Design of Offshore Structures
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Module - 06
Lecture - 01
Design against Accidental Loads 1

So, today we are going to see a new topic basically the design for accidental loads as you can see you know whether it is onshore or offshore structures the normal conventional operating loads do exist as well accidental loads which the occurrence could be rare. That is if it is frequently occurring then it should be included as part of the operational loads. So, this accidental loads could occur either due to a natural hazards or may be due to manmade hazards. So, we are going to see both of them and then see each one how to deal with it.

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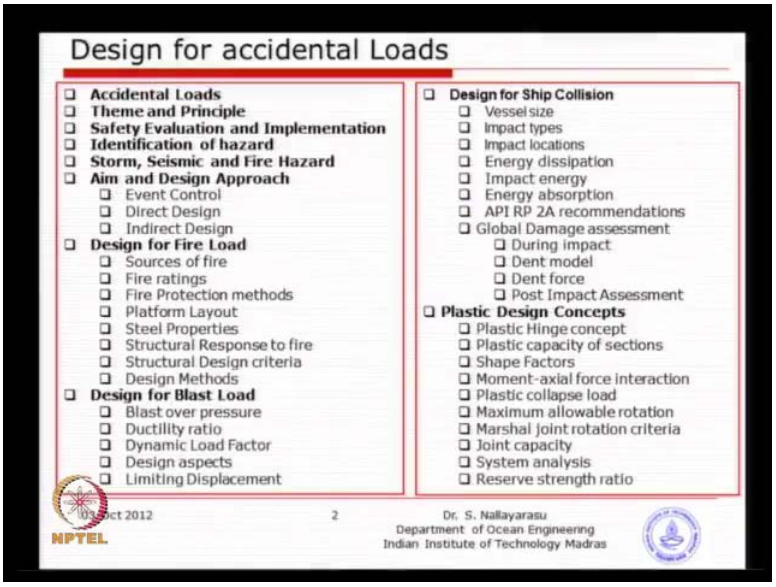

So, if you look at this topic is going to be designed based on a slightly different approach, so far we have been using allowable stress method and then empirical methods for design of tubular joints and members, most of them are empirical, but the principle is demand versus capacity limiting to you know yield point. That was the idea we were looking at and also we learned about the LRFD method though it is limiting to yield, but we are looking at you know the probability based design.

Whereas, when we went into design of tubular joints we were looking at slightly higher than yield, but just below ultimate strength so we are just looking at first crack versus yield and then safety slightly higher. So, all those things we were trying to do using empirical methods. So, in this particular aspect of accidental loads though we call it accidental loads they may occur at any time given the duration of the life time design of the structures.

So, basically it is going to occur sometime only the frequency of occurrence could be very low so that means depending on the higher that the amount of risk you would like to take you could design the structure in a different manner. And also this this loads arising from you know basically accidental needs it could be fire it could be natural hazards or other forms of you know the impacts due to incoming ship is basically offshore sources we are talking about.

And basically or can be a dropped object from somewhere from a crane you are lifting a heavy weight that object falls down because failure of crane failure of structure failure of rigging. So, it could cause substantial damage. When you are evaluating this accidental loads if you are trying to design based on the similar allowable stress methods try to save the structure that is what the idea. The most of our allowable stress design we were looking at structural safety you do not want the structure to have you know at the end of the load case or load occurrence you want to have structure intact with all requirements for strength, serviceability and operability is not changed.

That means, even after the load occur you will be able to operate the structure or the facility as normal. Whereas in case of accidental loads if you expect the same thing you could do that, actually nobody is going to prevent it from doing that only thing is the requirement will be so enormous that it might become impossible to invest so much of effort in terms of design and operation. So, we need to find alternative idea. At the end of the day I want to take a higher risk because it is a lower occurrence so I will take a higher risk if it occurs let the structure collapse or let the structure fail, but at the same time I will be able to save human life I can lose the structure, but I do not want to lose the life.

So, that is the idea behind all the design based on accidental loads so we are going to look at a slightly different approach rather than the design for saving the structure, all the

operational condition when we are designing a structure, we do not want to have the structure having deformation excess ably in addition to what we can accept for operation. So, while doing so we have to identify first what are the hazards what are the accidental loads that is going to arise for offshore situations and basically apply that, these accident does not cover you know. Basically purposeful hazards like somebody is going in like twin tower hitting with air craft is not designed for such type of activities.

What we are looking at is a mostly the operational based hazards because you are having a hydrocarbon facility and it explodes due to inefficient design or over pressure it is not that somebody is going to make a bomb and plant it. You understand the idea know so basically this is the hazards arising in either from nature because of storm because of earthquake or because of the operational hazards because you are dealing with hydrocarbons. So, we will only limit our discussions to that and that is the purpose of this design and if you look at the whole arrangement of this is sequentially organised to understand the hazard classification. And then will just look at the design approach whether, we will actively design the structure or we will just do a prevention of hazard from happening.

You know that is what we are just going to look at the you know event control we know that fire is inherent if you have hydrocarbon facility with various other mechanical devices even a small spark can create a fire. In fact, if you have read the newspaper few days back in the newspaper the gas from a cylinder was leaking they did not even switch on the gas cylinder actually a switch for electrical button had a small spark which cause the whole cylinder to explode. There was no actually fire in the stove, but just the electrical spark mixed with the gas has just exploded and few people got killed.

