Advanced Design of Steel Structures
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Lecture - 58
Blast resistant design - 1

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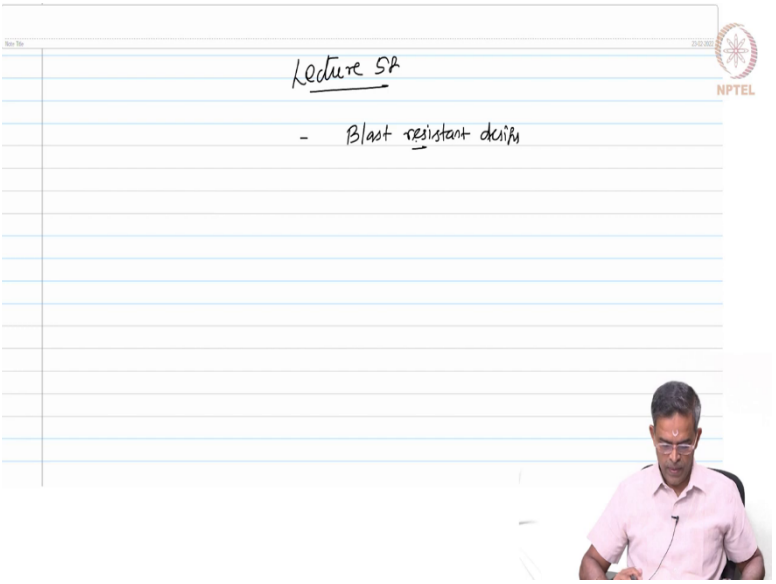

Friends welcome to lecture-58 of the course Advanced Steel Design. In this lecture we are going to learn more about Blast resistant design.

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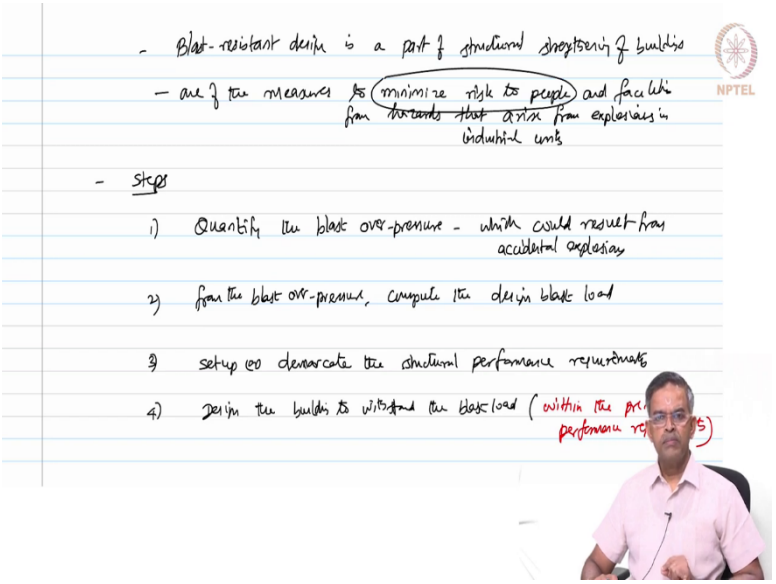

Blast resistant design is a part of structural strengthening of buildings. It is one of the measures to minimize the risk to people and facilities from hazards of accident explosions happening in the industrial units. So, the primary objective of the blast resistant design is essentially to minimize risk to people. Now, let us ask a question what are the steps involved in Blast resistant design.

The 1st step is quantifying the blast over pressure that could result from accident explosions, step number 2 establish the design blast load. So, from the blast over pressure compute the design blast load. The 3rd step would be set up the structural performance requirements and the 4th step could be design the building to withstand these load very important within the preset performance requirements that is very important there is no blast proof structures.

For a blast resistant design, you set up the performance requirements of the structure. It can be immediate occupancy it can be life safety and so on. There are collapse prevention like earthquake engineering. There are many preset performance requirements which you can set as a designer. Now you have to design the building under the blast loads, so that only those preset performance requirements are met not beyond that.

So, you have to lay down the conditions of requirements of the building under the blast loads which is pre laid. So, there is no post investigation of requirements after the blast test happened. So, it is very important that the blast resistant design has a prerequisite, you must

set the standards the deflection requirements, the strength requirements, the performance criteria of the structure which you are going to design for a specific blast load.

