when you do as 400 degrees, we could actually allow up to 60 percent of the original load. Whereas, when you go to 600 degree c and we can only allow 27 percent.

So, basically that is the idea behind you know, you, you keep increasing the stress, you have to keep reducing the applied load. And otherwise, you cannot maintain the unity check of one, which demarcates the failure to non-failure. So, that is the simple difference both methods, if you consider basically the change in modulus as elasticity, both methods are reasonably correct, as long as the strain values are smaller. When the strain value goes larger and larger, that is where the problem starts to crop up because, modulus values will start changing.

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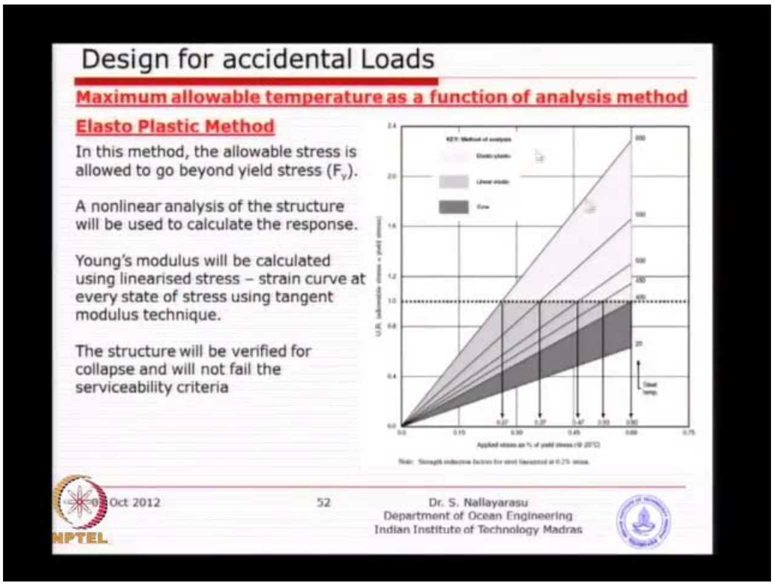

The elastoplastic method commonly used for large deformation structures, not for stiff and steel structures basically, specialized structures like, you can use this method. Because, the time consuming process you have to model the material characteristics, you have to model the geometric second ordinal linearity. And whenever you go beyond then, you will be using the extra strength, that is not strength available even the elastic limit to the failure also called ultimate strength, which normally in most of the design we do not allow and you will use that with appropriate factor of safety. So, basically in summary the design of structures for steel is very simple idea, what we need to know is the strain value, increased temperature multiplied by the thermal coefficient.

And you will get the strain, from strain you can go back to deformation and stresses and correspondingly work out the unit disaggressive. Or you limit the temperature to a particular limit and then, calculate the reduction factor in the yield, compute what will be the allowable applied load or you calculate backwards, what will be the second the property either way. So, basically what we need to remember in design for temperature is, trying to modify this yield strength and young's modulus.

So, in the examination point of view I think you will be given simple exercise of reading the chart, you know nothing more than because, basically system analysis cannot be performed because, where you are replacing the rings modules value. Whereas in the component calculation either you will be calculating the section property required or you can calculate the limiting temperature or limiting strain. So, most of time you will use this chart, what we were looking at.

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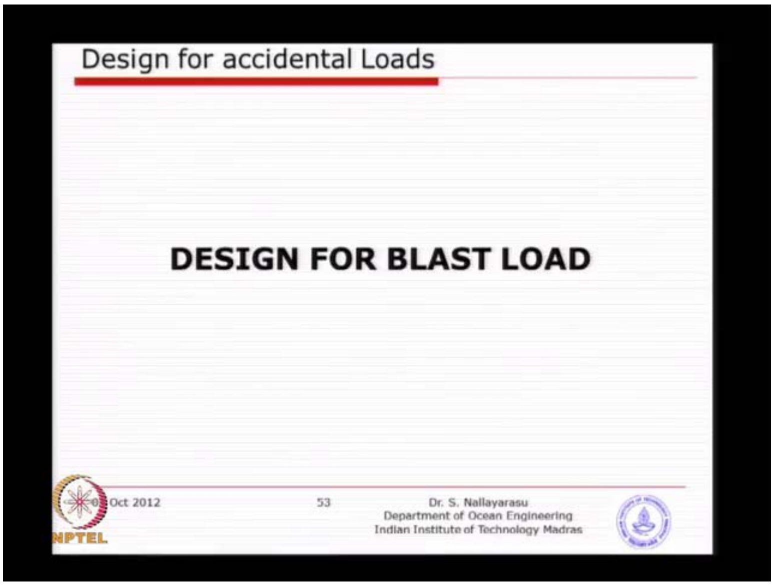

