

Safety in Construction
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Lecture-25
Managing Hazards in Construction

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Hazard

- It is an unsafe physical condition that is always in one of three modes
 - Dormant - unable to cause harm
 - Armed - can cause harm
 - Active - causing injury, death and/or damage
- 2 important aspects of the hazard - likelihood of its occurrence and the severity of the consequences
- A safety engineer should have the expertise to
 - Identify hazards
 - Evaluate the risk of harm those hazards can create
 - Inform all levels the magnitude and peril the hazard can create
 - Define safe design criteria or construction methods

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Construction Safety Engineering Principles by David V. Maccollum (2007)

The slide includes three images illustrating hazard modes: 'Dormant' (a construction site with a red circle around a potential hazard), 'Armed' (a construction site with a red circle around a hazard), and 'Active' (a red scribble representing an active hazard).

So, in this we will be discussing about hazards. So, hazard, how do you identify a hazard? How do you analyze it and how do you manage the hazard? So, primarily it is a very simple topic, but it is a very critical topic and it is an important safety program when you want to have a zero accident in construction site. And most of the hazards these days are all handled and managed very easily with the help of building information modelling.

So, I have also brought in one or two experts who have worked in this topic. So, they would be sharing small presentation on building information modelling and safety related issues, so you can go through that. So, this lecture primarily I will be focusing on the theoretical portions and aspects of hazard management. So, what is a hazard? Many of these issues are all known to you because this was discussed in the first week of the lecture itself.

Hazard is an unsafe physical condition that is always present in any construction site. So, this hazard is actually in one of the three modes, one is called dormant, second one is armed and the

third one is active. Dormant is it will not cause any harm; it is present there but it is not in the path way where the workers are moving in or it is not visible to the workers but the hazard is still there.

For example, reinforcements stored in a far of place, the hazard is not removed, the hazard still exists, but the workers are not frequenting to that area that is primarily called dormant hazard. Armed, it can cause harm to any worker, for example there is a gap in the walkways. So, this wherein workers are moving walkways are primarily meant for workers to move along, so these gaps can actually pose hazards, when the workers are frequenting that area.

Active is maybe there is a large water body here in the sense water has spilled over. And there is an electric wire which is passing on, so this is primarily an active hazard, it can cause injury, death, damage, any time of the period. So, two important aspects you may have to look into the hazard, one is the likelihood of the occurrence and the next one is the severity of the consequences.

Your safety engineer or a safety supervisor should have the expertise to identify hazards. So, primarily if these are the tasks planned for the particular week, you should be able to identify what are the critical operations to be carried out and what are the different hazards seen in those critical operations and what is the risk of our harm those hazards can create. Hazard and risk have a little difference in meaning.

So, risk also poses the hazard, the dangerous situation plus the exposure to the dangerous situation that is measured in terms of risk. And inform all levels the magnitude and peril the hazard can create. And define safe design criteria or construction methods to eliminate or at least to try to get rid of the hazard.

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Current Situation

- Construction safety planning is the key to preventing hazards, which prevent injuries, which prevent litigation. Tort reform does nothing for hazard prevention
- Effort of construction industry seems to be spent on defending hazardous circumstances over and over again from courtroom to courtroom
 - After the trial is over, the information is locked away forever in court records, and nothing ever is done to save other worker's lives
 - No formal means or mechanism to collect and summarize hazard information developed in personal injury litigation
 - All hazard data developed by the litigants in discovery should be made open to the public to let all available hazard information stand the light of day
 - All the vital information lies buried in court archives, and the construction industry is kept in the dark about repetitive hazards that are causing injury and deaths all over the country
 - Not in seeing that hazard prevention information submitted to the court is given to the right parties
- Lawyers who initiate protection orders, request isolation of experts during hearings, and withhold safety information are, in all reality, great hindrances to safe construction planning
- It is unwise to keep a hazard as you may have to pay for the harm it causes
 - When you pay to remove the hazard, it costs you a little money- that's all
 - When you do not pay to remove the hazard, you sometimes lose everything to pay for the harm it caused
- When personal injury occurs, it often is initially assumed that the victim was at fault, the equipment was misused, etc.
 - The courts have shown that these assumptions are not always correct and that on-the-job injury is often caused by hazards that could have been discovered in the safety planning

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So, what is the current situation, most of the accidents happening today this also we have discussed in the chain of events theory or domino theory. Actually, this is a result of one factor wherein a person was identified as a causal factor with which the accident has happened. But if you start analyzing the root cause of the accidents the direct, indirect cause, the tertiary cause and so on.

It would be like some management situation, some hazard present in the project and the construction site which made the worker to behave in a different way and resulted in an accident. So, this you would have noticed when we discussed the theory long, long back. So, now if you see as a result of the accident somebody got injured then it comes to litigation or an arbitration it comes to court trials.

