**Ethics in Engineering Practice**
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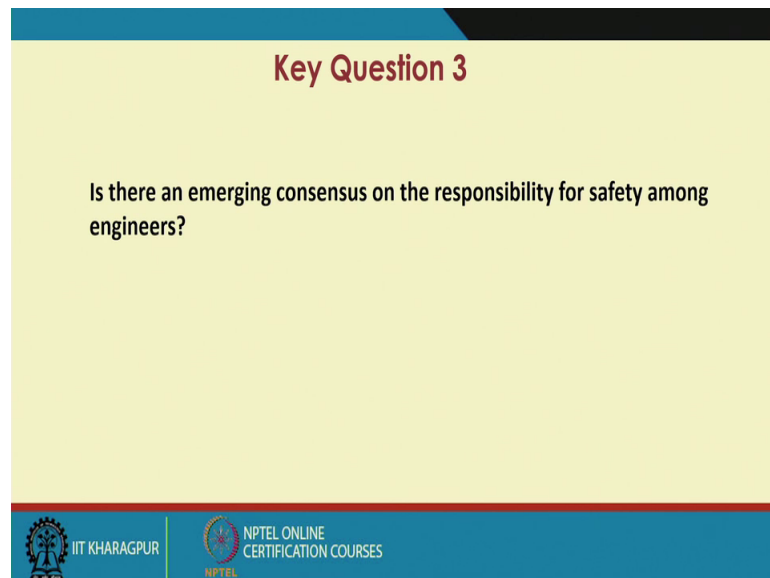**Indian Institute of Technology, Kharagpur**

**Lecture – 33**
**Key Questions – Central Professional Responsibilities of Engineers (Contd.)**

Welcome back. Today we will continue with our discussion of the Key Questions regarding the Central Professional Responsibilities of Engineers. Today we will mainly focus on the discussion of the professional responsibilities of engineers with regard to safety. We will discuss two-three cases also and try to see as in a given situation; what was the correct step to be taken by the engineers who were a part of that situation.

So, we will start with the first key question for today is like is there an emerging consensus on the responsibility for safety among engineers.

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So, like repeatedly we have been discussing on this topic like safety and concern for the well being of the like people at large, the public at large is one of the primary responsibility of engineers. Now, what we find is the engineering has also different specializations, different divisions and there like different kinds of engineers. So, what we are going to discuss over here like given whatever kind of engineer you are, whatever

be your specialized knowledge and responsibility expertise is, is there any consensus regarding the responsibility of safety amongst the engineers. So, let us see.

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First we will try to discuss like why safety is a special responsibility for the engineers, because they are at the interface where a product or a service is getting developed and the users are using it beneficiaries are using it. So, it means it may not be always possible for the users to understand the hazard part of it. So, it becomes primary concern for the engineers to look after the safety part.
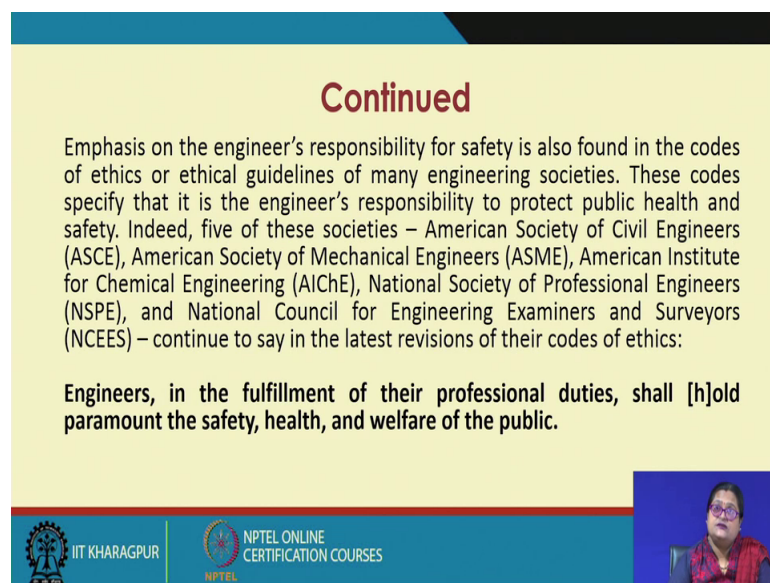
And to like take a proactive measure to see the system whatever they have developed does not do what they do not want it to do and that is the safety issue and it performs what it is expected to perform. So, that is the performance issue. So, it should not do what it is not expected to do because there could be some you know like if there are not very knowledgeable customers, responsible users we can imagine like or maybe it is mishandled by someone.

