Offshore structures under special loads including Fire resistance
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Module – 03
Fire Resistance
Lecture – 43
Blast Resistance I

Friends, welcome to the lecture 43 in module 3 where we are discussing about methods on Fire Resistance under the NPTEL course titled Offshore Structures under special loads including Fire Resistance. In this lecture and subsequently in another lecture, we will discuss about methods and parameters that control blast resistance in offshore platforms. So, this lecture is Blast Resistance, in the series of that lecture we have the first lecture on blast resistance now.

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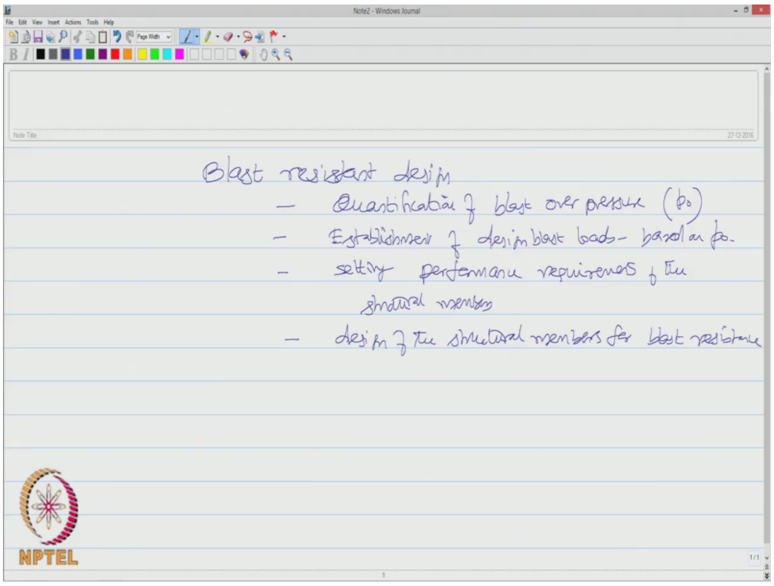

In the last lecture we said that blast resistant design should emphasize quantification of blast over pressure p o, establishment of design blast loads based on over pressure, setting performance requirements of the structural members and design of the structural members for blast resistance.

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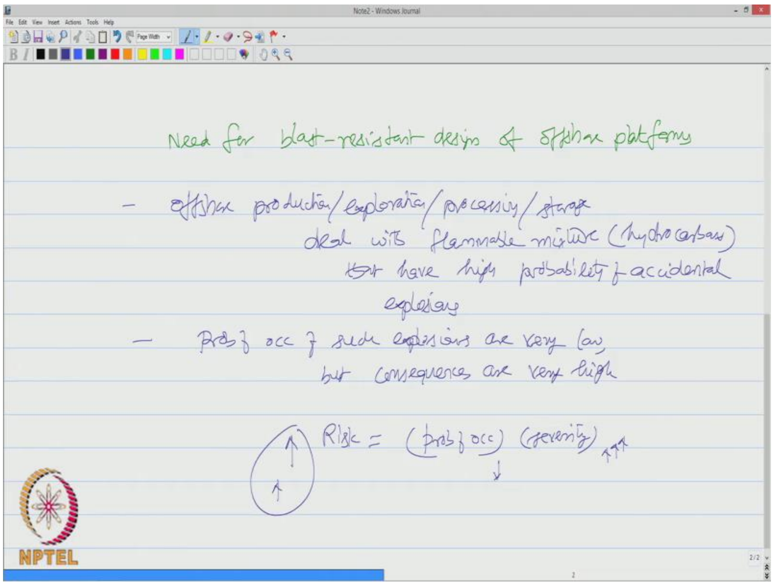

Let us ask a question what is the need for blast resistant design of offshore platforms? Friends we do agree that offshore production platforms, in fact, even exploration platforms and to some extent even processing platforms and to a large extent storage vessels deal with flammable mixture let us say hydrocarbons; that have high probability of accidental explosions.

Even though the probabilities of occurrence of such explosions are very low, but their consequences are relatively very high. We all agree and know that risk is actually a product of probability of occurrence of an event and its severity, even though the probability of occurrence is lower in case of explosions occurring from flammable mixtures, the severity or consequence is very very high leading to a very high risk factor involved therefore, offshore platforms must be blast resistant.

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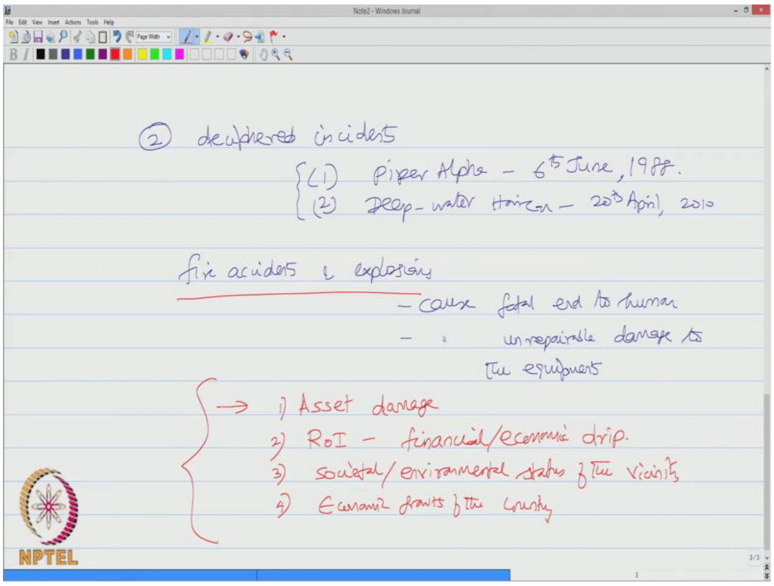

We can quote 2 deciphered examples; I should say 2 deciphered incidents which demand the necessity of blast resistance; the piper alpha incident which occurred on 6th June 1988, the second is accident happened on deep water horizon, which happened on 20th April 2010. These are 2 classical incidents quoted as standing examples which emphasize the necessity of explosion protection or blast resistance of the structural members of the platform.