Once it is preset then you will design the building. For that computed blast load to meet these preset requirements.

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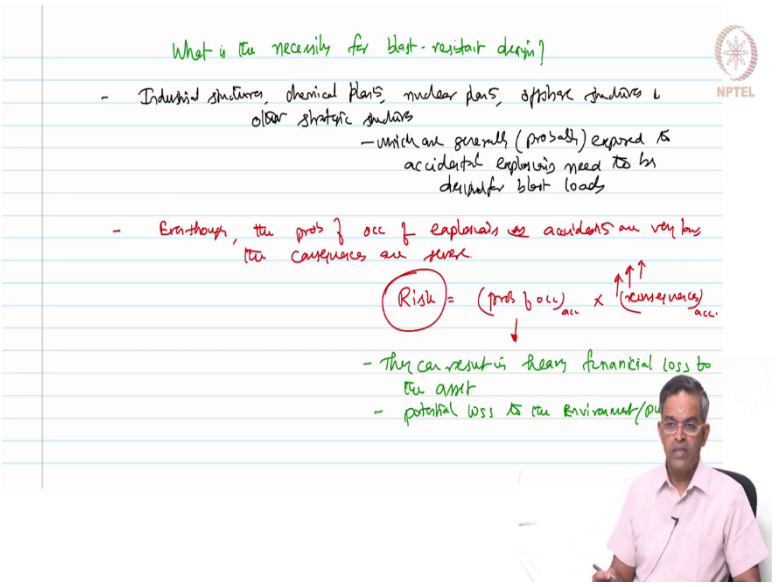

Now, the question comes what is a necessity for a blast resistant design. So, what is the necessity? Now different kind of structures which are exposed to accidental cases need to be designed for this. So, we have to say here that industrial structures, chemical plants, nuclear power plants, offshore systems or offshore structures and other strategic structures which are generally exposed or probably to accidental explosions need to be designed for blast loads.

$$Risk = (probability\ of\ occurrence)_{accident} \times (consequences)_{accident}$$

One may ask a question what is the probability of this blast or this explosion happening that is a good question. So, let me answer this. Even though the probability of occurrence of explosions or accidents are very low, the consequences are severe. Friends risk is actually the product of probability of occurrence of an accident and the consequences if it happen. Even though the probability is low, but the consequences are very severe.

So, it has got a very high-risk factor. So, accidental explosions since they have very high-risk factor they can result in heavy financial loss to the asset. It can cause potential loss to the

environment and public. So therefore, there is a necessity for blast resistant design of certain class of structures you do not have to design all structures for blast resistant design. You are going to see what is the probability of that kind of system which can or which will be exposed to accidental explosions.

If you have a probability of occurrence of these accidents happening in that particular building or structural system, then it should be designed for blast tested or blast loads. We can give a very classical example of two well-known accidents especially in offshore structures.

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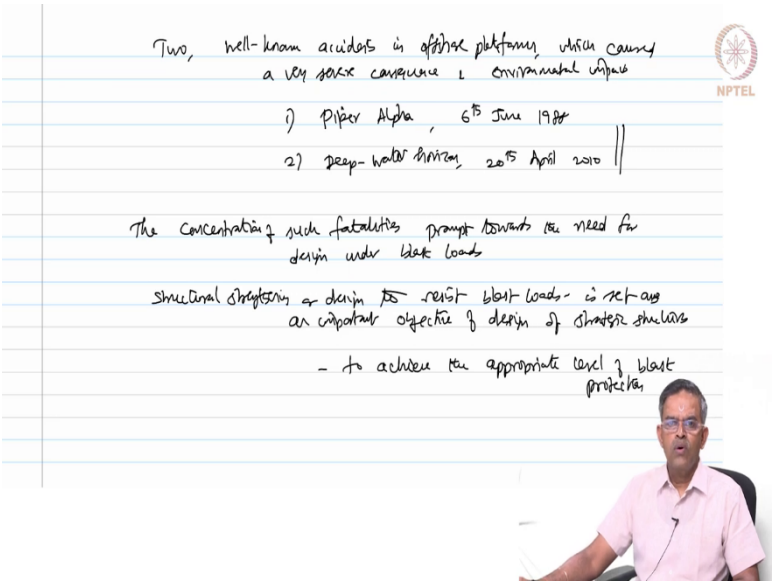

Offshore platforms which caused a very severe consequence and environmental impact: 1 is piper alpha happened on 6th June 1988, the 2nd accident happened on the platform deep water horizon which is 20th April 2010. Though the frequency of these accidents is very large they are not very close, maybe it is about 25 years.