The next one what we are going to see here today is the design against blast, I think we have discussed about this fact that, blast deserted fire or fire in the state initiated blast or have to be treated little bit carefully. So, in this case we are just going to look at the fire initiated blast, fire is already occurring and there is blast. And that blast, the behavior needs to be understood, the load is going to be dynamic. I think most of you might have studied dynamics of structures going through a course now no, not yet, you know the single degree of freedom response at least you need to remember, I think you might have also studied in your basis, in your physics.

So, basically we need to see how the response, if the loading cycles or loading frequency is comparably close to the system frequency. Then, how the response is going to be increased? We call it resonance, I think that is the most critical part of the whole business. Both in terms of cyclic loading like wave loads or in this particular case, the blast is going to be the pulse load, very small duration or large amplitude. So, what really happens you know basically, you will be locking to a resonance area where, the amplitude of response of the structure could be several fold, higher than conventional static response.

You know, if you calculate a simple beam apply the blast load and try to find out what is the deflection at the center, you may get few millimeter if you just ignore the frequency response function. Or if you take account you may get several time may be, 5 times, 6 times. So, that is the exactly we need to find out the blast load is going to be dynamic, it is not static load and the duration, the smaller duration we are going to have trouble. Imagine you have a blast and just over long period of time the behavior will become almost equal to static loading, that is exactly the idea and will see how the behavior modeled.

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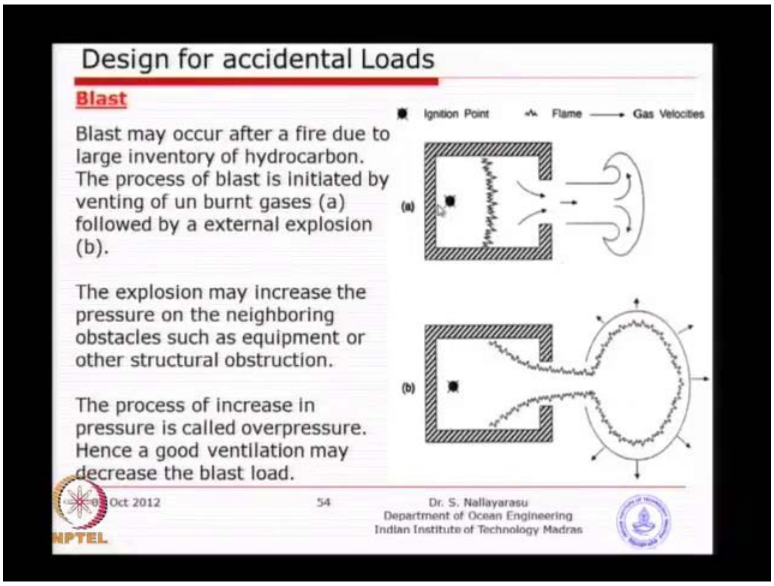

If you look at this typical compartment, blast occurs as long as the ventilation is there. The most important problem is ventilation, you know if you do not have the ventilation, the, what is a blast? Blast is basically an ignition of a source material, it could be gas in this case of platform or it could be oil or it could be other types of sources, which normally we do not use in our platforms. So, basically in this case if thus the ignition point is congested in that area, you got a large of lot of obstructions, there is the possibility of the exposes, exploded gas is unable to escape. Then, there will be a further increase of pressure which we call it the blast over pressure.