So, fire accidents and explosions cause fatal end to human as well as cause un repairable damage to the equipments, what I should say is they cause a proportional value of asset damage, it effects to return on investment leading to financial or economic drip which also effects the societal and environmental status of the vicinity and it anyway affects the economic growth of the country.

So, fire accidents explosions are very severe long term consequences therefore, it is important that even if these accidents occur very rarely the consequences arise from these accidents should be controlled to the maximum possible limit so that the platform damage or the asset damage is as far as possible limited within acceptable standards.

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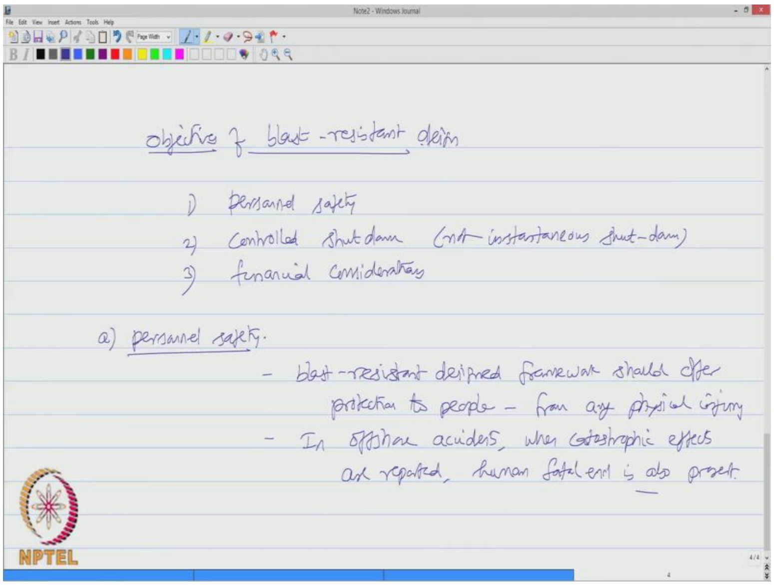

Let us ask a question what are the objectives of blast resistant design? What are we going to achieve? It has got 3 objectives; the primary objective is personnel working on board and their safety; second is it should enable a controlled shutdown not instantaneous and it should also consider and deal with financial considerations that arise as serious consequences or aftermath of any such accidents.

Let us talk about the objective expanded further on personnel safety. Blast-resistant-design framework should offer protection to people from any physical injury we have seen that in offshore accidents, when catastrophic effects are reported there has been some human loss present, this should be avoided because the risk involved in this kind of personnel safety is much larger under the societal image of the company.

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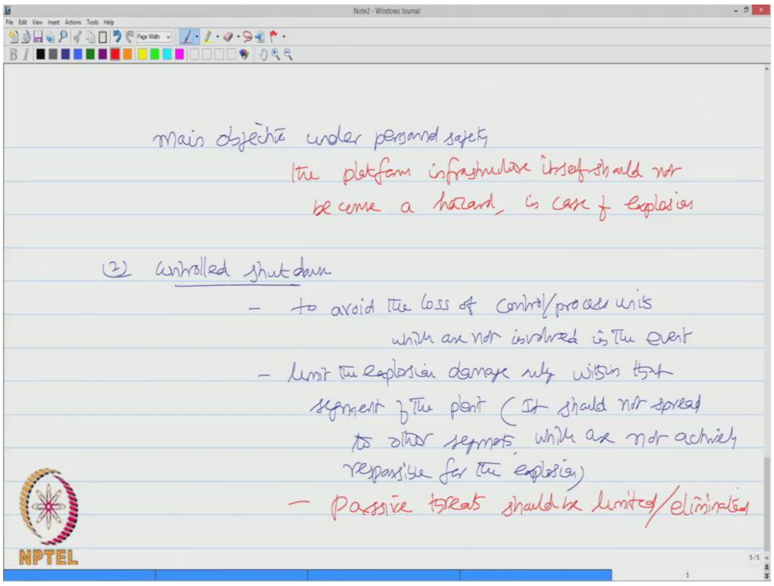

So, the main objective under personnel safety is that the platform infrastructure itself should not become a hazard in case of explosions. So, that is what we are trying to say. Let us talk about controlled shutdown, here the objective is to avoid the loss of control or process units, which are not involved in the event, I mean if the explosion is epicentered under specific segment in a flow line or process line, we would like to limit the explosion damage only within that segment of the plant, it should not spread to other segments which are not actively responsible for the explosion.

So, on the other hand passive threats should be limited in check. In fact, it should be completely eliminated.