So, at the time if you see many of the evidences related to the hazards all would have been collected, documented and so on. And they would be presented before the court trials also for evaluation and proceedings. At that time if this knowledge or I would say this learning of the hazard assessment is known to everyone then they can also manage the hazards better. What happens is once the, court trials are all over, these are all stored are archived in some files and they are not actually meant for opening to the public.

So, what happens is the learning and are all happening. So, these court trials they actually do not maintain a set of databases for maintaining a safety. If you want to have a good safety planning, then all these documents can be a real good source for identifying and the possible hazards. And we can also think of the probable solutions and you can think of how to manage economically and also within the time and cost.

So, construction safety planning is the key to preventing hazards which prevent injuries, which prevent litigation. So, efforts of construction industry seem to be spent on defending hazardous circumstances over and over again from courtroom to courtroom. So, from every course maybe the same situation in a different angle, you would be arguing in a different court.

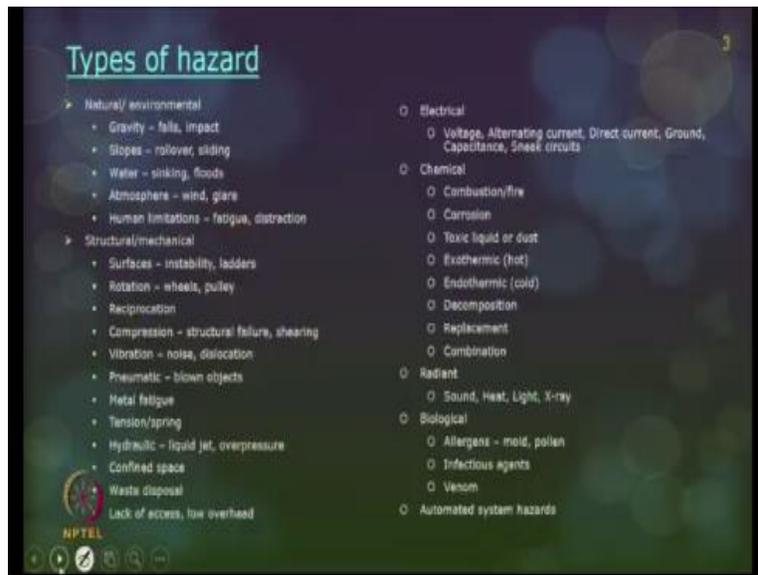
But since the proceedings are not revealed to the public, so right now this trend is improving. But still all these cases if they are becoming transparent then obviously we can easily achieve the zero accidents in construction sites. After the trial is over the information is locked away forever in court records and nothing ever is done to save others workers lives.

So, no formal means or mechanism to collect and summarize hazard information developed in personal injury litigation. So, complete database may not be obtained but even that may be like exhaustive database that are being collected, even that is not opened up for the public. All hazards' data developed by the litigants in discovery should be made open to the public to let all available hazard information stand the light of the day.

So, the vital information lies buried in court archives and the construction industry is kept in the dark with repetitive accidents and hazards repeating in the construction industry. So, lawyers who initiate the protection orders, request isolation of experts during hearing, so they are in general are the main hindrances to save construction planning. So, it is unwise to keep your hazard because you have to pay for the harm it causes.

But when you pay to remove the hazard, it makes you spend little money but when you do not pay to remove the to the hazard and you wanted to save that money, you have to keep in mind one day you are going to pay too big, these all we have discussed earlier also.

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Types of hazards, so these are some lists I have brought it from literature. So, natural or environmental, structural or mechanical, electrical, chemical, radiant, biological so, like this you can list out the hazard seen in any construction site. Natural and environmental, gravity, falls, impact, slopes, rollover or sliding, water, sinking or floods, atmosphere, wind, glare and so on, structural or mechanical, surfaces, instability, ladders, rotation, wheels or pulley.

Compression, structural failure, shearing, vibration, noise, dislocation, pneumatic on blown objects, metal fatigue, tension spring, confined space and so on. Electrical, voltage, alternating current, direct current, ground capacitance and so on. Chemical, combustion, fire, corrosion, toxic liquid, exothermic and endothermic reactions then decomposition and so on. Radiant, sound, heat, light and etcetera, biological, venom, infectious agents and allergens.

And automated system hazards wherein the system can cause a failure and you may do wrong handling of materials in site. So, these are all the different types of possible hazards. So, how do you analyze the hazard? There are a series of steps, first you have to look at the project as a whole. So, in the project it is very difficult to foresee a 5-year project and analyze all the hazards, probable hazards.