Same thing can happen in offshore facility you have got plenty of gas and if you have an electrical spark arising out of any of this, so many facilities you have or even mechanical spark rubbing of surfaces. For example, you have a large displacements of the structures happening and you have a metal contact which can rub can create spark which can cause immediate explosion. So, there is huge amount of possibility and that is where we need to see how to control that event from happening which is potentially possible it is under our control.

So, you can do that which is called the event control or you can look at the design directly or indirectly. What it means basically further after the occurrence of such an event how to stop it from propagating. You know there is a fire here that is not mean that the whole structure to get burned out so you can actually isolate the areas in such a way that the occurrence of event can be prevented from further propagating to other areas of importance. So, you can actually reduce the impact and then the direct design though it occurs we could we will try to control it, but if it is not feasible to control what we want is the human life to be saved wherever they are.

That means you need to have the structure designed in such a way that immediate collapse is prevented. So, that the people have enough time to escape from the facility so that afterwards if the structure collapse not a major problem. So, that is basically the direct design, indirect design is how much risk again you want to take. Basically, how much money you want to invest against the risk.

So, in that we have 3 or 4 categories of loads one is fire I think all of you know fire whether onshore offshore facility as long as you have the cause of fire and large inventory of inflammable material that is where the problem. You know onshore facility you may not have except may be refineries, oil storage tanks all other industrial structures and buildings you may not have so much of problem because the inventory of hydrocarbon is very limited, you may have one cylinder of gas not a big problem where as in the offshore facility you have large volume of inventory and that is where the so fire is inherent.

The next one is blast, the blast is nothing, but basically high pressure fluid explodes due to fire it could either way can happen either the fire initiated blast or blast initiated fire it could exactly the opposite way because one of the tank is exploding because of the pressure and then can cause fire. So, you can have any situation. The third one is the you know collision of ships with the offshore facilities whether it is a floating facility or fixed facility you may have steering vessels.

For example, a ship is going across one country to other country across you may have offshore structures, normally not normally we plan the facility in such a way that the navigational channels are all away from the offshore installations and demarcated they are not supposed to go there, but in case you might have heard 3-4 months back one of

the failed vessel from Dubai have drifted and just came to the coast of Mumbai I think you might have read in the newspaper.

All the way it was actually failed engine could not control the whole ship was abundant by the captain and crew and was just left in the open sea condition they just went back, but the ship was just going here and there and finally, cost of Mumbai across crossing all the oil facilities. Luckily, did not go across any of the existing installations so if it has crossed across you might see that platforms could easily disappear because the size of the ship is so large that the amount of impact force it could introduce it can destroy instantaneously.

So, we try to prevent by making sure that this drifting vessel does not come because you need to have enforcement loss. In this case it did not happen the other cause of ship collision can also happen because you know all this software facilities needs supply. They need food they need replenishment, supply of equipment's, repair works tools and tackles have to go come back, people have go and come back. So, this ships may go and against offshore facility and then load unload. During this process if any of the engine fail or human mistake you know when they are steering away you could see that they can actually make mistake everybody can definitely make mistake.

So, they can go and hit the structure inadvertently with a higher speed could not control because sea conditions are difficult to manure. So, there is a possibility that though you have actually avoided larger ships going to the field, but also the smaller ships coming to the your location can cause damage. That means we need to have fore thinking what could be the possibility of a shipping impacting the vicinity, what could be the size of the ship, what may be the velocity of arrival.

So, all those things you need to just look at it and evaluate the risk of and basically how much risk you would like to take higher the risk you want to take lower the design requirement, you do not want to take any risk that means you need a design for the possible maximum ship that you would like to come across this vicinity and design for it. That is exactly the problem the decision making is going to be very tough because whenever you are locating an offshore facility you do not want to have very close to fairway where the large commercial ships are going trade ships. So, you may be you

ignore no commercial ships, but the supply boats coming to the facility for sure you have to include in your design.

So, API have certain requirements that if you are designing offshore facility design for certain vessel size, but that is only based on the recommendations for their jurisdiction. Whereas, when it comes to other countries you need not follow, but if you follow it will be higher design. So, we are going to see that aspect of ship collision what exactly happens and what you are supposed to do as a designer to protect the structure or not to be decided by the owner. And for sure you need to decide to protect the human life when there is a platform installed and when there is facility where people are living.

So, basically that is the idea behind. There are 2 scenarios one is during impact and the post impact that means when the ship is impacting you suppose not to have immediate collapse of the structure. That means you should absorb the energy and in such a way that the structure deforms sustains and then not collapse that means there is a period of time which allows the people to evacuate. So, that is exactly the design requirement we are going to look at it.

But at the same time we need to have 2 cases one is conventional berthing of this ships to the structure which is everyday going to happen, every day you are going to bring some ships berth that is operational impact. That means you know note that there is no damage to happen whereas, the accidental impact which could happen due to failure of engine, sea conditions unfortunately higher than expected man made failures, errors. So, those things may happen and that that cases structure may get damaged you may have to repair it in the future to bring it back to service, but not necessary that it should collapse.