So, they occur very severe consequences at a very large interval of time. there is no recurrence of these accidents, because offshore platforms are example, are well protected in safety perspective and the firefighting systems are very effective and the design is very comprehensive. So, accidents are generally avoided.

But still if there is a probability even though the occurrence of this accidents are very very low, but the consequence are very severe. Therefore, one emphasizes the fact that such structures must be designed for blast loads to avoid fire and explosion which can be very

devastating. Furthermore, the concentration of such fatality points prompt towards the need for design under blast loads.

So, it does not pose any hazard by itself. So therefore, friends structural strengthening or design to resist blast loads is set as an important objective of design of strategic structures. This is to achieve the appropriate level of blast protection. Let us do this way. The next question obviously comes what are the objectives of blast resistant design.

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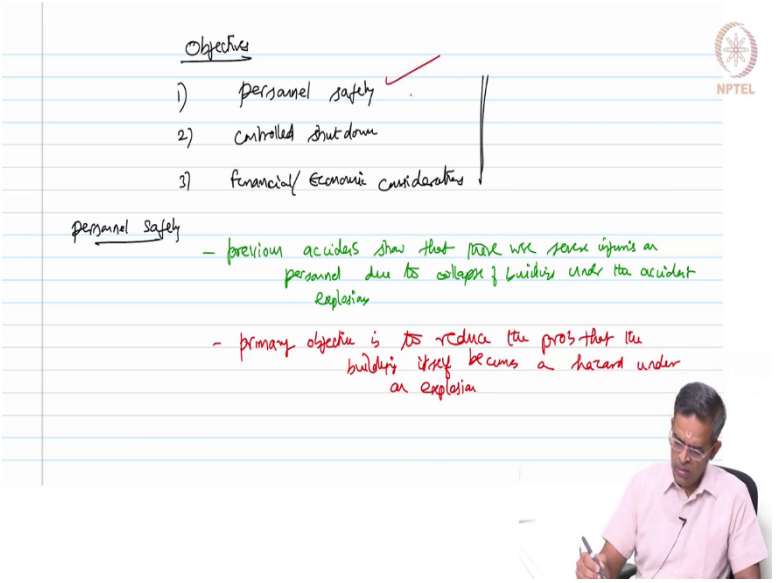

What are the objectives? The primary objective of providing blast resistant design for buildings are as follows: 1, personal safety; 2, one can initiate what is called as controlled shutdown; 3, financial or economic considerations. So, these are the three factors which control the objective of blast resistant design. Let us see one by one in detail. Let us talk about personal safety. Blast resistant design should provide a level of safety for persons inside the building.

The previous accidents, which has happened for example in offshore platforms show clearly that there were serious injuries caused because of collapse of buildings onto the persons. So, previous incidents or previous accidents show that there were severe injuries on personnel due to collapse of buildings under the accident explosions. So therefore, the primary objective is to reduce the probability that the building itself becomes a hazard that is a very important statement here.

So, the primary objective is to reduce the probability that the building itself becomes a hazard under an explosion, that is why we say blast resistant design is also said as structural strengthening under blast loads, the concept is same. Because in many incidents it has been reported that the building collapsed and personnel inside the building were severely and fatally injured.

To reduce the probability of building itself becoming a hazard when subject to explosive accidents, we are going to strengthen the building under these kind of blast loads.

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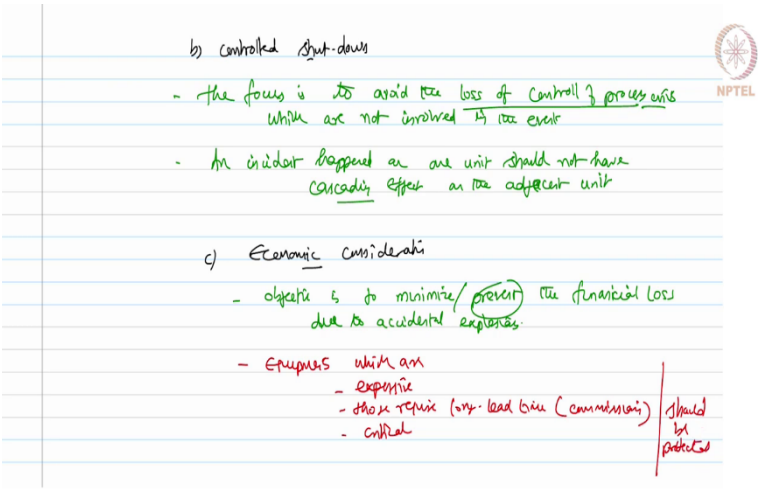