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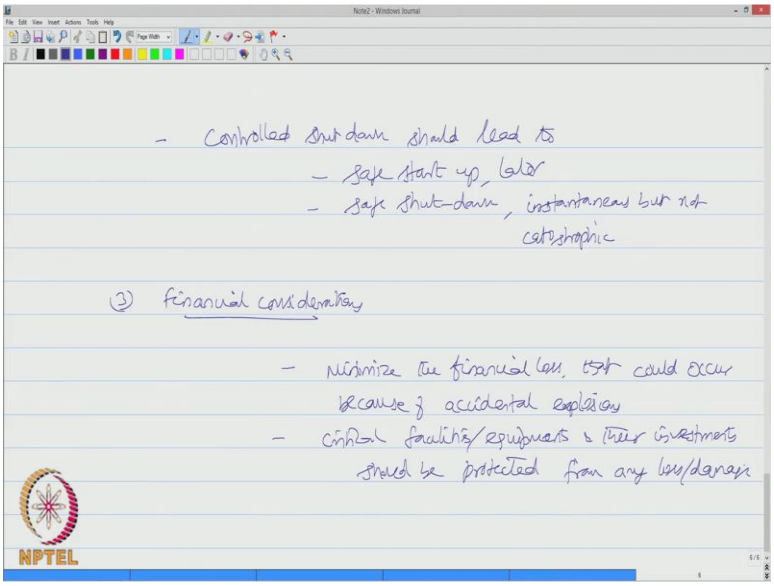

So, controlled shutdown should lead to safe startup later, safe shutdown instantaneous, but not catastrophic. Let see what will be the objective of blast resistance under financial considerations; blast resistant design should minimize, the financial loss that could occur because of accidental explosions, critical facilities equipments and their investments should be protected from any damage. Let see what are the blast resistant requirements? Blast resistant requirements anyway should follow standard procedure and international recommendations.

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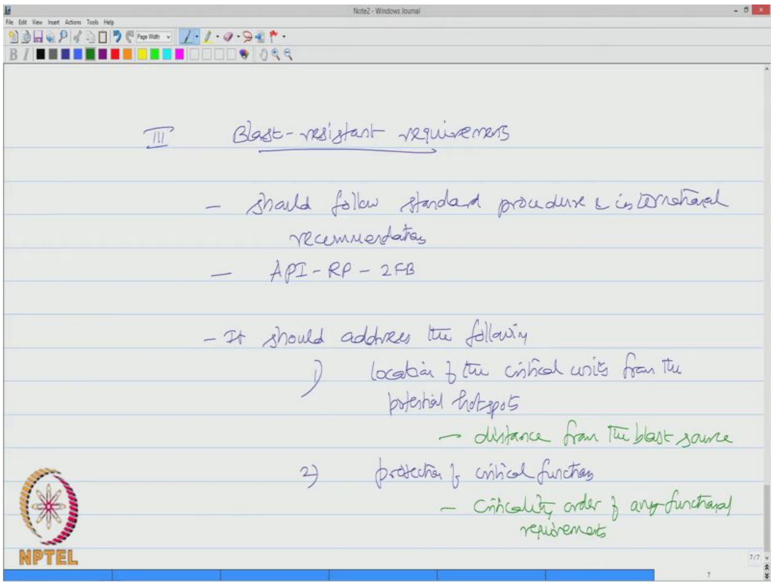

So, one recommendation which is very commonly prevailing in offshore standards is API recommended practice, 2 FB which deals with standard procedures and practices to make the system blast resistant, it should address the following; one location of the critical units from the potential hotspots because distance from the blast source is one of the important parameters, which controls the blast resistant requirement.

The second factor could be protection of critical functions because criticality order of any functional requirement is also another factor which governs blast resistant design.

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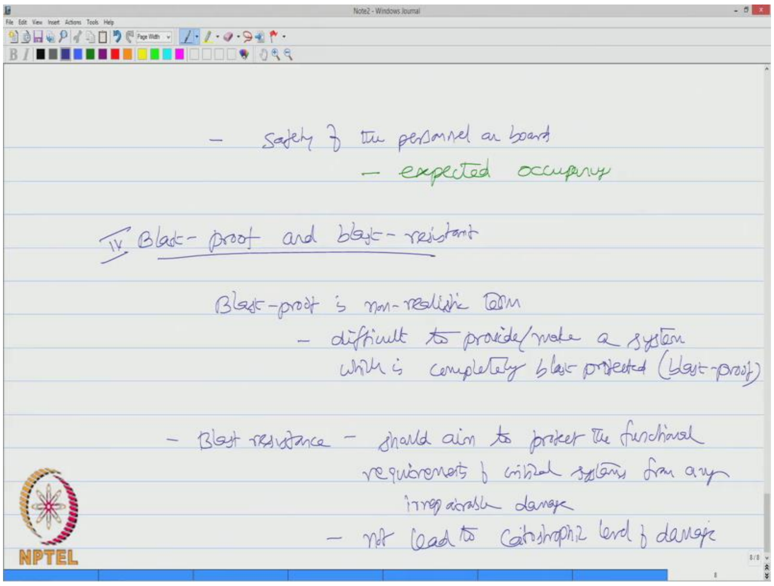

And thirdly safety of the personnel on board because expected occupancy is another factor which governs the blast resistant design.

Let us quickly ask a question what is the difference between blast proof and blast resistant? Blast proof is actually a non realistic term, it is very difficult to provide or to make absolute to make a system, which is completely blast protected that is let say blast proof therefore, blast resistant design should aim to protect the functional requirements of critical systems from any irreparable damage, it should not lead to catastrophic damage at any cost.