So, you need to have a redundancy in the system that the structure has got sufficient research trend that it is not collapsing immediately. While doing all of them we will see that we are not going to design based on allowable stress limiting our stresses to fraction of yield, we are going to go beyond. So, that is where we have the so called elasto plastic design I think few classes back we were looking at it in fact the difference between elastic stress distribution versus elasto plastic and plastic and we were deriving the safe factors for simple rectangular shapes, circular shape, hallow sections and so on.

And we define the safe factor how they actually behave and then we went down to define the collapse for simple boundary conditions pin pin conditions fix fix conditions. So, for

a simple structure of single span you have boundary conditions influencing, cross sections influencing, type of load influencing the collapse load. So, those things we already had some idea we are going to use that concept rather than simply going for a simple elastic beam theory, bending moment calculated, elastic section modulus, allowable stress, applied stress.

So, those things we will not use it because that may prove to be too expensive so that is why our idea has shifted from allowable stress to a stress based on ultimate strength of the structure until failure. So, this whole subject is very important in terms of you know the ultimate strength principles are going to be used in doing so we will also compare every time when we are applying. For example, when we are going to look at the system analysis we will look at what we have learned over last 20, 25 classes where we look at actual stress actual and bending stress interaction and we just had a linear interaction you know p by p a plus m by m a.

Here, we will look at it when you go to beyond yield how the linear interaction becomes nonlinear and why we are actually using the linear conservatively I mentioned in that day. So, will just look at comparisons all the time so that we could see what extra strength available when you go to non-linear and when we design allowable stress we actually go for conservatively taking the linear principle. So, I think this is a quite a important subject in the design of offshore structures we are going to look at 3 aspects fire blast and ship collision of course, the dropped object if you have time we will try to do this because it was not part of the syllabus.

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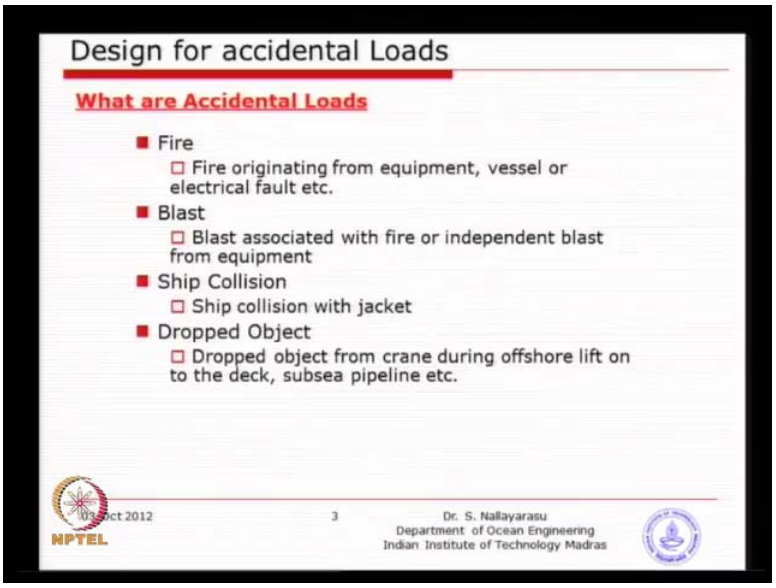

So, basically these are the accidental loads which I think I have spoken about enough fire, blast, ship collision and then the dropped object. The dropped object is specifically from you know the crane it is not the dropped object from air craft. You do not think about that kind of ideas is basically we are handling equipment's and basically supply from onshore to offshore. So, when you are lifting from boat to the platform failure of things can happen like rigging can fail, crane can fail because of overload you know sometimes you know you try to lift slightly excess loads, but forgetting about the dynamics associated.

You know you are lifting of a boat is moving up and down you may have a dynamic amplification. So, when you are doing trying to do that the crane fail and it falls down. So, all those things needs to taken into account. So, basically dropped object is a similar problem to ship collision except that the impact is coming from falling object. Otherwise, the principle of design is exactly same you are going to have a impact energy and you are going to look at what type of damage happened how much energy is absorbed while the structure is deforming whether it is a shipping or is a dropped object.

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The idea behind in designing against this accidental loads is to implement active passive mitigation measures is very important you could possibly think that I would design a structure which is robust enough like. You know olden days you know even now some sometimes people design in military bunkers I think you might have heard underground bunkers possibly make it so strong, so thick concreate underground even a big bombs can actually save the human life from them. You know because is buried underground you have a very thick concrete I think some of you have might read in the newspaper many countries have underground bombs shelters.

That is possible because enormous amount of energy can be absorbed by the earth and the ground conditions. Imagine you want to build a bunker on offshore platform it is impossible because the energy can cannot propagate down there and structure will actually before the bunker fail the structure will fail. So, to make the structure bigger you actually have to fill up earth. So, that is why the underground bunkers are different the design aspect compared to a design for explosion in offshore you have to make it flexible.

Once, you make it flexible what happens the energy is being absorbed by means of deformation once large deformation is there then what happens the external impact is absorbed by the internal work done by the structure as displacement times the force

introduced. So, the idea have to be slightly different rather than making a structure which is so rigid, but the foundation is week because the structure will collapse.