So, we have to imagine what kind of different situations could be there and take as many precautions as possible to ensure the safety of the device. That is why it is very important to understand like the system does not do what it is not expected to do. Given whatever it is so, there could be some safety lock, there could be some something embedded in the design itself like which does not open, if you are talking about devices of you are talking of a bridge, then it is strong enough to withstand like the heavy traffic. So, and withstand

attacks by maybe other, we were talking about for ships attacking other maybe if it is over water like ships passing below weight and there is a vibration. So, it is able to withstand that, it is able to withstand heavy traffic. So, we have to think of different situations and we have to take your like it does not do what it is not expected to do and it does what it is like expected to do. So, that is the performance issue.

It is like sounds similar like for physicians, it is given do not do any first it is, do not do any harm. So, that is the clear part that they are morally responsible to.

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So, when you are talking of these things what we find like there is the responsibility for safety of the engineers have been embedded in the codes of ethics of many engineering societies. These code specifies that it is the responsibility to of the engineers to protect the public health and safety. So, like 5 of these societies like American Society of Civil Engineers, American Society of Mechanical Engineers, American Institute for Chemical Engineers, National Society of Professional Engineers and National Council for Engineering Examiners and Surveyors, continue to say in the latest version of their course of ethics; like engineers in the fulfillment of their professional duties shall hold paramount the safety health and welfare of the public.

So, irrespective of whatever discipline you are in, irrespective of whatever is your specialization, it is found. Like the 5 main societies have come to the agreement, come to the consensus that engineers have as a part of the fulfillment of their professional duty,

the safety health and the welfare of the public is their major concern irrespective of whatever branch they are in whatever discipline they are in.

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We will try to look at it from again as we told like we will be discussing small cases and with respect to the cases we will see whoever is the engineer involved in it then what are the actions taken whether it was ethically correct whether something different could be done. So, for each of the key questions maybe we will take up small short cases and try to like elaborate on that.

So, let us look into the case of unanticipated factor, auto safety. So, it is given like you are a new engineer working as a part of a design team for a large automobile manufacturer. So, please note you are a new engineer working as a part of a design team for a large automobile manufacturer. The company is doing a major redesign of its one of its product lines. So, your team is responsible for designing part of the frame of the new car. As a part of the company's drive to make cars lighter and more efficient your car your team is directed to make some of the structural members out of carbon fiber composites.

The cross member that holds the rails of the frame apart was ideally suited for composite replacement. You test several different composite materials and layups and finally, choose one that you have reason to believe will work. Several prototypes of the cars are

built which you checked carefully. Your design is then approved and it is about to go to production.

Just today you found a problem with your cross member. A few inches of the cross member from the car that was winter tested showed extensive cracking. After looking at the design you realize that the cracked portion is in proximity to the exhaust system. You conclude that the hot pipe in cold weather created thermal stresses and caused the cracking. So, what can and should you do and how do you go about it?