The second one is what we say as controlled shutdown. The control shutdown refers to the objective of avoiding the loss of the control of process units that are not involved in the event. The focus here is to avoid the loss of control of process units. Let us say process units which are not involved in the event. At least those should be protected. Those are involved there can be a mechanical a collapse there can be a complete collapse of the equipment's and plants fine that is a devastating loss.

But those which are not involved in the event should be at least protected no? So, an incident in one unit should not have a cascading effect on the other. So, we need to have a stepwise shutdown of the process units such that the units which are not involved in the event should be protected. The third one is economic consideration presenting the economic factors help us to prevent or minimize the financial loss.

So, here the objective is to minimize of course to prevent which may not be possible, but to minimize the financial loss due to accidental explosions. Facilities with critical or essential equipment's which are expensive and those require long lead time to procure should be protected. Equipment's which are expensive those require a long lead time for commissioning. Those are critical, should be protected. Let us now go ahead and discuss what are the blast resistant requirements.

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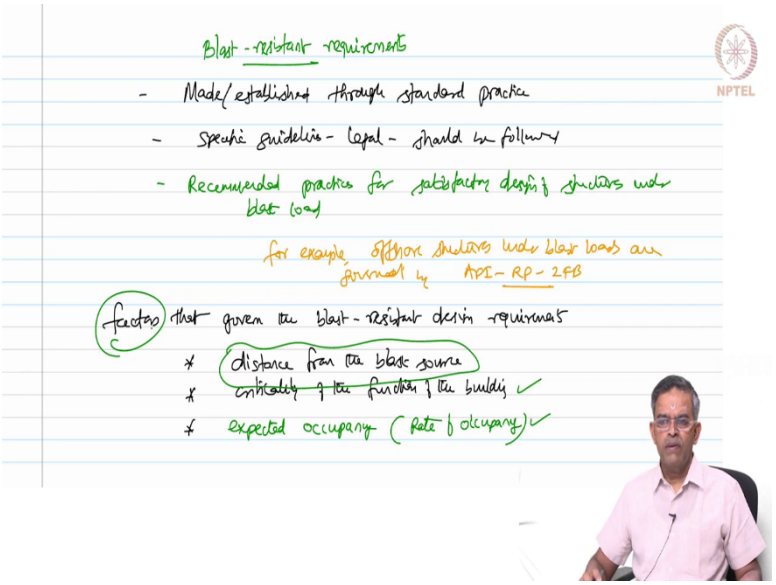

Blast resistant requirements are generally established through standard practice. There are specific guidelines issued by the factories prevention or protection act which are legal which should be followed. There are recommended practices for satisfactory design of structures under blast loads. For example, offshore structures under blast loads are governed by API recommended practice 2 FB, B stands for blast loads.

Let us ask a question what are those factors which will govern or influence the blast resistant design requirements. What are the factors that govern the blast resistant design requirements, if not we know the codal provision let us at least try to understand the factors. The factors are distance from the blast source where is the blast source probably located and where is the building.

Two, what is the criticality of the function of the building is it a strategic building, is it a normal structure etcetera. So, what is the strategic requirement of this? Thirdly and most

importantly, what is the expected occupancy and what is the rate of occupancy? That is an any given point of time how many people will be present to the building.

Because the occupancy rate can vary with time if it is an office building there can be specific working hours beyond which the occupancy will be minimum or during which the occupancy will be maximum and so on. There are structures where there are no occupancy, but the storage of valuable equipment's. For example, server units, where computers are being kept and so on, which are very highly strategic important.

So, criticality of function of the building, expected occupancy in terms of personal life and safety and of course, the distance or location of the building from the probable epicenter of the blast source. I am sure people will identify and know how to identify what are the probable blast sources, what are the reasons for industrial explosion which we will also discuss in detail in the coming part of this lecture. But blast sources can be easily identified in a given industrial plant.