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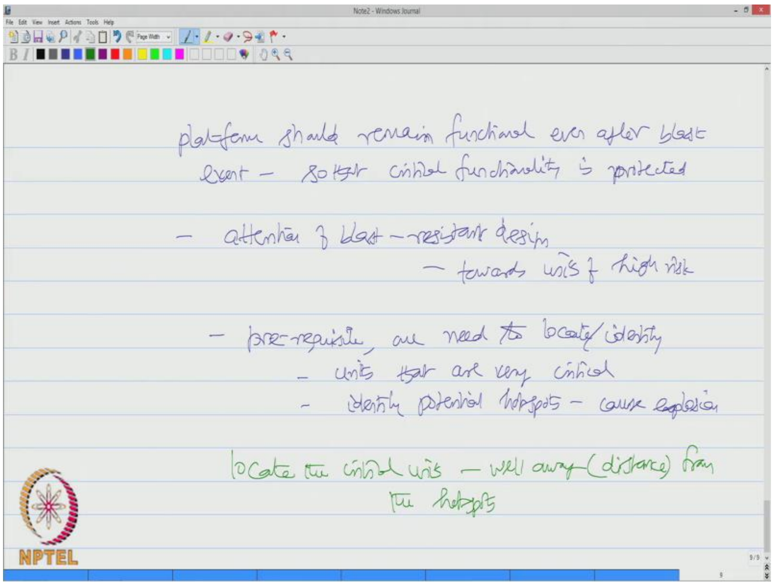

So, the objective is platform should remain functional even after blast event, so that the critical functionality is protected. So, the attention of blast resistant design is always towards units of high risk. So, as a prerequisite one need to find or one need to locate identify units that are very critical as well as need to also identify potential hotspots, which can cause explosion and therefore, locate the critical units well away in terms of its distance from the hotspots, because as you know distance plays a very important role in blast resistant design.

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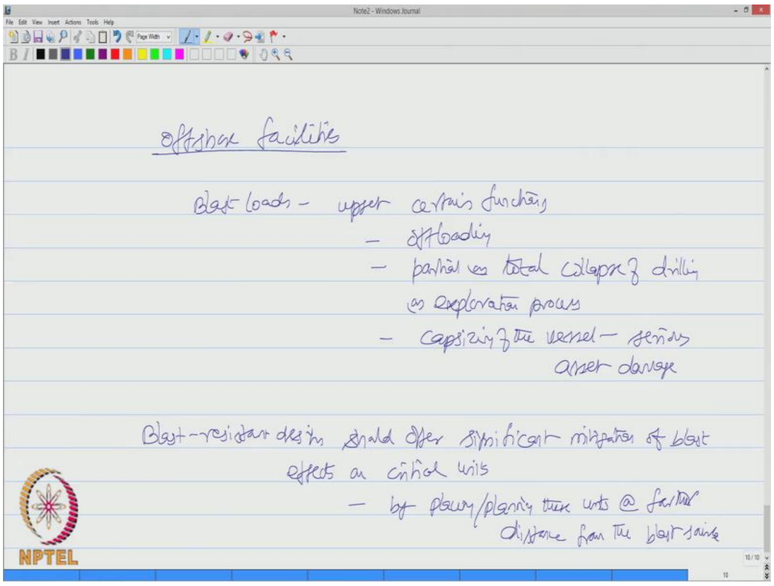

Let us apply this discussion to offshore facilities; blast loads can upset certain functions namely offloading, partial or total collapse of drilling or exploration process or also result in capsizing of the vessel itself creating very serious asset damage to the company therefore, blast resistant design should offer a significant mitigation of blast effects on critical units, this can be achieved by placing or by planning these units at farther distance from the blast source.

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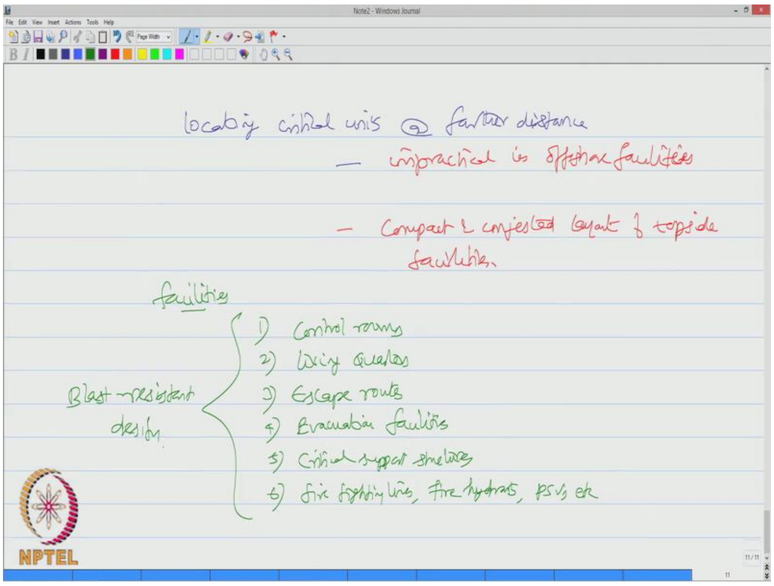

But interestingly friends locating the critical units at farther distance is practically not possible in offshore facilities, the reason being we are looking for very compact and conjested layout of all topside facilities.

Then can we list some of the important critical facilities which should be covered under blast resistance? So, the facilities which are important to be covered are the following control rooms, living quarters, escape routes, evacuation facilities critical support structures and lastly fire fighting, lines fire hydrants PSVs etcetera. So, these should be covered under the scope of blast resistant design of offshore facilities.