We have discussed this case earlier also will reimburse us this case based on our understanding of the dilemma and again in the last session we have discussed about justification, we have discussed about the excuses, we have discussed about who is responsible. So, what do you think like the engineer can do in this case?
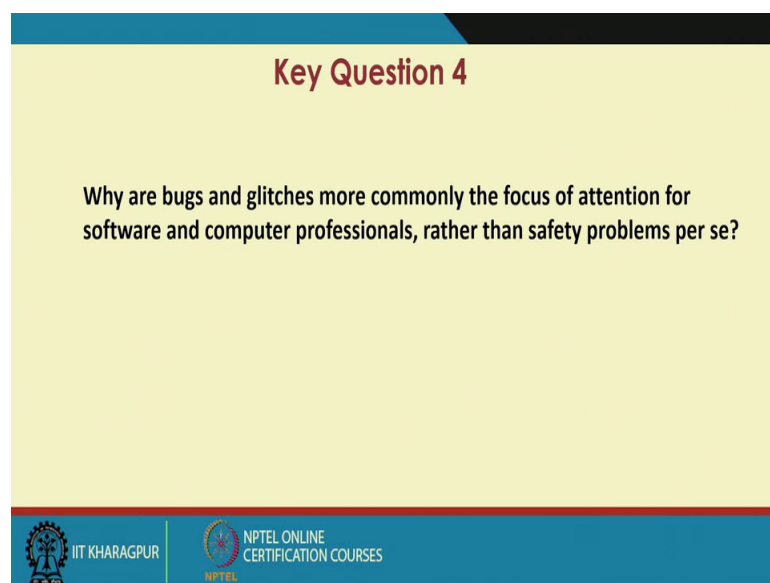
Like one option could be I remain silent, I do not report anything because you find like you are a new engineer you are not very you are a new engineer working as a part of the whole design team and it is a like your; and you find like your design team is responsible for designing a frame of the new car and you can justify your actions telling we did not select it to be done through carbon fiber. It is our, we got your team was directed to make some of the structural members out of carbon fiber composites.

And like then it was like the cross member that holds the rails of the frame apart was ideally designed for that. So, where comes your responsibility also you can justify telling like this has been observed in like know one of the curves which was winter tested this does not mean like this will happen to all the cars. Definitely this is not going to happen to a car, which is a summer tested or it may not happen to other cars also which are winter tested. So, this is just an odd situation where it has happened.

And like today it is going to go for production. So, it will be a huge loss for my company if I am like trying to stop the production and maybe the car has already promised like it is going to launch a new variety. So, best is to keep silent and I do not report about it or I try to justify about it. But is it ok? Maybe not. Why? As a engineer at whatever stage you find any fault is happening maybe it is you are much lucky like this has you are able to detect it as a part of before its started for production.

So, even if it is one car we cannot risk the life of the user for it, you have noted in one car you do not know like whether the same thing has happened in other cars, you do not know like whether the same thing is about to happen. So, because there are so many unknowns and you cannot compromise with the safety part of it. When you find like it is an important part of the design where extensive cracking, means it could risk the life of the users it is a part of your primary responsibility to like report it to your design team. And it is a part of your joint responsibility of the team to work like to rework on it and report the thing to the automobile manufacturer.
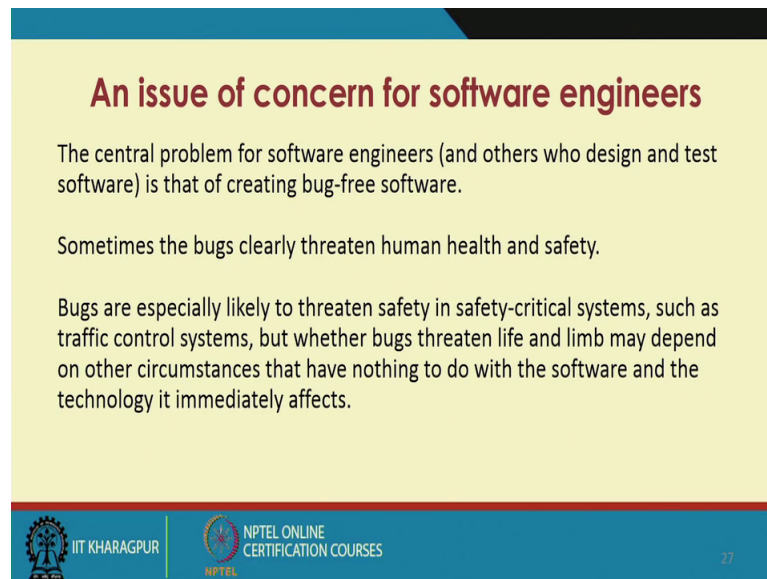
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So, this is where our primary responsibility lies for the safety welfare and health of the public at large. We cannot afford to take risk with the life of people, when we have detected something is wrong it is a primary responsibility to like bring it to the notice of others and see like what corrective actions can be taken about it.