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Hazard analysis

- Technique used to examine the workplace for hazards with the potential to cause accidents
- The workers are trained in hazard identification and asked to recognize and report hazards for evaluation and assessment
- Project hazard analysis
 - Should be performed prior to the start of the work and should be the basis for project specific safety plan
 - ◊ Anticipated phases of the project
 - ◊ The types of hazards likely associated with each phase
 - ◊ Control measures necessary to protect site workers from the identified hazards
 - ◊ Phases and specific operations of the project that will require further analysis
- Phase hazard analysis
 - It may be performed for those phases of the project for which the project hazard analysis has identified the need for further analysis
 - It is performed prior to the start of work on that phase of the project
 - ◊ Identification of the specific work operations or procedures
 - ◊ An evaluation of hazards associated with specific chemicals, equipment, materials, and procedures used or present during the performance of that phase of work
 - ◊ Identification of specific control measures necessary to protect workers from the identified hazards



But you can understand based on your previous experience where all major accidents can happen. So, those all phases can be identified there maybe 4 or 5 major operations, if you look at an apartment construction you may have excavation, foundation, superstructure then concreting. So, like this you can differentiate the major activities and identify where the maximum number of accidents have happened in the past.

So, that you can analyze and that you can take it a pass a phase hazard analysis. So, that operation you can study in detail and look at the number of sub steps. And that you can pick up 1 or 2 as a job hazard analysis or job safety analysis. There you have to go through four different steps and those four different steps will help you to identify and think of how to manage the hazards.

So, this is hazard analysis is a technique used to determine the workplace for hazards with the potential to cause accidents. The workers are trained in hazard identification and asked to recognize and report the hazards for evaluation and assessment. So, project hazard analysis should be performed prior to start of the work. All these hazard analyses should be done prior to start of the work.

And during the project execution also you have to do safety walk inspections, or we say walkthrough inspections. Safety inspections, if you have a building information model, you can

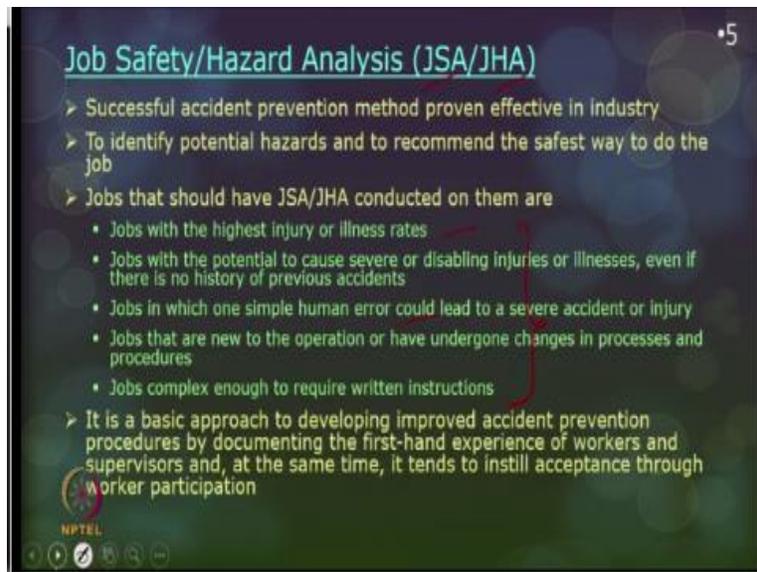
also do safety walkthrough virtually before the construction starts, so should all be done. So, project hazard analysis can be identified with the help of the project safety plan, with that you can partially identify what are all the different hazards linked with equipment, linked with major operations is easy for you to pick out.

So, anticipated phases are all identified, the types of hazards linked with each phase you can really link it up. Control measures, to some extent you can foresee in the design phase and partially in the construction phases also. Phases and specific operations that will require further analysis you may have to identify and narrow you down. So, now among the list of 20 lists of operations at least, you will identify one or two for critical analysis on hazards and then you may have to narrow down is to zoom in.

So, this phase hazard analysis may be performed only for those phases of the project for which the project analysis has identified the need. From this you are going to the next level it is performed again prior to start of the work on that phase of the project. So, the project can continue only before the start of that particular phase you may have to do the analysis.

Identification of specific work operations or procedures and evaluation of hazards linked with specific chemicals, equipment, material, procedure used or present during the performance of that phase of work. Identification of specific control measures necessary to protect workers from the identified hazards, all those will be studied here. Once you have thoroughly done that mapping and phase analysis is partially clear.

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So, you may have to do the job safety or job hazard analysis, both are almost the same? One is identifying the hazards and other one is safety analysis. So, in a way you are identifying the hazard and you wanted to provide a situation of complete safety in the in each of the construction operation. So, in short form it is referred as JSA job safety analysis or JHA which is job hazard analysis.

Successful accident prevention method; proven very effective in the industry, to identify potential hazards and to recommend the safest way to do the job. Jobs that should have the JSA or JHA conducted are some hints on how do, you select the tasks. Jobs which have highest injury or illness rates, jobs have the potential to cause severe or disabling injuries even if there is no history of previous accidents.