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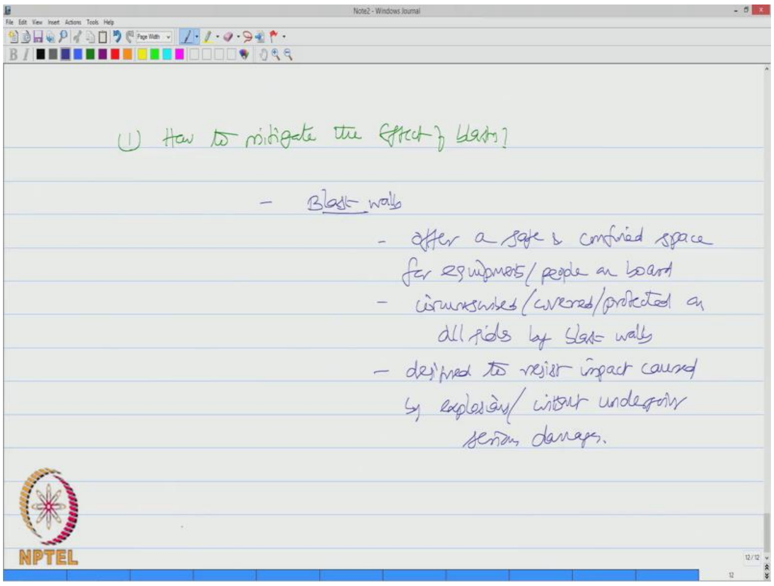

Next question comes how to mitigate the effect of blasts? One interesting answer is construct what is called blast walls. Blast walls offer a safe and confined space for equipments and people on board, which will be circumscribed or let say covered or let say protected on all sides by blast walls, blast walls are designed to resist impact caused by explosions without undergoing serious damages.

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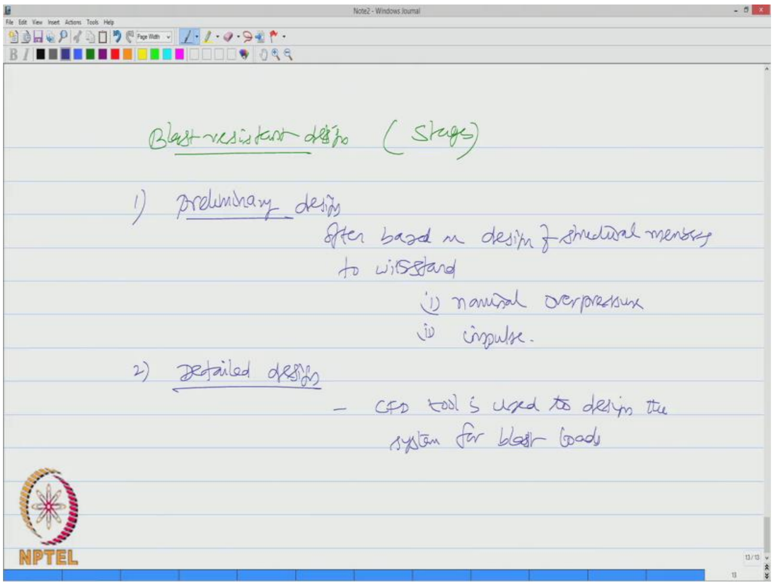

When we talk about blast resistant design, there are various stages let us talk about the preliminary design, which is often based on design of structural members to withstand a nominal over pressure and impulse. The second stage could be detailed design, computational fluid dynamics tool is used to design the system for blast loads.

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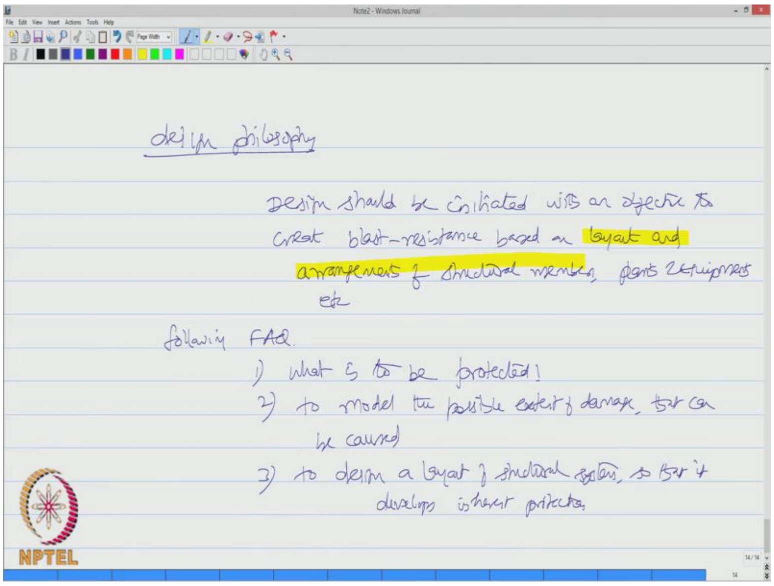

In detailed design the design philosophy focuses on the following methods, design should be initiated that or with an objective to create blast resistance based on even the layout and arrangements of structural members, plants and equipments etcetera. So, the focus is the design should start with an appropriate layout and arrangement of members. So, following FAQs need to be answered, what is to be protected to model the possible extent of damage that can be caused and thirdly to design a layout of the structural system so that it develops inherent protection.

Now, let us talk about blast loads; we all do agree that an explosion is a chemical process, which results in development of blast waves.

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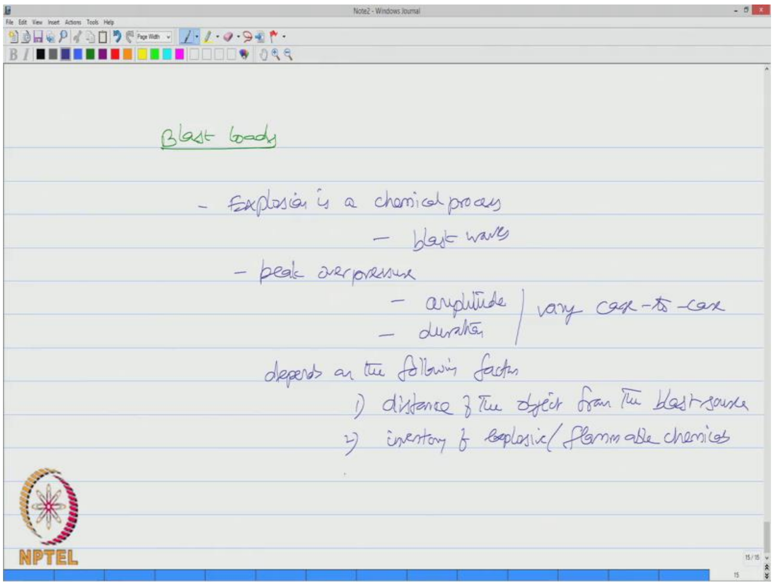

It causes peak over pressure whose amplitude and duration may vary case to case, it all depends on the following factors distance of the object from the blast source, inventory of explosive or flammable chemicals.