So, you make a compartment and just explore and typically that is what will happen and that is where if you have large ventilation, the gases could actually, the gas cloud can escape so that, the pressure, the over pressure will be reduced. In fact several times the damages are very large because of this, you know the ventilation is not there, that is why when you expose something in a open space nothing really happens. But when you expose the same thing in a congested space, with several ((Refer time: 29:06)) and other materials in the vicinity could to a serious damage.

So, that is why the blast basically, the combustion of unburnt gases trying to escape, whatever is brunt is okay, it will become a smoke, but the un brunt gases trying to escape will build up pressure and trying to expand. And that is called the over pressure generated by the blast and that is why, when you design an offshore platform, you need make sure that all directions. Whenever there is a large equipments, you need to provide the large space around and also ventilation to make the gases escape both the, during the blast as well as during normal operation.

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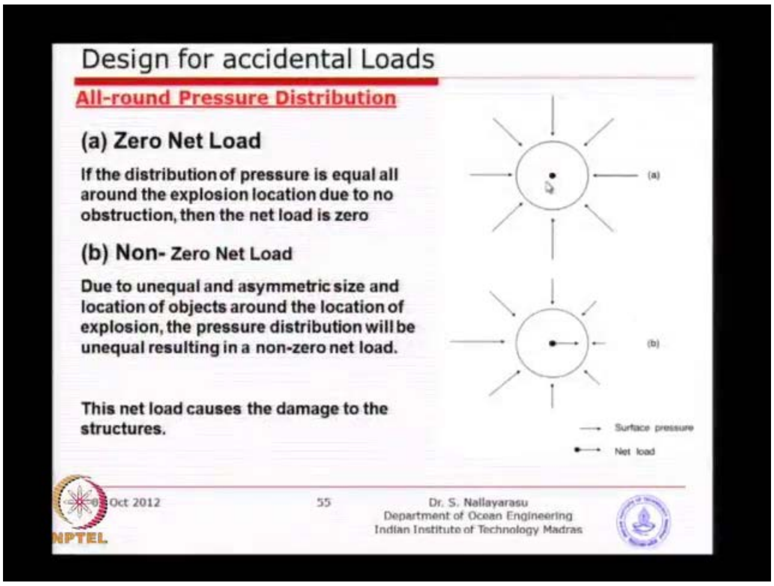

So, you see here at this picture as long as the obstruction or no obstruction, if there is an obstruction, if it is uniform then the net load is 0 or if there is no obstruction every, it can actually expand nicely. So, that net load will be simply not there whereas, there is unequal construction or kind of distribution something like this, then there will be a net load because of the differential pressure, which is caused by the drag. So, that is the exactly idea happening in the real scenario where, the equipments and the other facilities around particular location or designation and expose is not differently going to be a inform, there is no point of doing that.

So, that is why that net load causes damage to structures in terms of trying to rip-off the structure and the local vicinity or that whole thing can go and ((Refer time: 30:47)) on to neighboring wall or a bigger obstruction.

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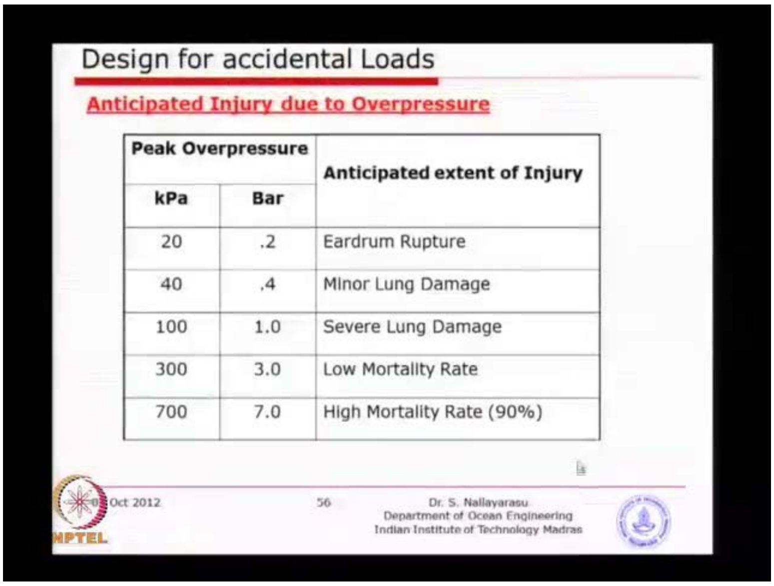