So, what we are looking at is active and passive mitigation measures both in terms of structural design as well as other forms of mitigation which can actually reduce the impact ultimately. One important thing principle you need to remember there is absolutely not possible to have a 0 risk nobody is able to come up with a design you could you could come theoretically, but practically making a risk to 0 is impossible.

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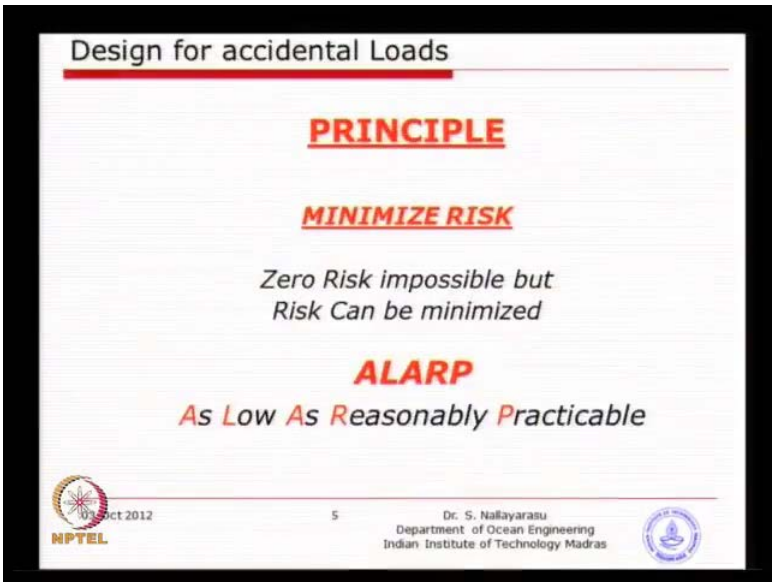

So, what we are trying to look at is minimize it as much minimize the risk so possible practicable you could achieve the same amount of risk at excessively higher cost impossible to implement, but that is not practicable. So, that is why you need to make sure that whatever is possible today you should do it not think about 100 years later I did may be not possible with the technology. If you look at this aspect 20 years back several things what we are doing is impossible. You know basically because of the changes of technology material changes of you know situation, changes of lot of other conditions and basically you need to see what is possible today and implement. So, risk cannot be implemented you need to minimize the risk.

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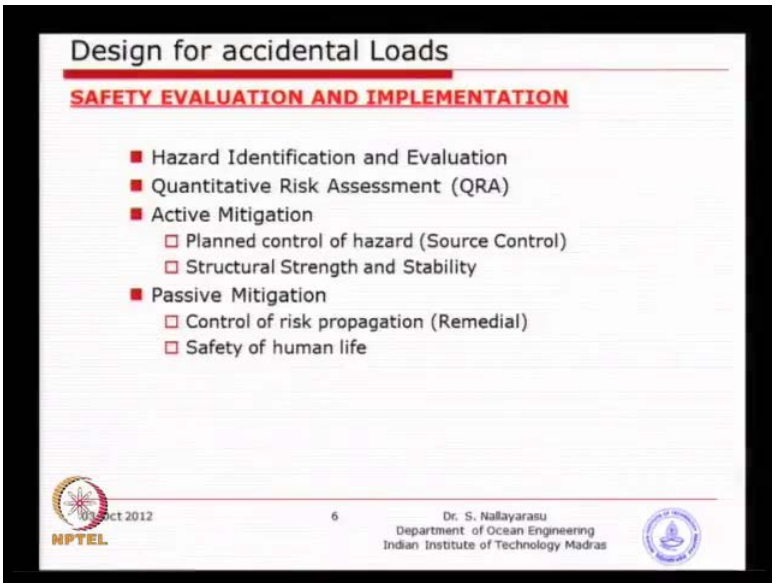

So, before we go forward towards trying to design we need to identify the hazard. Hazard is nothing but something that is going to create or generate is use to the design activities what we have carried out. So, hazard identification and evaluate them not only qualitatively you can say there is a fire what is the temperature of the fire, what is the extent of duration, what is the extent of size and basically that gives you a feel that what could be the damage that can be done by that fire to the structure.

So, basically you need to evaluate quantitatively not only that the frequency of occur ration of occurring how fast how quick the repetitive nature of this fire can occur which could actually give you a feel that you should include either in the general class of loading or it should be the special class of loading. So, quantitative risk assessment is part of any project whether it is onshore building, bridge, offshore platform you need to evaluate the risk, quantify them and then take a call. For this risk we do not want to call it a general class of loading we will exclude it from general design, but you can actually go for a special design.

So, quantitative risk assessment normally done at the start of the project and then re-evaluated at the end of the project you know once you have planned something and then revisit the risk at the end of construction to see that whether all the possible things that has been implemented or not, but the basis of the whole design process will be based on this QRA study which will be done as early as you are thinking about the facility. Active

mitigation, passive mitigation I think you can see here planned control of hazard if it is a manmade I think surely you have control over it, but if it is a natural hazard probably not feasible to control for example, earthquake can we control the earth quake we may not be able to do that similarly, storm, cyclonic storms or seasonal storms you may not be able to control.