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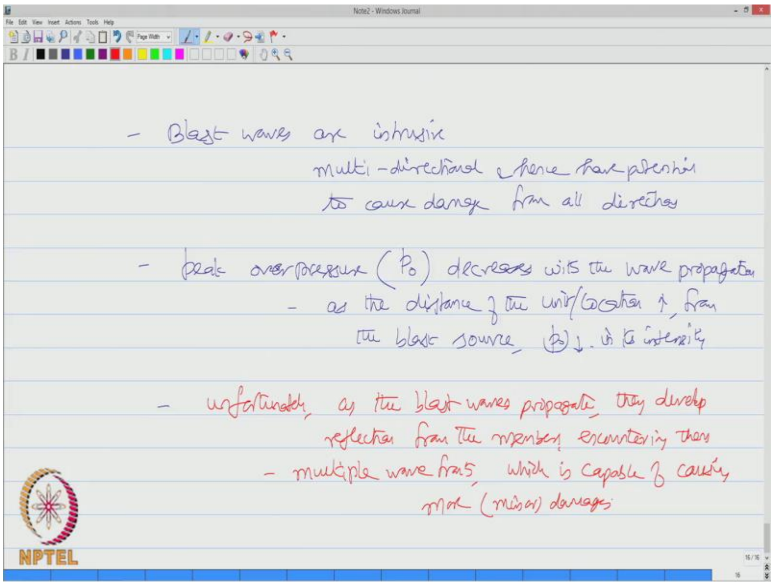

It is interesting to note that blast waves are generally intrusive multi directional and hence have potential to cause the damage from all directions; we also have seen in the previous lectures that peak over pressure decreases with the blast wave propagation, it means that as the distance of the unit or location increases from the source, peak over pressure decreases in its intensity, but unfortunately as the blast waves propagate, they develop reflection from the surface encountering them, this will generate a multiple wave front, which is capable of causing more of course, minor damages.

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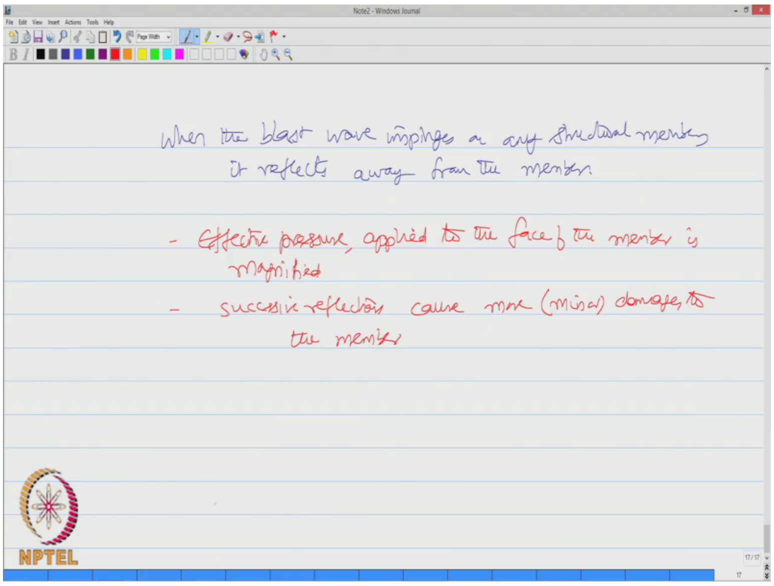

On the other hand when the blast wave impinges on any member or any structural member, it reflects away from the member therefore, the effective pressure applied to the face of the member structural member is magnified. Successive reflections cause more damages to the member.

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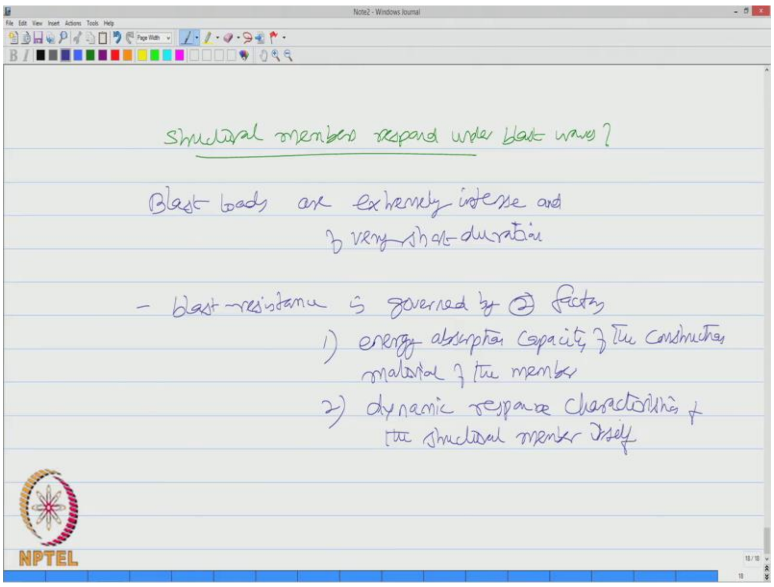

Let us have a look at how do structural members respond under blast waves? We do know that blast loads are extremely intense and of very short duration therefore, blast resistance is governed by 2 factors; the first factor is energy absorption capacity of the construction material of the member, secondly the dynamic response characteristics of the structural member itself.