Jobs in which a small human error can lead to a severe accident or injury, jobs that are new to the operation or have undergone changes in the processes or procedures, jobs complex enough to require written instructions. For all these then you may think of doing the JSA or JHA. It is a basic approach to develop improved accident prevention procedures by documenting the first-hand experience of the workers and supervisors.

And at the same time to instill the acceptance through worker participation because the workers are the one who are actually linked with safety.

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So, when you involve the workers that you may also get a better solution to handle a safe analysis. So, now you to perform a JSA or JHA the following questions can be asked and you can get the answer. So, first what you should do is you have to, so this is actually a photo taken from a website. So, you have to look at all the hazards from six directions, one is from the top, one is on the front, the back, then on your sideways, 2 sideways, and one on the ground, which is below your space.

So, you will have six directions to look through for any of the operations a worker is performing and accordingly you may easily be able to identify all the hazards present in the construction operation. Some of the sample questions, what can go wrong? What are the consequences? How can it happen? What are the contributing factors? How likely is, it that hazard will occur? The answers can be again they are the probable answers.

Can any body part be caught in or between objects; do tools machines or equipment pose any hazard? Can the worker make harmful contact with a moving object? Can the worker slip, trip or fall? Can the worker suffer strain from lifting, pushing or pulling? Is excessive noise or vibration a problem? Is a worker exposed to extreme heat or cold? So, if you look at all these topics that we have discussed earlier, you may have to look in any of these six directions then you can easily identify all the hazards.

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The slide is titled "Four basic steps of a JSA/JHA" and is numbered "7" in the top right corner. The first step is "Selecting a job to be analyzed". This step includes three main bullet points: "Establish a methodology to prioritize and select the jobs to be analyzed", "Jobs must be ranked in the order of greatest accident potential", and "Following criteria should be used for prioritizing the jobs". Under the third bullet point, there are five sub-points: "Accident frequency - a job that has repeatedly produced accidents", "Accident severity - every job that has produced an injury that resulted in lost time, restricted work cases, etc. should be analyzed", "Judgment and experience - many jobs qualify for immediate JSA because of the experience", "New jobs, nonroutine jobs, or job changes - for the jobs that have never been done at a particular worksite, hazards might not be fully known", and "Routine jobs - in routine jobs, the employee is exposed repeatedly to hazards". The slide also features the NPTEL logo in the bottom left corner and navigation icons at the bottom.

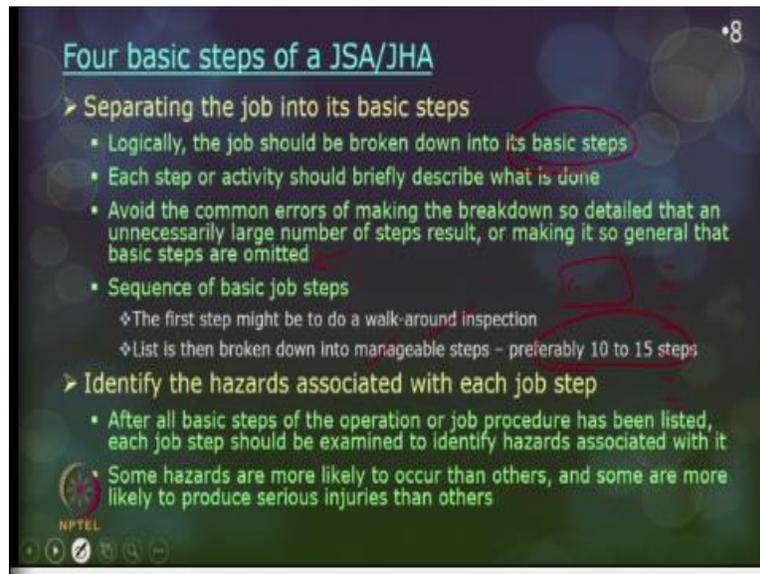
Now, there are four steps as I told you to easily do the JSA. Number 1 is selecting the job to be analyzed, some tips for identifying that we have seen earlier. So, jobs which were not done routinely, but still a simple error can pose a real accident. And jobs that were done infrequently, like this you can choose your priority on the jobs for hazard analysis. So, you establish a methodology to prioritize and select the jobs before the project starts you have to make a wise decision on how to prioritize activities for hazard analysis.

Because you may not be able to do for all the activities in the construction site, so jobs have to be ranked in the order of greatest accident potential. Some criteria which can be used are accident frequency, a job that has repeatedly produced accidents. Job severity, a job may not have produced too many accidents, but it would have got a severe injury rate, in the sense a serious accident. Judgment and experience many jobs qualify for immediate job safety analysis because of the experience.