Typical you know basically, the over process expected in the offshore platforms, not as high as 7 bar. Most of the offshore platforms are designed for less than 1 bar many, but in special cases some of the platforms also designed for 3 bar over pressure. So, you could see here 2 bar is nothing but 300 kilo Pascal, which is 30 ton per meter square. So, if you look at 0.2 bar is 2 ton per square meter. So, imagine 2 ton per square meter is very large loading 20 p k i is huge loading and when you design for 30 ton per square meter, which is possibly the heaviest load the civil engineers may not have even seen you know such type of loading, would possible to design any structure for such type of loading, especially when you want to design for gravity.

So, that is where the problem will come so, you can see here the expected type of damages to human being because, after all we are worried about you know the injurious and the mortality. Basically if you have such type of over pressures and that is where the damage is too much. So, most of the cases we have less than 1 bar, some times as much as 7 bar only very few platforms, especially when you have a congested space.

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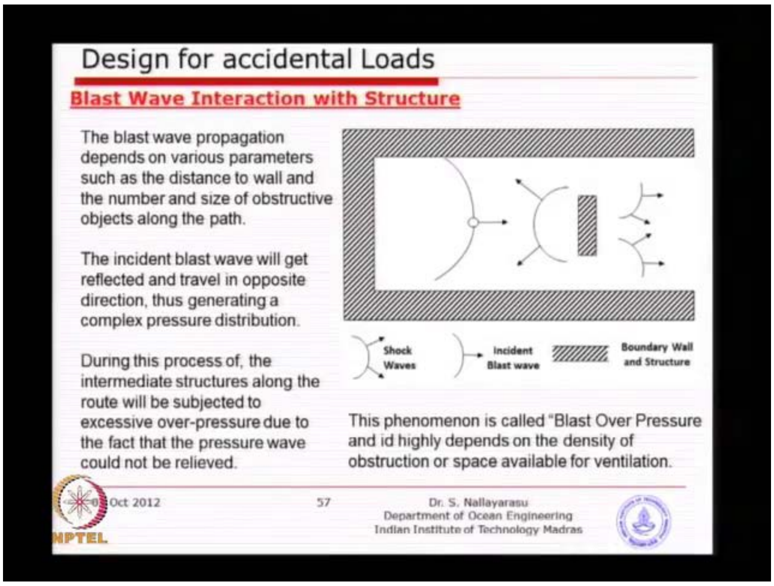

So, how the blast wave interact with structures depends on you know the type of obstruction and basically the enclosure that you have. So, you see here the, similar to our the chalk piece, you have the surface face then, you go to our wave base, the incident waves and the reflected waves get actually interacting and the effect will be increasing further more. So, you can see here an obstruction is here and basically, the shock wave propagating from one end because of the explosion comes backwards for an obstructed space or a wall. So, you will see the, unless you have 100 percent ventilation, you will see a savior interaction, which will be very difficult to stimulate and that is where the pressure will buildup and wherever the weakest component on the wall, will try to export in the direction.

So, this idea is the prediction blast over pressure, typically there is no software to stimulate this. What people have done is, they have done several full scale testing, you know the join industry report which is was referring, the interim report basically have done several full scale model fabrication and ignited with artificial you know detonated the and mastered the over pressures, with several degrees of ventilation, you have. For example, in this particular case you enclose it and only provide a weaker particular space so that, exceeding the particular over pressure, that will actually blow off. So, that means the over pressure will build up is so much.