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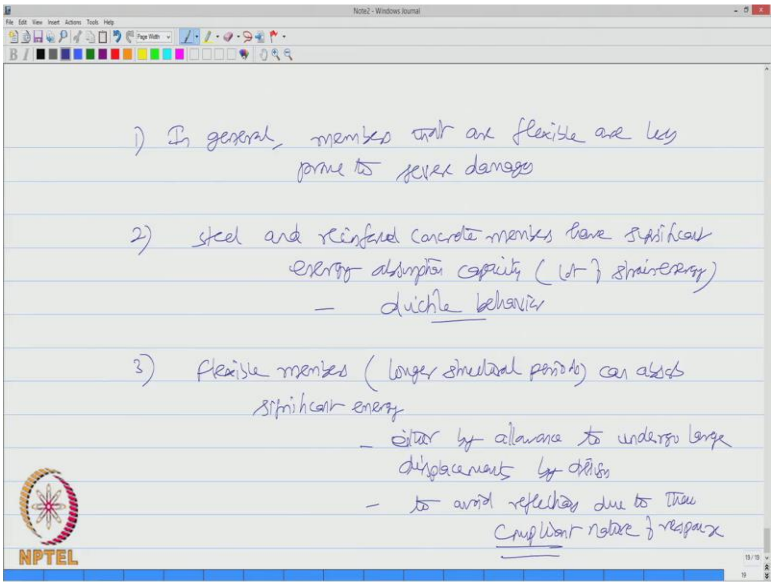

In general structural members that are flexible are less prone to sever a damage that is the first issue we have. The second advantage is steel and reinforce concrete members have significant energy absorption capacity that is they have lot of strain energy stored in the material because of their ductility.

Thirdly flexible member that is members, who has longer structural periods, flexible members can absorb significant energy either by their allowance to undergo large displacements by design or to avoid multiple reflections due to the compliant nature of response. We already said compliancy is a boon in terms of the structural response behavior of offshore structures. Therefore, recent new generation platforms are designed essentially with high degree of compliancy in the design layout itself.

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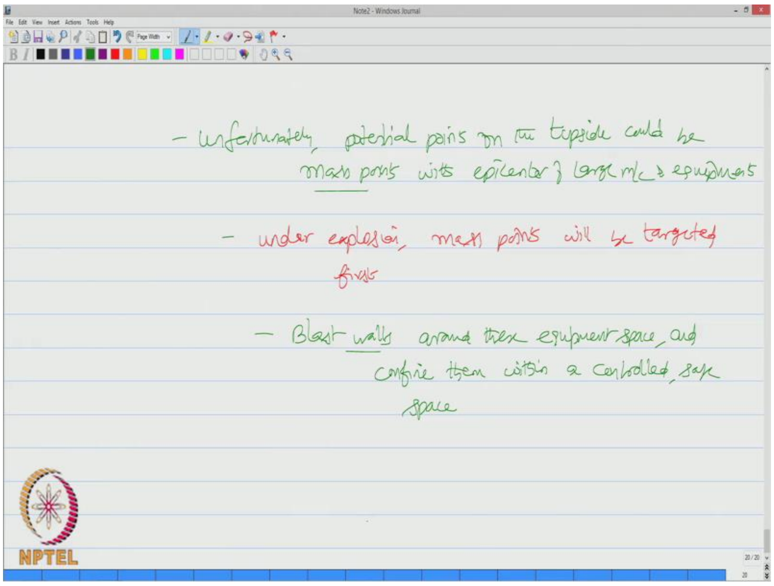

Unfortunately potential points on the top side could be mass points with epicenter of large machinery and equipments because under explosion mass points will be targeted first. So, how to protect these points or these segments which are epicentered to the large machinery and equipments, one can construct blast walls around these equipment spaces and confine them within a controlled safe space.

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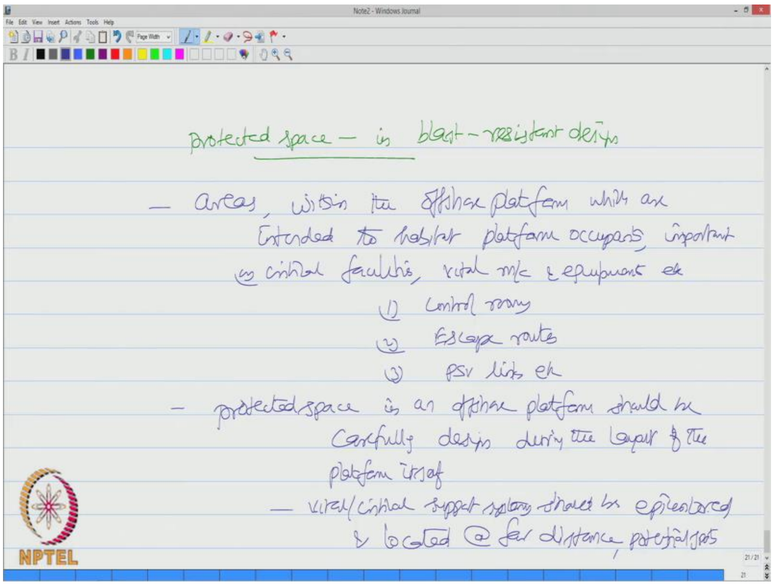

Now, we talk about something called protected spaces in blast resistant design; what is a protected space? These are areas within the platform which are intended to habitat platform occupants, important or critical facilities, vital machinery and equipments etcetera. Example could be controlled rooms, escape routes, PSV links etcetera. So, protected spaces in an offshore platform should be carefully designed during the layout of the platform itself, vital or critical support systems should be epicentered and located at far distance from potential spots.