So, what is the distance of the building which you are going to design which needs the design for blast resistance? One of the important factors is the distance. If it is located much far away from the probable blast source, then that unit or that part of the building need not be designed for blast loads. So, we are not looking here the recommended guidelines specifically for any or by any code, we are looking the factors that govern these guidelines.

Now friends, there is a big confusion in the glossary of terms blast proof and blast resistant. Let us see what it is.

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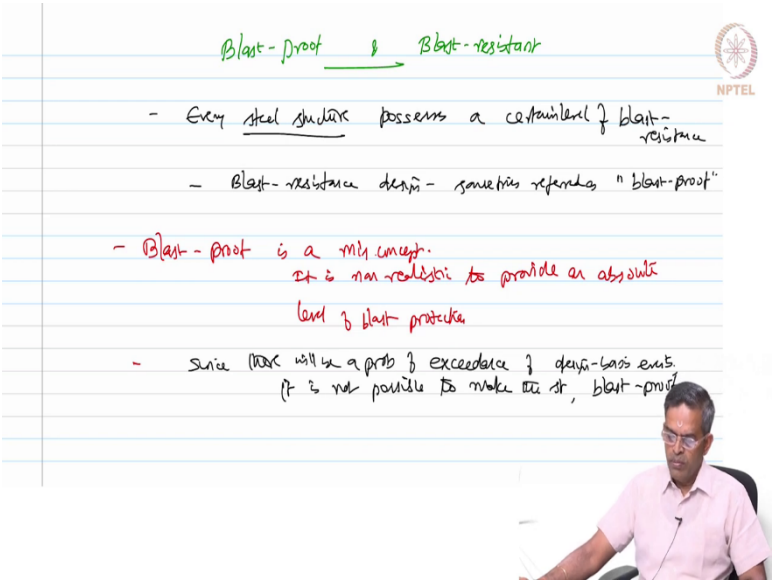

Friends, every structure which is being designed be it strategic non-strategic has some level of blast resistance, because blast resistance is a part of strengthens structural requirement and buildings constructed by steel essentially do possess this inherent characteristic. So, I can now say very clearly here every steel structure possess a certain level of blast resistance.

Now the blast resistant design is sometimes referred as blast proof, but it is very important to know that blast proof is a mis concept. It is nonrealistic to provide an absolute level of blast protection. There is always some probability that a design basis event can be exceeded.

Since there is a probability or there will be a probability of exceedance of design basis events, it is not possible to make the structure blast proof. So, one can only do blast resistant design.

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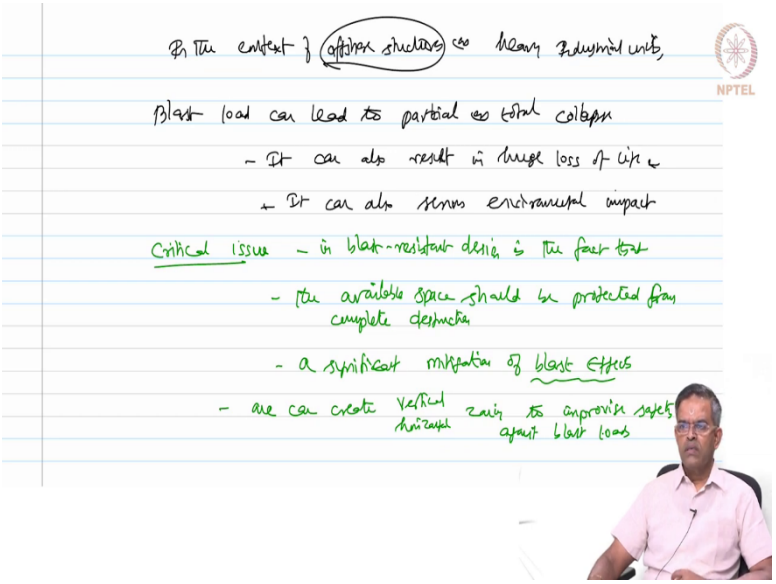

In the context of offshore structures or heavy industrial units blast load can lead to partial or total collapse. It can also result in huge loss of life and it can also cause serious environmental impact. This is true in case of offshore structures. So therefore friends, critical issue in blast resistant design in blast resistant design is the fact that the available space should be protected from complete destruction.