So, like that they have done the experiments and come up with the report, depending on the porosity of the structure porosity does not mean that, we like the structure porous. The obstructions on the facility, you know you have pipes, you have equipments, you may have structural columns, you may have structural beams. So, put together a volume is defends x y z volume and how much is occupied by the obstruction and how much is not occupied by are empty space. So, that ratio is very much important, depending on that the values are recommended and basically will see in the next few slides. So, the blast over pressure is very important to obtain from references are from others sources so that, it can be used for design.

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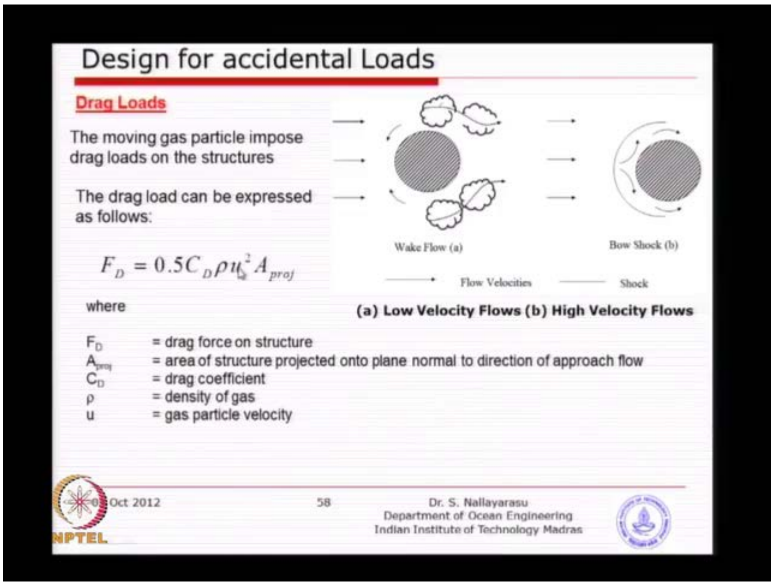

Typically you see here, as long as you know the velocity of flow, theoretically you can stimulate gas floe around solid bodies or obstructions you can calculate the drag force, as long you know the velocity of the flow. So, depending on the type of objects that is being, if it is too small mostly the flow will go around creating a drag and if it is slightly bigger, not too big, it may actually create a soft force. Because, it is an abstraction that is crossing, depending in the shape and size things could be different, but as long as you know the velocity, you could use the projected area to find out, what could be the potential drag force that causes. So, the potential drag force once you know, then you can design the structures. Typical pressure time curve is just given in this graph.

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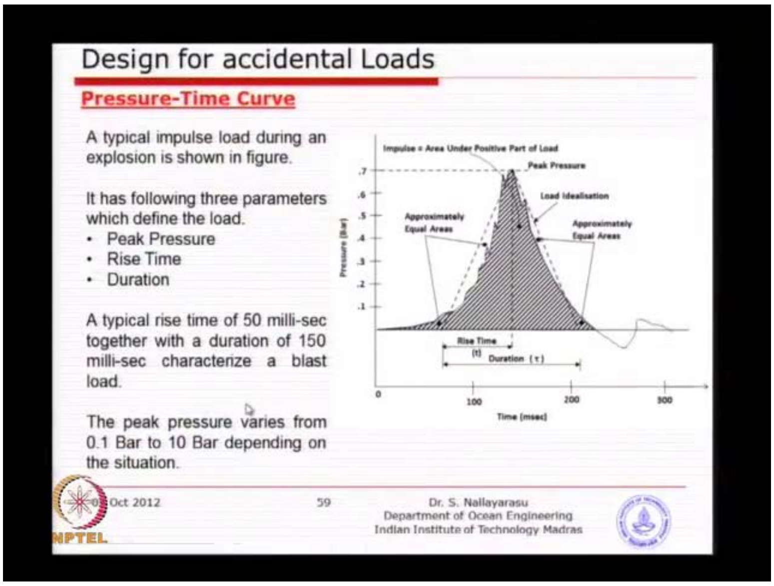

So, you can see here potentially it will be lees then 150 mill second very small, time period is quite small. The most important is the rise time, which is basically so, you see just idealized, you know just like a triangle. Whereas, you may not see a nice triangle like this, you may see ah things like this changing within the time period, but for the analysis purpose we normally use a simplified triangle. So, the three parameters one is peak pressure, basically the value of the pick, it could be at the center of or it could be at the, of the center because, not necessary that you will get nice symmetric triangle like this. And then, the rise time in the, in this case is 50 percent, this basically the half of the total and the total duration of the pulse.