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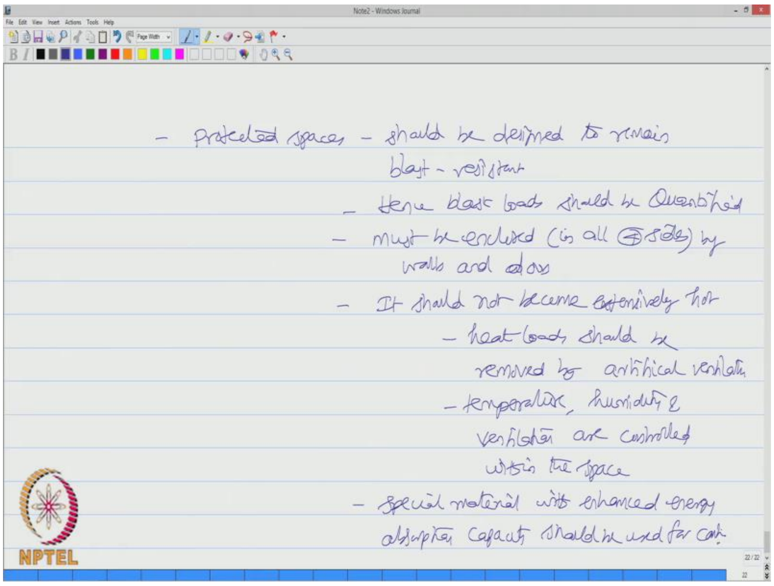

So, protected spaces should be designed to remain blast resistant. Hence, blast loads should be quantified. Protected spaces must be enclosed in all four sides; by walls and doors. It should not become extensively hot; therefore heat loads should be removed by artificial ventilation; so that temperature, humidity and ventilation are controlled within the space. Special material with enhanced energy absorption capacity should be used for construction.

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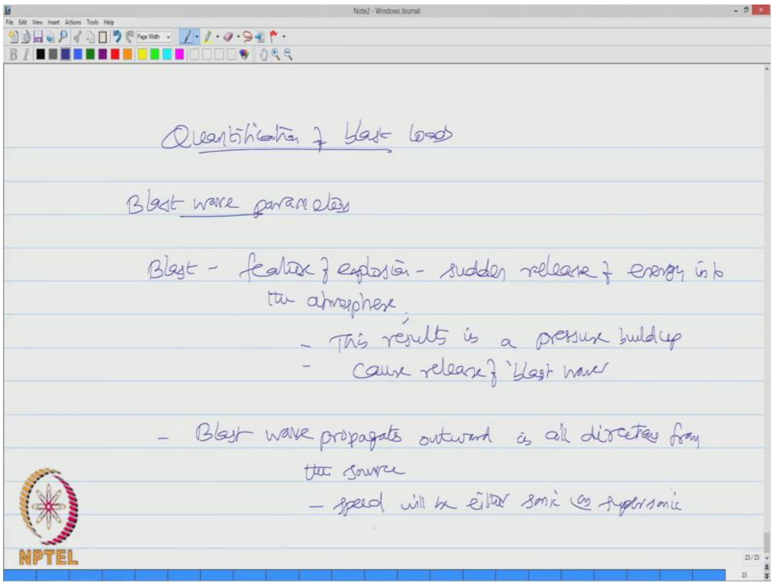

Let us look into the quantification of blast loads. For that let us first understand; what are blast wave parameters. Blast is actually a feature of explosion in which there is a sudden release of energy into the atmosphere, these results in a pressure buildup which causes release of what we call as a blast wave. The blast wave propagates outward in practically all directions from the source. The speed of the blast wave; speed will be either sonic or supersonic.

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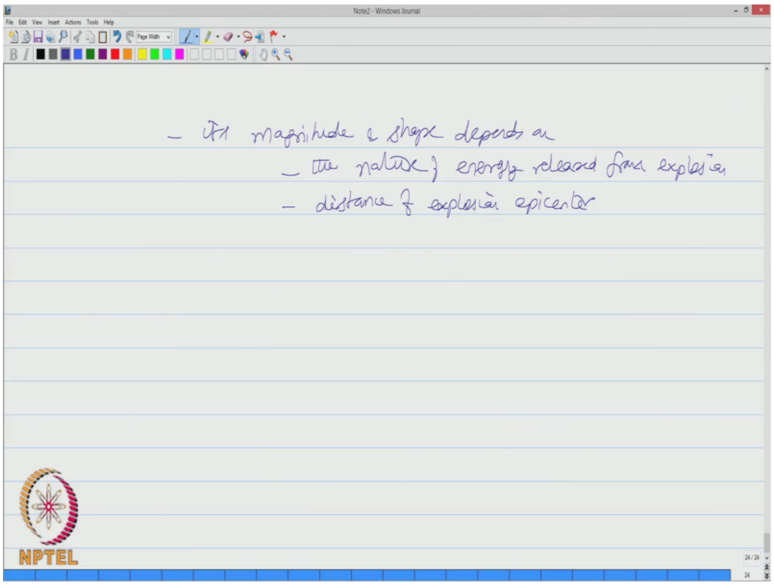

Its magnitude and shape depends on the nature of energy released from explosion, and distance of explosion epicenter. There are different types of blast waves which we will discuss in the next lecture.

Thank you very much.