Next will go for the key question 4 for this module, like why are bugs and ditches more commonly the focus of attention for software and computer professionals rather than the safety problems for safe. So, you may think of like why these are more of focus for the attention of the computer professionals because in the 5 societies we have talked of mechanical engineers, we have talked of chemical engineers, but we have not discussed about computer engineers. And that is why we are asking this question why your bugs

and ditches more commonly the focus of attention for software and computer professionals rather than the safety problems per safe.

Let us see what is under like this question and what are the expected like me. If we are going to explain for this like what are really bugs and ditches.

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The central problem for software engineers and others who design and test software is that of creating a bug free software. Sometimes which happens like the bugs of course, threatens the human health and safety. So, we may be thinking like we may be you know kind of thinking in the point of dilemma, they are concerned about bugs they are not concerned about safety that is not the case, the bugs me threaten human health and safety that is why I software engineers they are more concerned about the bugs. Bugs especially likely to threaten safety in safety critical systems such as traffic control systems.

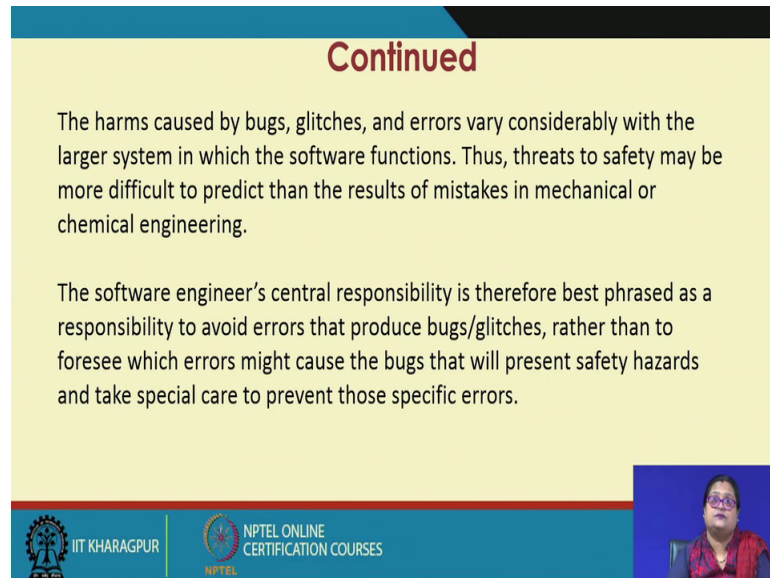So, but whether they threaten life and limb may depend on other circumstances which may not be directly linked with the software and the technology it immediately affects. So, we have to understand like some bugs present in the software may threaten in a safety critical system, but whether it will threaten life or not it is dependent on others circumstances as well. So, when it is affecting it is not that the computer engineers are not concerned with safety; they are concerned with bugs means they are trying to ensure like the system which is using the software is functioning in a proper way. So, that the

any malfunction of that system does not lead to safety issues and accidents. That is how they are also very much concerned with the safety and health aspect.

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The harms caused by the bugs glitches and errors vary considerably with the larger system in which the system functions. Thus threats to safety may be more difficult to predict than the results of mistakes in mechanical or chemical engineering, because in mechanical and chemical engineering maybe it is feasible like you can just detect it on the spot.

So, but for the software engineers because the softwares are embedded in a larger system like in which it functions it is difficult to detect it, because it is difficult to detect it that is why the responsibility is further critical. And we cannot tell like they are not concerned about the safety, because if something goes wrong it is very hard to detect it in that cases they should be more careful about it off to not to do any error part.