So, these three parameters are required so that, we can go back to a mathematical model and use the dynamic equation and substitute the loading and can find out the structure response. And as I mentioned earlier, the peak process vary from 0.1 bar to 10 bar, typically for offshore applications, not more than 2 or 3 bars.

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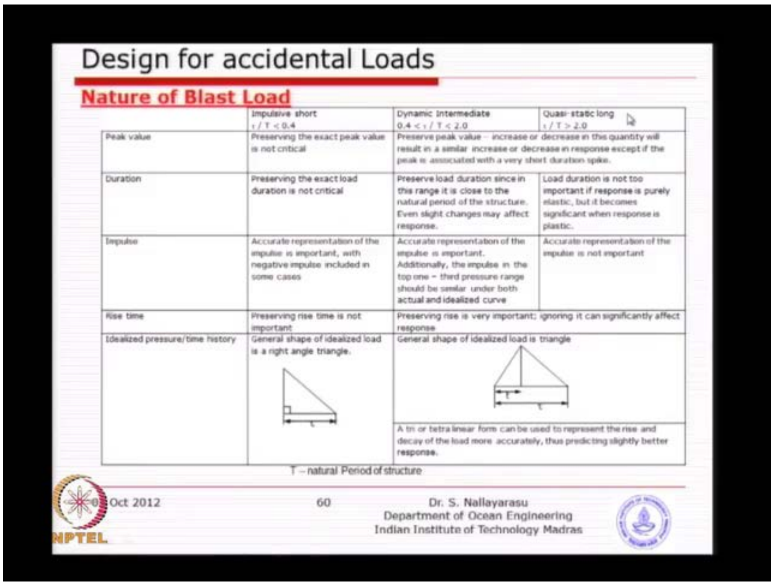

And depending on, you know the, the type of impulse you can go the, the last one first, the ratio of total duration divided by the natural frequency. If it is greater than 2 that means, basically behaves as most, almost close to static or quasi static. So, you do not need to worry about the so, the duration of loading is very large, is sustained loading, isn't it? So, you can treated as a static structure, you do not need to vary about dynamic. Whenever the pulse so small then, it is just excited and then the load reduces. So, the structure starts vibrating depending on the frequency, you will see into resonance and that is the most important one and you can see here the rise time is quite very small or does not exist.

Straight away, value picks higher value and starts reducing and most of the detonated explosions will be something like this, the peak value will be reaching in very very small period almost 0 and then comes down. Whereas, when the explosion happens after a fire you may see that, there could be a similar situation because, already fire is there, the detonation can happen very quickly. So, these three we need to understand how we deal with it because, each of this area you can defined a particular analysis method. So, as I mentioned the last one, we really do not need to worry about dynamics, the first one for sure very short impulse and second is in between 0.4 and 2.

So, basically for the first and the second one, we use a dynamic analysis whereas the last one, you could use a simple static analysis of course, in the slight increase in the dynamic load factor and approximation, which we can use it, because, still we are trying to convert the dynamic loading to static loading. So, you just multiply by a dynamic load factor, which is what is mostly practiced in the industry because, a first two involves considerable amount of time and effort. So, we try to do is, we try to do a single area of freedom of model of the first two items and try to find out, what could be a possible dynamic load factor, go and apply to a quasi-static model, which is a simple static analysis and increased the loading by that amount and then find out what is a response.