Because available space in offshore facilities very limited and very expensive, therefore we need to protect that space. So, we are looking for a significant mitigation of blast effects; significant mitigation of blast effects. So, we are not looking for complete blast proof concept by looking for blast effect mitigations on the design.

So, one of the important factor as a designer which you can consider is by keeping the strategic units away or locate them well away far away from the probable blast source, both horizontally and vertical we call this as horizontal vertical zoning. So, one can also ensure or one can create a vertical or horizontal zoning to in improvise safety against blast loads. Of course, you cannot do this for the entire structure, you can do it for part of the structure.

Consequentially, the following parts of the structure should be however protected. what are they? So I will ask a question.

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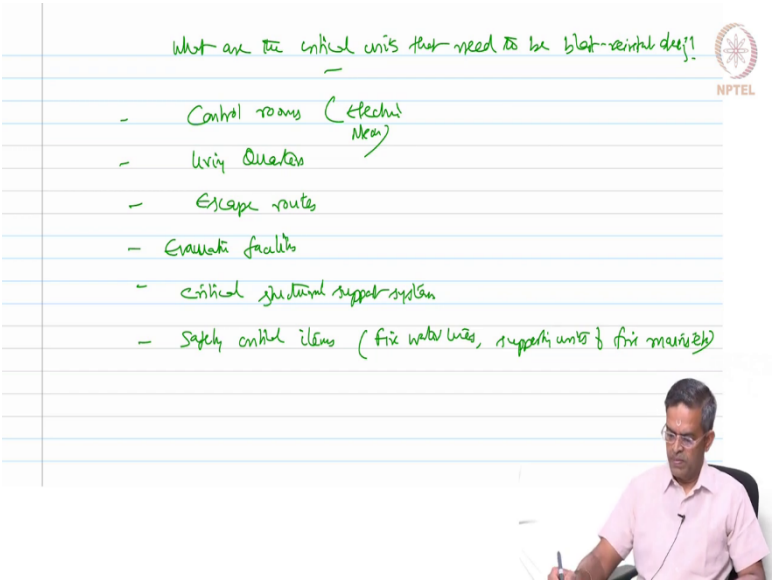

What are the critical units that need to be blast resistant design? Ask this question. What are these units? One, control rooms both electrical and mechanical. Two, living quarters where the occupancy rate is very high. Escape routes, evacuation facilities, critical structural support systems and safety critical items.

Such as for example, fire water lines, supporting units of these supporting units of fire mains etcetera. They should all be designed to remain as blast resistant. As we discussed we realize that one need to mitigate the effect of blasts.

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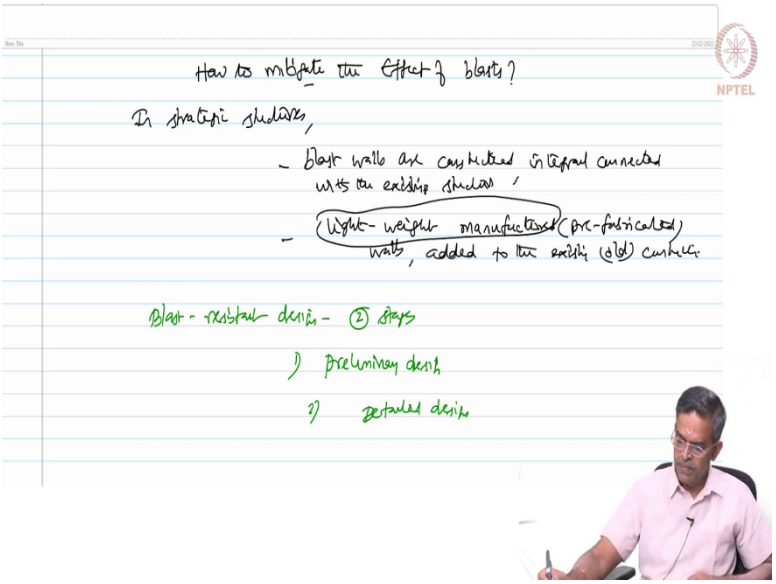

Now, the question comes how to mitigate the effect of blasts. We can cite again an example offshore facility. Generally, in strategic structures such as nuclear power plants, offshore facilities, dams' etcetera, blast walls are constructed integrally connected with the existing structure that is one option we have.

The second option we have is people use lightweight manufactured walls I should say prefabricated walls which are added to the existing old constructions. You may ask me a question why we are adding light weight manufactured walls. During blast friends when it starts blasting the walls, it results in flying off the construction particles.