So, what we can based phrase the software engineer's responsibility is that of reducing the error, avoid errors that produce bugs and glitches. So, at a foresee like which errors might cause the bugs that will present safety hazards and try to like prevent those specific error. So, this is like avoid error and also to take proactive measures to find out to do test situations to find out what could be the possible errors which can produce bugs and how to like prevent it so that this may not make a threat to the safety issues.

So, if you are thinking like the computer engineers are not concerned with the safety issues that is not the right way to think, because they are very much concerned with the safety issues and because the any errors committed by them in the program may lead to further like escalate the safety like hazards. So, it is important for them to prevent them. It is very important for them to check those errors from occurring.

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Next we will move on to again a small case to deal with it, so that we can understand it in a better way. So, what we find a software bug that threatened the U.S Air super Air Forces superfighters. This example concerns the U.S Air Forces latest superfighter, the F-22 "Raptor". The Raptors cost more than dollar 300 million each, but for a while a software bug caused havoc in this pricey planes when they crossed the international dateline. The glitch came to light when in February 2007, a group of 10 Raptors headed across the pacific for exercises in Japan. These Raptors suffered simultaneous total nav-console crashes as their longitudes shifted from 180 degree west to 180 degree east.

Tanker planes accompanying the Raptors had somewhat older navigation kits, so the tanker planes did not did not experience the same nav-console crashes. The pilots of these tanker planes were able to guide the raptor pilots back to Hickman Air Force base in Hawaii. The glitches fixed later that month and the planes flew you to Kadena. Because of the accompanying tanker planes the software bug wasted time and money, but they did not cost lives.
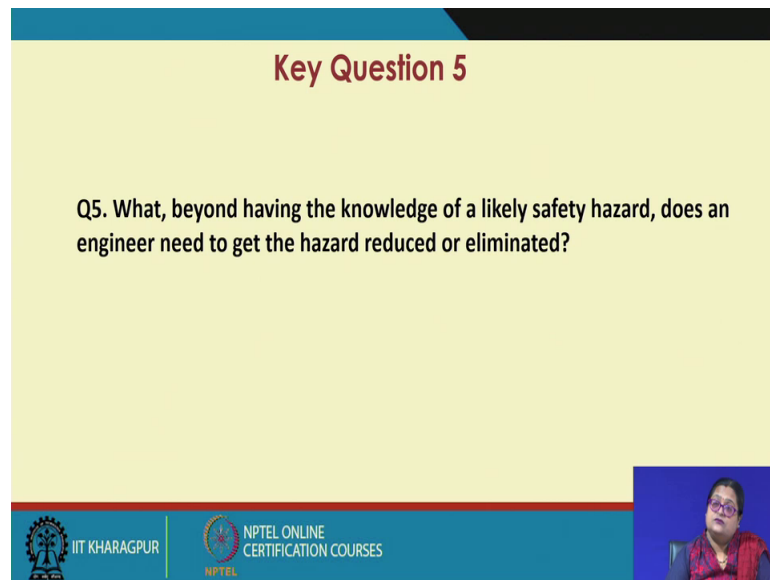
So, this example clearly focuses on the importance of an error free software for the smooth functioning of a such an important and pricey like air force super fighters. What you find over here like when the program had some bugs and it could not detect the longitude and shifted it shifted from 180 degree west to 180 degree way east then this led to like major issues, and if it were not for the tanker planes it would have led to disaster.

So, it would have costed lives. So, what we find over there the software bug wasted time and money, but it could have cost lives also if the plan a plane would have landed in a wrong place. If it were not for the tanker planes they would not have been able to come back to the air force base, and use find like the huge some like which each of the plane cause. So, it is huge money, huge time also and you can see the importance of having a error free software over them.