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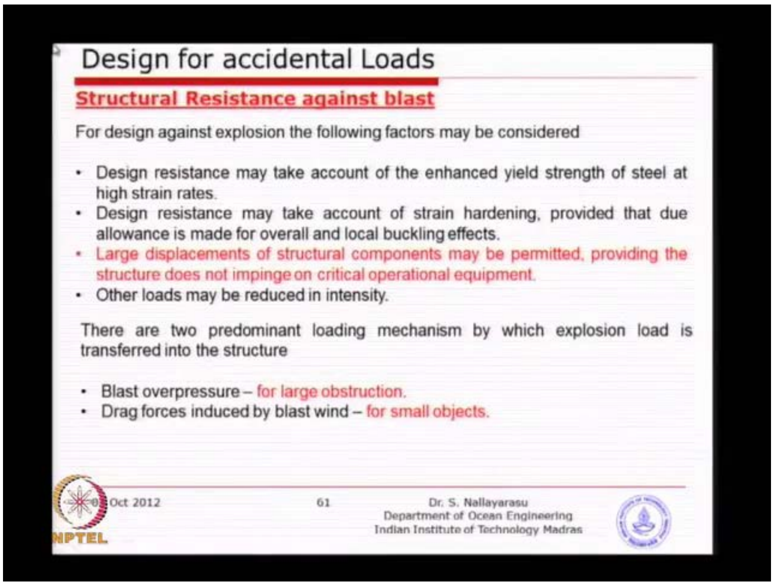

So, structural resistance against blast loads basically, the idea behind is the large deformation and you can see here, the important thing is when the large deformation is occurring should not go and impinge on to neighboring equipments because, that may trigger subsequent basically a blast or fire. So, the important parameter is, one is the over pressure which we discussed about it. Basically for large obstruction because, it is unable to escape or smaller obstruction you may actually have a drag force, which very similar to any drag component like wind.

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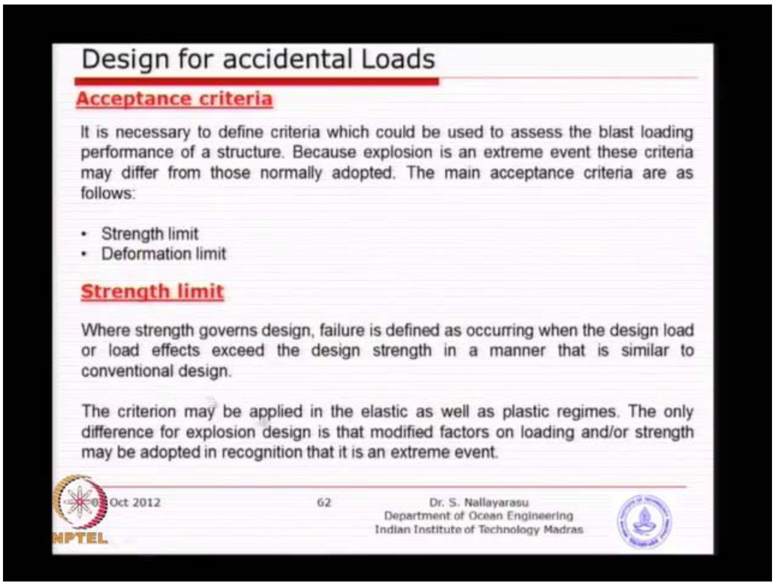

Acceptance criteria we just need to fix up, one is the strength limit, the other one is deformation limit, I think deformation is very easy to understand, we want to limit the deflection to say half a meter. Because, we want to keep the equipments in the near or you may set the value meter as long as you want to waste 2 meters space in that vicinity. So, it all depends on the space availability, as know very well the space availability is very difficult in offshore platform, not easy to get large open space. So, you typically give a meter and put all your equipments around.

So, when the deflection happens so, the deformation limit is very easy to set, how you obtain the deformation is the most important. Whether you want do a simple static analysis or you want to do second order non-linear deformation or you do a consist analysis with a load factor multiplied. Strength limit is again, similar idea like, what we discussed about the temperature. Similar you can do a static analysis, multiplied by the dynamic amplification or you can do a non-linear analysis.