I know this particular job is really hazardous, so maybe it does not cause any more accidents or any severe accident. But still based on my gut feel and judgment I know this can be serious, this has to be evaluated. New jobs, non routine jobs or change in jobs, for the jobs that have never been done at a particular work site, hazards may not be fully known, because the workers may have lost the memory or on how are the hazards available and so on.

And what are the safe inspections that they have to be carried out, they may have forgotten, so it is better to do that. Routine jobs, in routine jobs the employee may be pose exposed repeatedly to certain number of hazards that also you may have to assess, if it is a routine job.

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So, first one is selecting the job, the next separating the job into its basic steps. For example, it may be even loading, unloading of your steel reinforcement, this example I have covered earlier also. So, for this you may have at least 50 steps at least, the truck may have arrived at the site, then you call the engineer for weight checking, then they take the weight of the entire reinforcement, they enter the register and then maybe they do preliminary tests there if required.

And then the truck enters the site, and again you wait for the workers to unload the reinforcement, and again register is entered as to know in the certain godown, where is the reinforcement arrived at and again make this that and characteristic features of those reinforcement and some sample may be taken for experiment again if required. So, and then what happens is the empty truck returns back.

So, like this there may be a series of steps, you may have to separate the job, identify one operation loading and unloading of reinforcement, you will have to break down the job into number of basic steps. Logically a job should be broken down into basic steps, only if you break

down the step, you will know where the hazardous step lies in. So, each step or activity should briefly describe what has to be done and what you have to do is the basic steps should not be omitted.

But you should not be having too many details, for example loading and unloading itself if you have almost like 50 or more than 70 or 80 basic steps. Obviously, if you are doing the same way all the operations then you may not be even able to analyze the hazards completely. So, keep it as minimal as possible but at the same time identify all the hazardous tasks in the sense let the hazardous tasks be revealed out that you may have to keep in mind.

The first step, how do you do this maybe you may have to do a walk around inspection. And you have to break down the list into manageable number of steps. So, preferably keep 10 to 15 steps because you can easily identify all the hazards if you are keeping it very simple and small. The third step is to identify the hazards linked with each step. Now you have listed out all the 10 to 15 steps, maybe in one particular operation like concreting or shuttering or deshuttering and so on.

Then it is easy for you to identify the hazard linked with possible hazards, you can easily think about it. After all the basic steps of the operation or the job procedure has been listed out, each job steps should be examined to identify the hazards linked within. Some hazards are more likely to occur than others and some are more likely to produce serious injuries than others, so that you have to identify and do.

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Four basic steps of a JSA/JHA

- Eliminating/ controlling the hazard
 - There are ways to eliminate the hazards by choosing a different process, modifying an existing process, substituting with a less hazardous substance, or improving the environment
 - Find a new way to do the job
 - ◊ If the sequence of job steps or the deviations from established job steps are critical to the safe performance of a job, this should be noted in the JSA/JHA
 - Change the physical conditions that create the hazard
 - ◊ Physical conditions may be tools, materials, and equipment that may not be right for the job
 - ◊ These conditions can be corrected by either engineering revisions or administrative revisions or combination of both
 - Change the procedure to eliminate the hazard
 - Reduce the frequency of performing that specific job. Reduce exposure
 - Contain the hazard with enclosure, barrier or guards
 - Use protective devices such as PPE

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The last step is to eliminate or control the hazard, this we will see what is a managerial step of managing the hazard. There are many ways to eliminate the hazard maybe you can modify the existing process, you can substitute with a less hazardous substance or improve the environment, improve or maybe promote safety, more safety measures and so on. So, find a new way to do the job, if the sequences of job steps are the deviations from established job steps are critical to the safe performance of a job.

Then this should be noted down in the JSA and you may have to think of finding out an alternate way. If the physical condition is what is creating the hazard, then you may have to think of improving the site conditions of the hazards are easily carpeted in. And change the procedure to eliminate the hazard, reduce the frequency of performing that specific job. So, in the sense reduce the exposure to the hazard or contain the hazard with the enclosure barrier or guards.

Maybe one equipment is not working and it is posing a hazard maybe you can put a small fence, so that people are not going towards it. And the last one is use PPE as a personal protective device.

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Hazard Management

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- Once the hazards are identified, reduce the risk created by the hazard based on priority
- Control measures to control a single hazard
 - Design to eliminate or minimize the hazard
 - Guard the hazard
 - ◊ Install fences, guard rails for openings
 - ◊ Make the hazard location inaccessible
 - Give a warning
 - ◊ Active/intercessory warning devices – alarms, horns, flashing lights
 - ◊ Signs & symbols – passive warning system
 - Provide special procedures and training to educate the workers to handle the hazard
 - Provide PPE
- A job safety assessment or analysis should be performed at the start of any task or operation

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So, this we will see here.