So, that is why it is definitely an issue with the safety and it is very important for the software engineers to focus on the bugs and glitches. And to find out to be proactive, enough to find out what could be the bugs and ditches if they would have like in this case. If they would have foreseen like this could happen and could have arrested for this problem beforehand like thinking like this could be the possible errors happening and how to arrest for this problem then this situation would not have happened at all.

So, there relies the central professional responsibility of the computer engineers also to do foresee situations which may lead to errors and then find out how to arrest for it. So, that once the software gets embedded in a bigger system it does not cost life, money, time etcetera.

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We will come now to the key question 5, so which talks off like what, beyond having the knowledge of a likely safety hazard. Like is it is it only I should I am having the knowledge and I should go stop over there or is it a part of my responsibility also to see like the hazard gets eliminated or reduced. So, is knowledge enough or an action proactive nature is required action is required so that I see that the hazard is getting reduced or eliminated.
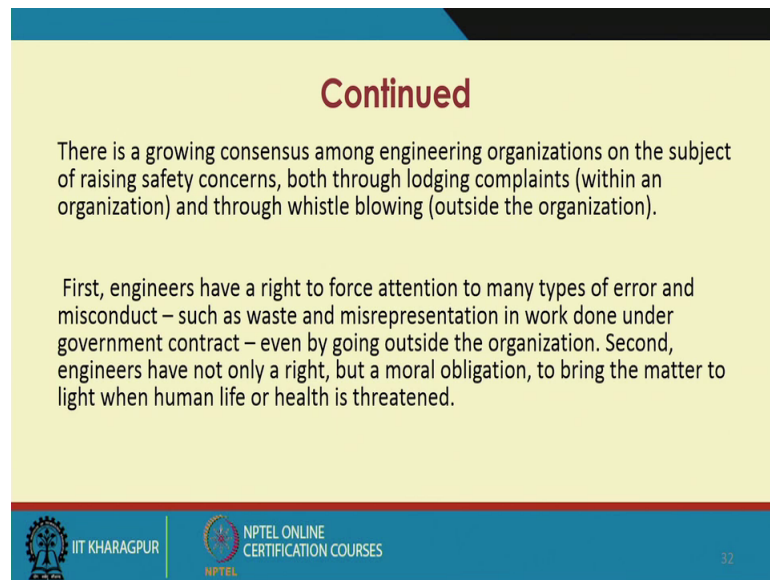
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So, here comes the question of whistle blowing. So, when I see something is wrong we I should not sit back with that knowledge it requires a part responsibility on my part also to move ahead to like make people known about it, to report it to the concerned authorities so that they can take care of it. If they are not then maybe I need to move to the public at large first to the higher ups again. And if again that approach is not working and it is a part of my responsibility to move to the public at large also, to gather a public opinion about it which may help to reduce the term.

So, like it is not enough for in by just preparing engineers to become my safety hazards. So, it may be important definitely it is important, but it requires a positive attitude and action of behavior so which is going to prevent accident. So, because engineers do not have the authority to remedy the errors that they have detected, so it sometimes happen there is a difference in thought process between the decision makers in their organization to attending to it and the engineering, like engineering ethics. So, which talks of like whether I am more loyal to my organization or I am loyal to the public at large. So, this type of dilemma will be there.

Like in the last case of the carbon fiber frame that we discussed about the car. So, this new engineer has detected some fault you he or she may report it to the higher up, but that person is not in a decision making position to take a decision whether to replace those parts or not. But then what is that person going to do should and what is its professional conviction like asking him to do? So, he may report again, he may try to influence, he may try to make people understand with his professional expertise what could be the long term effect of this thing and how it is going to affect the image of the organization, how it is going to affect the trustworthiness of the organization to the public at large, but the ultimate decision will be taken by the organization.

Now, what if the organization is not listening to this person views and continues with the production of the car; follow its old ways of doing things are not taking into consideration the alarm raised by the engineer regarding the safety issues. We will try to see again discuss this with the help of a small case.

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What we find over there like there is a growing consensus amongst the engineers like it is a part of their responsibility to regarding safety concerns to raise complaints and through if within the organization and if it is not heard they can go for whistle blowing outside the organization also. So, they have a right to force attention of the many types of errors and misconduct. So, like as misrepresentation in the work done waste under government control etcetera.