If the wall is made of steel or made of concrete of large jellies etcetera which is very heavy in shape and size the blown off particles during blast load can also cause cascading injuries to the public, to the personnel located around the epicenter of the blast flow as well as to the plants and equipment's. So, generally people recommend try to use light weight units please understand lightweight units does not mean we compromise strength against safety.

It is only a partition wall which is going to cause or which is created which is added later to create a cite of a blast wall. The blast walls are generally constructed with light weight, but with strong integrity and strength. Having said this the blast resistant design has got 2 stages, generally it is carried out in 2 stages. One is of course the preliminary design, the next one is the detailed design. Let us quickly see what do we cover in preliminary design.

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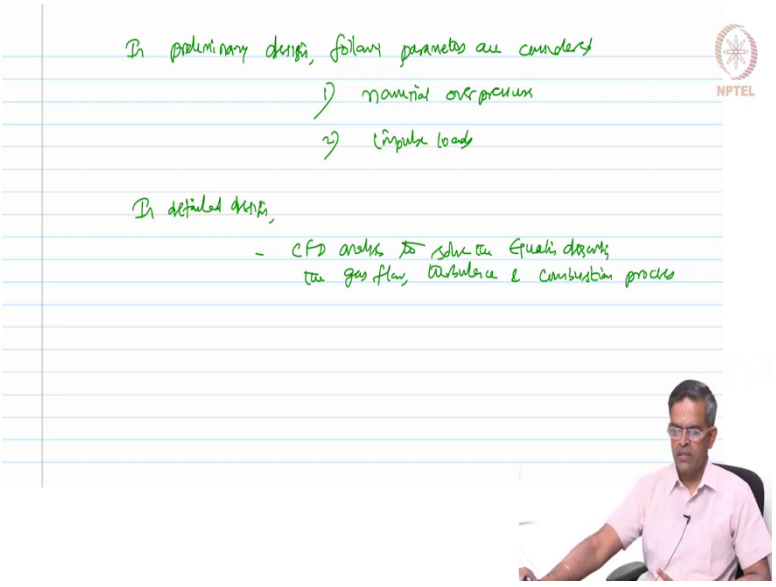

In preliminary design following parameters are concerned. 1 - nominal over pressure, 2 - impulse loads. In detailed design one has to do a CFD analysis to solve the equations describing the gas flow, turbulence and the combustion process. Let us ask a question what is the design philosophy of blast resistant design, we will discuss this in next lecture in detail. Now we will take up a summary and quickly summarize what we have learnt in this lecture.

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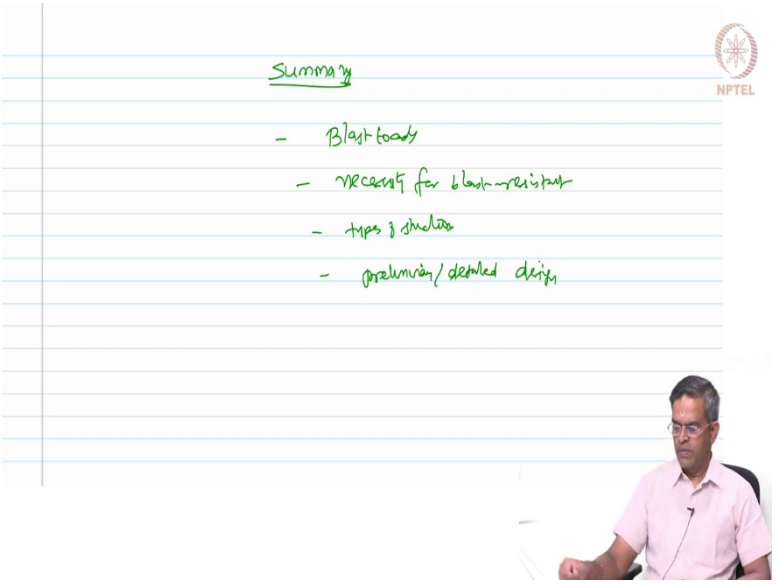

In this lecture we understood about blast loads, the necessity of design structure for blast loads, what kind of structures are designed for blast resistance. We have also learnt the methodologies of preliminary and detailed design for blast resistance. We are in the process of learning the design philosophy for blast resistant design.

Thank you very much and have a good day.