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Hazard Management

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Focus to do something with hazard
Or PtD = safe constructability

Focus to do something with behaviour to reduce exposure of the hazard

Most effective

- Remove hazard
- Replace hazard
- Isolate workers from hazard
- Change the way people work
- Protect workers with PPE

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So, this is actually hazard management, if you see here this is actually a 5 step process on how to manage the hazard. Number 1, elimination which implies remove the hazard, number 2 substitution, replace the hazard, number 3, engineering controls, isolate the workers from the hazard, administrative controls, change the way people work, last one is PPE, protect the workers with a PPE, if at least this will minimize the damage to the workers.

So, now what are these? This is focused to do something with the hazard, maybe prevention through design or safe constructability that we have discussed in the designers in the first or

second week we have discussed. That can be able to help us with elimination and substitution. If you think the way you use concreting is creating a problem maybe you can think of a steel structure with the glass facades or maybe modular construction or maybe prefabricated construction wherein mixing of concrete in the site is totally avoided.

So, you can think of a lot of ways of eliminating the hazard and by substituting it with an, other material or at least changing the way it can be done. The last three steps are generally to do with the way the hazard is exposed out. So, suppose if a worker is wearing a hard hat, maybe the falling objects or something may not give him a serious brain injury or a head injury, but it may be a partial injury to him. So, at least the impact level of the hazards can be minimized, so that you can surely do. So, these are the five steps.

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Modified Methodology to Reduce Hazards			
Activity	Hazards	Original Procedure	Modified Procedure
Handling of MS beam in steelwork	Trips, Fall & Hit Injury	Manual - chain pulley block system	Use tower crane for handling
Builder hoist operation	Fall of Person or material	Builder hoist	Use multi functional hoist
Builder hoist operation	Hit injury & crushing	Unguarded rotating parts	Use multi functional hoist
Builder hoist erection	Hoist collapse	Builder hoist	Use multi functional hoist
Builder hoist erection	Mast fall due to loose soil	Compacted ground floor	PCC on ground floor
Erection of scaffolding	Fail of person	Old tubular jallies prone to toppling	New walkway jallies
Concreting with pump	Hit by pipeline	Pipeline fixed with rope & clamps	Use static bracer

I will show you with the examples for the first one or two steps. This is a modified methodology to reduce the hazards. So, handling of MS beam in reinforcement, so some analysis was done in one of the local projects in Delhi. So, handling of MS beam in steel work, so hazards can be trips, fall or hit by injury. So, original procedure was manually done, chain, pulley, block system was used, so then later on modified procedure just for promoting the safety tower crane was used for handling.

Builder hoist operation, fall off person or material, this is a builder hoist. So, the original procedure was handling of materials with the builder hoist. Then the modified procedure was used multifunctional hoist which is shown here. Builder hoist operation again, hit injury and crushing, so unguarded rotating parts, so again suggestion is using a multifunctional hoist. Builder hoist erection processes, so during erection you may have a hoist collapse.

So, original procedure was with a builder hoist, again modified procedure is suggest using a multifunctional hoist. So, all the three hazards can we eliminated when you shift the procedure of the work itself. Builder hoist erection, the mast may fall due to loose soil, this is primarily called as a mast, it may fall if the soil is very loose. The original procedure was compacted ground floor.

The ground was compacted and then the mast was laid, the revised procedure is trying to put a PCC on the ground floor, so that the ground floor is very firm for the mast to not fall down. Erection or scaffolding, so this is an old tubular jally which was used, so there was an hazard on toppling of the jally itself, fall off person from there. And this is a new walkway jally and which is firm and fixed with all guard rails.

So, this was treated as an equivalent for the older processes. Concreting with pump, this was hit by pipeline because a pipeline was fixed with ropes and clamps and there was hazard related to that. So, just because of safety promotion was there, so people were started using on static boom placer, with which the concrete was placed and this hazard was completely eliminated. So, these are primarily elimination and partially the examples I shown here and partially they are actually substitution also.