So, but even by going outside the organization, but definitely first it should be reported within the organization, they should try to like convince the organization about the long term benefit of taking care of the safety issues rather than looking for short term gain, and in the long run which may affect the image of the organization in the mind of the public and the trustworthiness. Secondly, the engineer is not only have a right, but they do have a moral obligation to bring the matter to light when it is a concern of human health and or human life which is getting threatened.

So, what we find over here is again a case: Garcia a renowned structural engineer is hired for a nominal sum by a large city newspaper to visit the site of a state bridge-construction project. This project has been plagued by construction delays, cost increases and litigation, primarily because of several well published on site accidents.

Garcia it is the bridge and performs a one-day visual inspection. In the very general terms, her report identifies potential problems and proposes additional testing and other solutions. In a series of feature articles based on Garcia's report, that city newspaper alleges that the bridge has major safety problems that will jeopardize his completion date. Allegation of misconduct and incompetence are made against the project engineers the contractors and the state highway department. The state holds an investigation in which Garcia states that a report only identified potential problems with the safety of the bridge and was not intended to be conclusive.

What is your ethical evaluation of Garcia's agreement with the newspaper? In the light of this experience, what safeguards might an engineer seek as a condition of accepting an exciting assignment like Garcia's?

So, what do you find over here like the news Garcia only made a statement about the potential problems. So, she does like one day of visual inspection, she has not done any in depth study to draw some conclusive findings about it. But what we find this newspaper has and what she has stated in her report that additional testing and other

solutions are required further, like further investigation. So, of those problems, but this newspaper have made big statements based on that report and like in brings allegation like the bridge has made a major safety issues, and like the project engineers, contractors, and state highway department like were all held for misconduct and incompetence.

So, what we find like as a structural engineer? If we are first whether we will be taking up any responsibility as such for a nominal sum by a large city newspaper without knowing whether there is any mollified intention of the newspaper, we do not know like who that newspaper is like ran by is it a neutral organization or it has some like political affiliation. And whether we could take any safeguard, like whether we can enter into an agreement like they fear because any report given by a structural engineer carries lots of weight with respect to the and responsibility. So, can the newspaper like maybe misquote her reports. So, whether he should enter into an agreement like they should not be misleading the public taking her reference. Also we have to question over here was it ok for Garcia to tell about the potential may be experienced, fine.

But it requires a lot of responsibility, professional responsibility and trustworthiness before we like write a report and make certain comments about certain things. So, is it ok only through one day visual inspection like without doing any other testing, is it ok for her to tell about this the potential problems or she should have gone for some at least some few tests before she can tell about it.

So, these will be the questions that will be coming over here, because that talks of the responsibility at when I am uttering something, when I am making a statement we have to understand it really has a great impact on the public at large, and also on the like other stakeholders involved. So, it is a part of my responsibility before we make in a statement to follow all the testing processes possible before I arrive at that conclusion.

So, we can question over here also like was it a right step taken by Garcia just to make a visual inspection and write a report or though she is written about potential problems. So, and then if she is written about potential problems is it a part of her responsibility also to cross check with the newspaper like whether they are misrepresenting her report and using her name to like book people for misconduct and other things because we do not really know the true intention of the newspaper. So, we have to understand this part of the responsibility also.

So, it is not the knowledge about the safety issues which are important only it is definitely the knowledge is important, but we have also as an engineers, it is a involvement with the to see like whatever we are reporting about the safety issues that it is represented properly, it is not understated, overstated or not like misused by other parties for their own intentions. Because at the end of the day the safety, health issues and the well being of the public at large is major thing.

So, if Garcia has reported about the potential problem the newspaper should report till there only, and like should not have hyped it to, so much before further testing is done to make a conclusion like, yes these are actual problems and corrective actions are to be taken. We will visit more of key questions in the next modules, discuss with these small cases.

Till then thank you.