So, those kind of source control is not feasible for natural hazards, fire for sure you can control you can make all the equipment's fire safe so that no spark can be generated, no leakage of gas even if there is a leakage automatic shutdown. So, lot of things that you can implement in the system so that the planned control of hazard can be. While doing so you evaluate the risk you have done whatever possible today whatever system control you have done you have implemented. But after that you can go for each of the activity at the end of your design I have implemented a flan proof instruments, spark proof switches, liquid you know leakage proof all your pipes and vessels. But what is the probability of that particular equipment or the facility failing. So, every one of them will have a probability of failure.

So, you collectively call all those probability of failure of individual components and you can just come up with a situation where what could be the probability of occurrence of a particular hazard like fire. And for that you evaluate the structural strength if that happens what could be the potential strength I require and design it. So, basically that is the active parfait. Passive basically control of risk propagation you know you are not having hydrocarbon facility everywhere only a hydrocarbon we will have facility for living people are living for operating this equipment's.

You may also have facility where you produce support system for human life for example, you need drinking water isn't it for sure they need water, they need definitely a water making system, they need electrical power there will be a electrical power producing system, they may require additional other facilities. So, you will actually segregate this in a safer location, but the fire occurs on a hydrocarbon location where you do not want that fire to propagate to the living facility. So, basically control of risk propagation by means of additional things you incorporate.

For example, this is the hydrocarbon area where you have some equipment's and facilities the next room may be somebody is living there. So, you can make this barrier

stronger enough to resist fire isn't it and stronger enough to resist the blast so you make a blast proof barrier. By implementing this you are actually reducing the propagation of the risk from this room to the next room so you can actually implement this, this is basically a indirect means of reducing the risk.

Ultimately, what we look for is protecting the human life on that side basically the all this passive requirements trying to save the people give them enough time if there is fire at 0 time here give them half an hour. So, that they can escape that means you need to have systems in such a way that when there is a fire alarm should go on automatically that means that alarm should not get damaged during that fire. So, that alarms should be fire proof alarms, so lot of things can be implemented. So, passive active in actual industrial design we do not differentiate, actually we put few systems together multiple layers of protection you may have active and passive mix with the structural design. So, that one fail the next one will take over.

Typical example will be you have a fire barrier you will also have a fire sprinklers like water sprinklers when the fire occurs immediately the sprinklers should get on and spray water on top of the fire though we have a fire barrier where people are very safe does not mean that this will not switch on the fire sprinklers automatically it will switch on. So, you will have several layers of protection so that even one of them fail still can save the human life.

So, the safety evaluation is a very serious business and is actually a very long large topic I do not think we want to go in very in depth in this subject, but is itself is a discipline health safety issues are very important and health safety issues can actually come out as a design issue. You know we will talk about lot of health and safety issues, but then each one of the health and safety issue could actually propagate as a load condition for the design of the facility which will change the design that the way that you are making.

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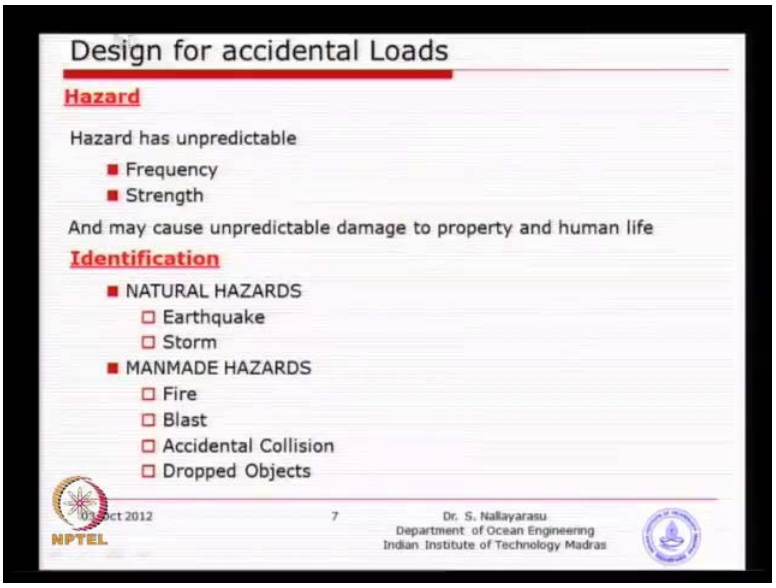

So, hazard what we require as a designer structural designer we require to know what is the strengths you know fire can occur, but if it is only just a minor fire does not matter, basically we need to know the strength and the frequency basically what is the frequency of occurrence which will come out of the safety studies depending on type of facility. And may cause unpredictable damage to property of human life all this hazard can create such a trouble that you may not be able to design. For example, you possibly cannot think of designing any facility for aircraft impact like what happened into twin tower, possibly you think about design it makes, such a systems that it may not be feasible to even construct and that is where you need to identify certain things that you can exclude.