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SoP - Excavation		
ACTIVITY	HAZARD	Existing Control Measures
Site Clearing	Manual clearing - Leg injury	Use Gumboot & complete clothing or use machinery for clearing
Bush clearing	Snakebite in grassy area	Carbolic acid sprayed before work start & gumboot to be worn to avoid snake bite
Leveling by Man & machinery	Equipment injury	Check the fitness of equipment with respect to safety aspects before use
	Mishandling equipment & accident	Operator identity required/ don't allow unauthorized person to operate the vehicle
	Run over on people resting under vehicle	Inspect before starting the vehicle. Providing rest shed for the workmen
	Hit Underground Utilities	Get the clearance from concern dept. Work permit system to be followed
	Over head lines	Expose the utilities. Insulated materials before digging
Excavation	Damage to underground electrical, Telecom cables and water services	Erecting goal post with warning signs. Restricting the vehicle movement by fencing
		1. Follow Excavation clearance permit system. Look for route markers 2. Make trial pits in case of doubt 3. Look for warning tapes/ cable covering mats/ concrete saddles/ sand padding. 4. Adhere strictly to manual excavation in case of presence of underground cables.
	Fall of Vehicle into the excavated pit	1. Provide hard barricades with min clearance of 2m from the excavated pit 2. Ensure adequate illumination & danger lighting 3. Post reflective warning signs & blinkering lights to highlight deep excavation
	Fall of person into the pit while walking/working	1. Provide barrier away from the edge of excavation 2. Provide sign boards & blinking lights
	Fall of objects (stone, boulder, soil etc.) into excavated pit	1. No materials shall be stacked at edge of the pit. 2. Min 1.5m clearance shall be given
	Congested work site; too many persons working in the trenches	Provide adequate emergency access Allow only minimum Required number of persons to work at the same time
	Earth moving equipment operation	Keep distance of minimum 5m between two equipment while in use. Use only authorised equipment and employ experienced operators. Ensure safe overhead distance can be maintained otherwise suspend the activity. Ensure strict supervision

Some more examples on how to maintain safe processes. This is again can be called as a safe operating procedure, like this you can create a safe operating procedure for all the operations. So, that you need not have any hazards all can be revealed out in the whole processes. Site clearing and bush clearing, so manual clearing you may have leg injury, you can use gumboots and complete clothing or you can choose machinery for clearing.

Snakebite in the grassy area, maybe the carbolic acid can be sprayed before the work start and gumboots can be worn, so that snake bites can be avoided. Leveling by man and machinery, equipment injury, so check the fitness of the equipment with respect to safety aspects before use. Mishandling equipment and accident, operator identity required, so you should not allow unauthorized operators to operate the vehicle.

Run over on people resting under vehicle, so before you start the machine see whether any people are there down or else you can also provide rest assured for the workmen. Hit underground utilities, get the clearance from the concerned department, identify all the utilities and then only you may have to do. In a way, work permit system required and expose the utilities, insulated materials also should be used before you start digging.

Overhead power lines, erecting goalposts with warning signs, also you can put adequate fencing, so that the vehicle movement is restricted. Excavation, damage to underground electrical,

telecom cables and water services, follow excavation clearance permit system, look for route markers, make trial pits in case of doubts, look for warning tapes, cable covering mats, concrete saddles or sand padding, adhere safety to manual excavation in case of presence of underground cables.

Fall off vehicle into the excavated pit; provide hard barricades with minimum clearance of 2 meters from the excavated pit. Ensure adequate illumination and danger lighting, post reflective warning signs and blinkering lights to highlight the deep excavation. Fall off person into the pit while walking or working, provide barrier away from the edge of excavation, provide signboards and blinking lights.

Fall off objects into the excavated pit, no material should be stacked at the edge of the pit, minimum clearance of 1.5 meter should be given. Congested worksite, too many people working into the trenches, provide adequate emergency access allow only minimum required number of people to work at the same time. Earth moving equipment operation, keep minimum distance of 5 meters between 2 equipment in use. Use only authorized equipment and employ experienced operators.

Ensure safe overhead distance that can be maintained otherwise close the activity and you have to postpone the activity later, ensure strict supervision in case of equipment. If you see all these, these hints are all picked up from the earlier topics, when we were discussing about each and every topic on excavation and so on. We have discussed several issues there; from there you can pick out all these and you can easily write a safe operating procedure.

So, that workers will be very clear on how to do, so this is a sample I brought out on excavation, like this you can bring it out for each and every topic.

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The standard of care

- To avoid the hazard, it must rely primarily on the physical elimination of each hazard, rather than human performance
- A well-known tenet of safety engineering states "Any hazard that has the potential for serious injury or death is always unreasonable and always unacceptable if reasonable design features and/or the use of safety appliances are available to prevent the hazard"
- The key to successful safety engineering is to identify and design out as many hazards as possible
- The identification of hazard is the basic building block of ensuring an inherently safe construction project
- The most puzzling process is how an engineer can initially identify a hazard and how a potential hazard is recognized

At the time of design & construction planning

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The basic standard of care, to avoid the hazard, it must rely primarily on the physical elimination of each hazard rather than human performance. So, if you do not remove the hazard, the hazard is still available there. So, primarily the first two what we have talked in hazard management, eliminating the hazard and substituting the hazard are the best procedures wherein the hazard is not coming in the scenery at all.

In all the other three steps, you are only trying to minimize the impact that was caused by a hazard. Any hazard that has the potential for serious injury or death is always unreasonable and always unacceptable if reasonable designing features and or the use of safety appliances are available to prevent the hazard. So, the key to successful safety engineering is identifying and design out as many hazards as possible and rule out from the processes.