Among, the hazards basically the natural hazards are very easy to identify so far earthquake storm, storm includes all the propagation of sea conditions it could be cyclonic storms or it could be seasonal storms or it could be tsunami induced wave motion. So, all related to the ozone conditions earth quake I think all of you know the reason for the earthquake is basically the plate tectonic changes. So, basic problem is we got identified when it will occur what could be the magnitude.

Similarly, the storm at least storm we have a reasonable idea now a days at least in the modern times we have some amount of knowledge that we could predict the storm can happen in a reasonable time period next few days, next three days, four days at least

some predictability is there. Whereas, the earth quake unfortunately have no means of identification when and where and how much will be the going to happen.

The man made hazard I think we have seen all 4 of them is very easy to identify if you know what you are designing for then you will be able to come up with whether fire will occur or fire will not occur similarly, blast and collision of ships. So, all this are under our control to some extend not to the 100 percent extend that you could say day after tomorrow there is a fire going to be happening for sure you could not predict, but at least the extent to which it may actually damage you could predict to some extent. So, that your design can be implemented accordingly in many cases we do that, but beyond our control sometimes the expected things may not happen it go beyond you know the destruction could be higher than what we have estimated.

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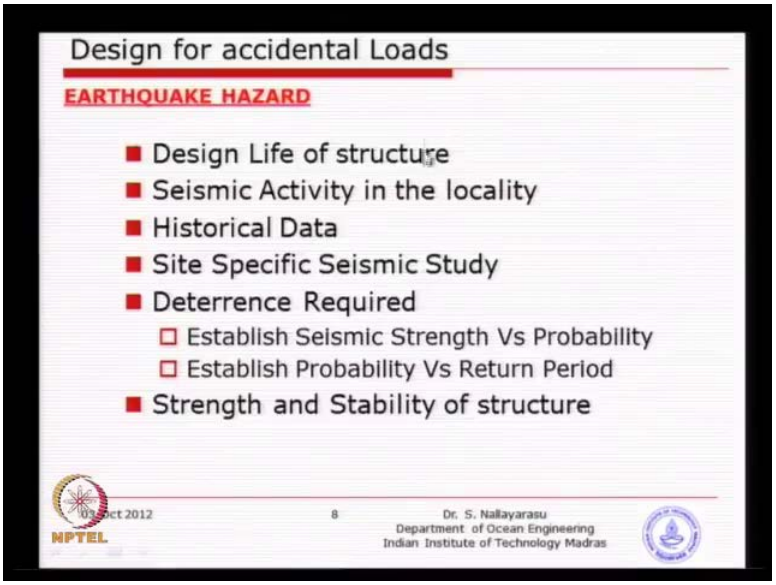

So, in earthquake hazard what we are looking at is basically the design life of the structure, seismic activity in the locality. Wherever you are constructing your structure, historical data of what was happening over last few 100 years because this will give idea what needs to be designed. Because this is an unknown hazard very difficult to design for, site specific seismic study, which should you know several specialist engineers are available. You can give them a chance to evaluate based on the tectonic plate arrangement at the locality and come up with the possible probability that when, and how

much could be the potential the seismic acceleration, depending on the locality of the structure from the past data, what you have collected over the last several 100 years.

So, this seismic study is basically again a kind of prediction means of using old data and using the geological features of the earth's crust and they will come up with this could be potential and that is how if you look at several countries every country has got their own seismic codes. They come up with predicted values benchmark by previous history what has happened in that locality and every time when new earthquakes comes you change the codes because every time it comes something new because it is so unpredictable.

And then we look at this 2 things, strength versus probability, probability versus your return period you link it and you know what is the design life, if you are designed life of the structure is 100 years for possibility of definitely we need to look at previous few 100 years and just predict for next few 100 years and use that information to decide what strength of the earthquake I should use it for the design. If it shorter the duration the probability of that bigger earthquake happening will be small, longer the duration of structure design life the possibility of occurrence of that earthquake within the designed life is higher.

So, you could you could actually see the link between designed life versus the risk of an particular event to happen. So, that is why very important once you decide that designed life immediately linked with the strength of the hazard that is going to happen. If the structure is very temporary for example, you are only having the structure for 1 year then you could possibly reduce the strength of the earthquake because that maximum earthquake happening in this particular year you can calculate the probability will be very small so you can reduce.

And then finally, once you have all that analysis done to arrive at the strength of the earthquake which is nothing, but the ground acceleration then possibly you can design the structure for that particular. So, every structure in built in the earth possibly designed for this kind of condition depending on the strength of the earthquake in that particular locality depending on the country, depending on the location.

So, I think most of you might have studied in our country we have code IS code which classify the whole country into several zones, zone 1, zone 2, zone 3 and so on. So, higher the zone number will be the higher the ground acceleration happening and you

take that ground acceleration design the structure which I think we have look at it in the design load case time. Those I think in module 2 we were looking at how to calculate the acceleration forces basically mass times the ground acceleration including the dynamic effect. So, basically that design is done and you have a probability of non-failure of the structure because you have designed for it.

Storm hazard exactly similar we have done exactly calculation of wave heights, wave periods, return period's, maximum wave heights calculate the wave loads and design for it.

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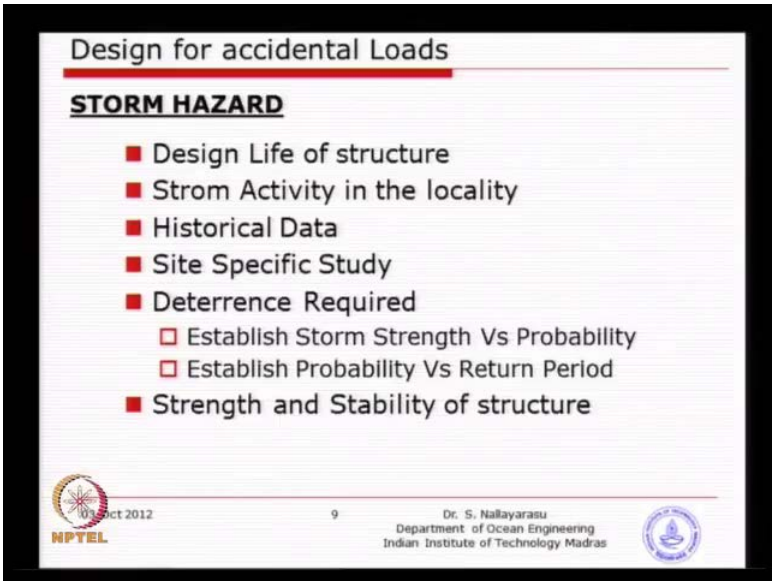

So, strength and stability has been achieved by means of predicted value of hazard as long as they do not exceed your structure is safe.

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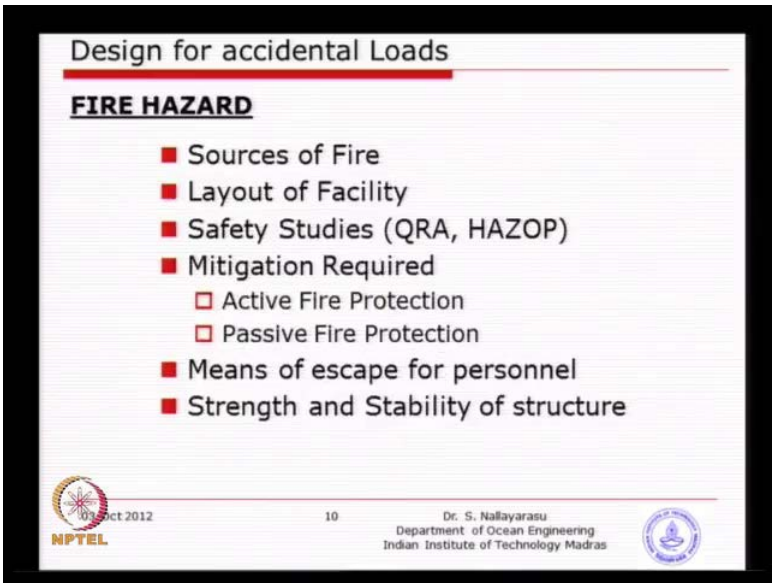

Fire hazard basically what we need to look at is the source of fire important is a layout of the facility very important that you organise yourself do not put your kitchen in the middle of the house isn't it you put it there. In case of fire, the fire spread in all directions so that is why you will see most of the layouts, whether it is due to technical reasons or due to vasthu you can see the fire or the source of the fire, or the kitchen is kept in one particular location at the one corner so that the fire does not.

Similar, idea when you are building a hydrocarbon facility you need to make sure that safe zones, unsafe zones unsafe does not mean that the location is not unsafe is basically the chances the probability of such event happening is higher because of the dealing with hydrocarbons. So, you just segregate so the layout of the facility is very very important that you organise yourself that the propagation becomes less risk to human life.

And then the safety study is basically to find out the probabilities and the risk. This the idea of HAZOP basically hazard and operability in a basically very simple step when you are getting a gas cylinder at your home you must make sure that it is leak proof number one. The seal is intact and you should know how to operate if you do not know any one of them can happen for sure you are going to have fire isn't it, you do not know how to open how to connect. That means you have not been having sufficient experience to connect it you have not been trained or you do not know how the valve works.

So, basically that hazard and operability is highly linked the safe equipment can become unsafe because this particular operation was done in a unsafe manner or the inexperienced person has been operating that particular equipment. From nowhere a hazard can be created that is why this hazard and operability study for each of the activity that is going to be performed in the facility needs to be carried out. So, every one of them needs to be documented so the next time when this guy goes to operate a valve you should know which is the close position which is a open position. Instead of closing he can actually open it and make the fire happen and that is what had happened in the past. Several accident in offshore is actually due to human error because things were going wrong.

Mitigation required I think we spoke about it early on active passive which we will elaborate it later on, and then means of escape to the personnel in case of fire they should have sufficient time number 1 sufficient strength of the structure along which, they are running around should actually be there. You know they should not be running towards the fire to reach a boat if there is a boat on the other side and there is a fire in the middle they should have a boat on the safe side of the facility.

If you ask them to run across fire they will die before they reach the boat. So, basically you need a planning in such a way that the means of escapes should be safe path so that they can reach either a life boat or a other means of safe locations. Sometimes we do have safe locations where they can stay for a longer period of time prior to external help arriving, do not expect them to jump on to water all the time that will not be a very safe especially in cold climate like if you go to Narsi if they are on the platform, they will live if they jump out of the platform for sure they will not be able to survive because the temperature are sub 0. So, it will be impossible for them to survive for few minutes.