Identification is a basic building block for ensuring inherently safe construction project, if you are not able to identify, then it is very difficult for you to proceed with hazard analysis at all. So, the most puzzling process is how an engineer can initially identify a hazard and how a potential hazard is recognized at the time of design under the time of construction planning, that is all the real challenge here.

So, during the design itself, you can think of alternate procedures, you can think of alternate ways to change and handle a hazard. In construction suppose the design is fully done also, during

construction at least some sort of substitution measures and elimination measures can be really brought in. So, if you are not vigilant at that time, and you wanted to do safety control measures after you have planned the design and construction, then you are actually too late you may have to manage with PPEs or administrative controls or the other controls. That is the only one option you will have.

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Now, let us quickly wrap up this, so this is actually a recap on hazard control. Workplace procedures adopted to minimize injury, reduce adverse health effects and control damage to plant and equipment. So, this is a hierarchy of control, elimination, substitution, engineering controls,

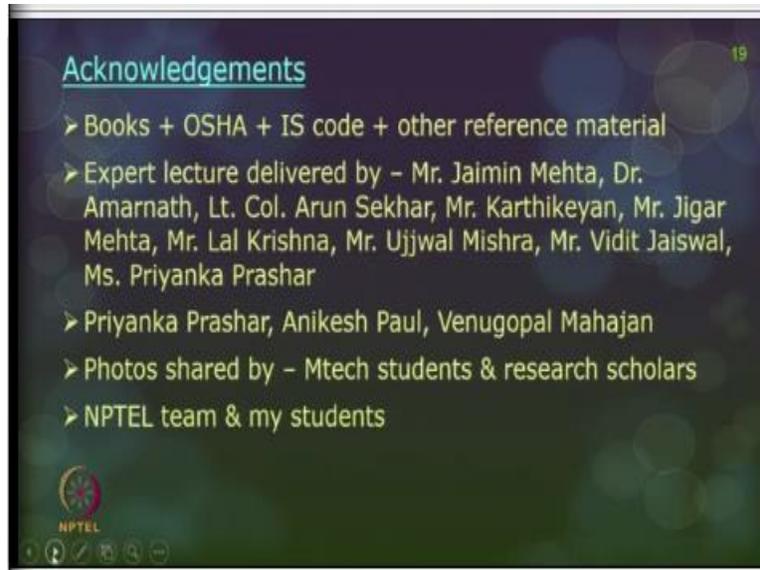
administrative controls and PPE. So, this is primarily in the way of increasing effectiveness, elimination is the best effective method.

This is increasing participation and supervision needed if you want to go in the reverse order. Controls are usually placed most effective to least effective, at the source along the path and at the worker, so you may have to think of this particular path. Elimination, remove the hazard from the workplace, elimination is a preferred way to control your hazard and should be used whenever possible.

Substitution, substitute hazardous materials or machines with the less hazardous ones then engineering controls, design or modifications to plants, equipments, systems and processes that reduce the source of exposure. Automate the hazardous processes, use mechanical lifting devices or transportation instead of manual methods, enclose and isolate the hazard from workers and so on. Administrative controls, controls that alter the way the work is done, implement job rotation and work rest schedules.

That limit a time a worker is exposed to a substance or processes. Establish safe work practices, such as standard operating procedures, in emergency response training, good housekeeping personal hygiene practices and so on. The last one is PPE, so it should be the last level of protection used when all other methods are not possible. If you see here the steps, identify the hazard, assess the risk, choose the best control for the hazard, implement the chosen control and evaluate the effectiveness of the control.

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At last, we have come to the end of this course. So, acknowledgments, I am very grateful to acknowledge so many people and so many sources from which I have developed this 8-week course material. So, many books I have referred and everywhere then and there I have given the references. And also, in the main page of the course page itself I have given so many lists of books.

And lot of OSHA material I have taken up and several IS codes and at the end of each and every lecture I have given in the last slide what are the list of IS codes and all other reference material, without which I would not have been able to finish this lecture. And there were so many experts and thankfully who came forward to deliver small short safety talk.

And which will be not for evaluations in the examination but without that this course may not be a complete package. So, thanks to Mr. Jaimin Mehta, and he is from AECOM (35:04), Dr. Amarnath he is from L & T, lieutenant cornel Arun Sekhar from MES. Mr. Karthikeyan is a freelance person working in an industry, Mr. Jigar Mehta again from L & T, Lal Krishna from DMRC, Ujjwal Mishra, Vidit Jaiswal, Priyanka.

All these are my students still they are working as in some small projects. And the TA students, Priyanka, Anikesh and Venugopal for helping me in preparing slides and making so many photographs and into life by drawing it on 3D forms and for editing and for helping me in the

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