So, basically means of escape needs to be designed not only in terms of location also the structural strength while they are running the beam should not collapse they will go together with the. So, that means even if there is a fire along that particular escape path structural strength and integrity should be maintained for the duration of the escape required. So, if you are expecting this people to reach that location by say 20 minutes, 30 minutes the structure should not fail even if there is a fire or other form of hazard exist. So, that means the strength and the stability becomes very important in this particular case of issues.

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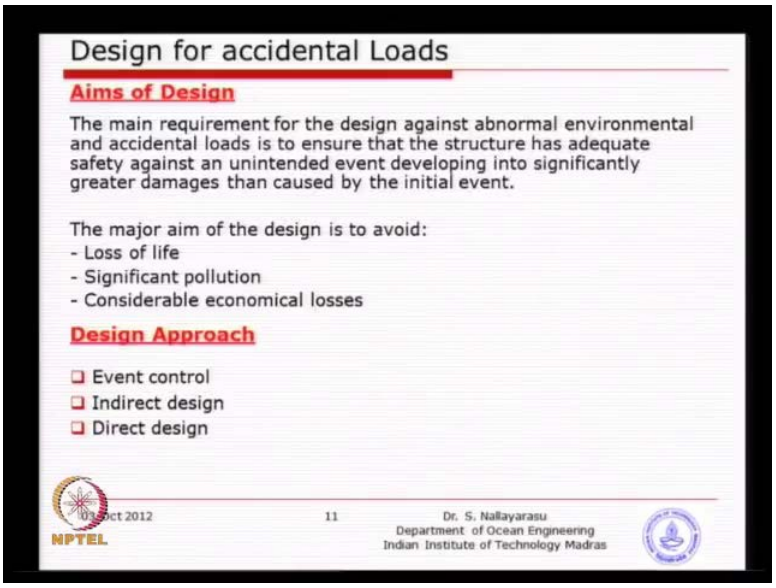

I think we have discussed about this aims of design the first priority is given to loss of life to avoid loss of life not making them to die. So, the idea is not the structure and the property that is the secondary. The second one is significant pollution you know now a days this pollution control is very, very essential compared to 30 or 40 years back now if you have a pollution you have a serious damage to your property also to your organisations. So, you have to make sure that in case of fire pollution is under control or you could control afterwards without spreading to larger area of extent you know that is very important.

Then finally, you come to a situation where try to make reduction in the economic losses. So, basically implement system in such a way that your system is not going to collapse totally you can actually come back and then rebuild it with a minimum amount of economic losses so that is the idea. That will be the last one and basically the design approach we have seen even control indirect and direct design I think we will see one of them one by one.

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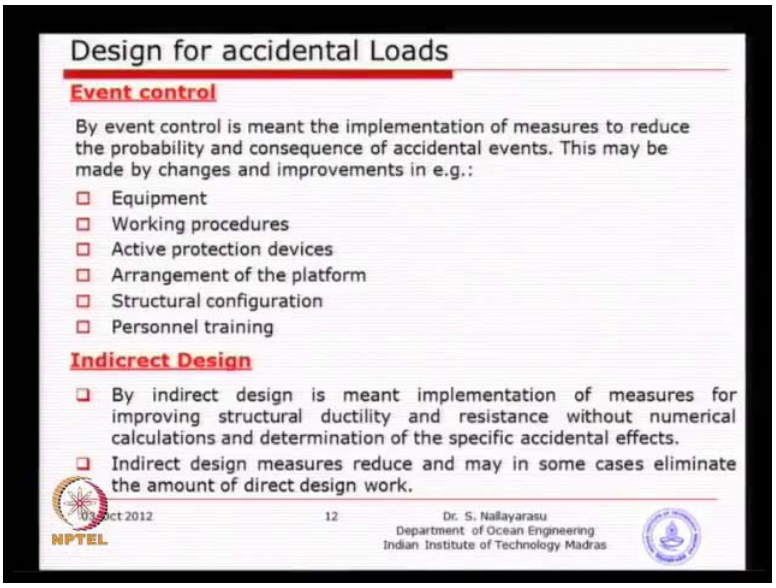

Even control basically working procedures, selection of equipment, active protection devices like alarms and systems, arrangement of the platform from safe to unsafe in the decreasing order of the risk and then structural system configurations, design in such a way that even if one area is under fire, even that part of that structure collapses the reminder part of the structure is stable. Imagine you have only one leg what will happen if one leg is falling down the structure is no more, but if you have several columns even one part of the column or one leg is failing the remainder of the systems will be able to sustain for some more time. So, basically the structural design is very important the configuration of arrangement.

Personnel training that is the most important one, even a safe system can be made very easy to unsafe by the human practice. So, that means you need to train them to make sure that they are able to operate it safely. Indirect design we are going to do that in terms of selection of material, selection of you know basically the system design implement indirect messes in the structural configuration that even such incident happen it may not collapse, I think we will stop there you have class know.