Product Design using Value Engineering

Prof. Inderdeep Singh
Department of Mechanical and Industrial Engineering
Indian Institute of Technology, Roorkee

Lecture - 09
Functional Analysis

Namaskar Friends! Welcome to session 9 of our course on Product Design Using Value Engineering. So, we have already completed 8 sessions focused on the basic aspects of product design and the very basic points and factors, historical perspective related to the concept of value engineering. And, if you remember we have already seen, what is a value engineering job plan, what are the various stages or phases of a value engineering job plan, how we have to conduct a value engineering study.

The first and foremost part in any value engineering study is the identification of the function. Each and every product that we are using has been designed developed as well as offered to the customers in order to satisfy one or a combination of needs and requirements. So, each and every product is performing certain function. Now, how the product is performing the function, whether the customer is satisfied with that function or not, how effectively, efficiently, reliably the product is delivering the intended function to the customer is always the object of concern for the product designers.

So, the first and foremost word that is important in any value engineering study is the function. And, we have already seen that value or worth of product is directly proportional to the functions, the product is offering to the customer and inversely proportional to the cost. So, we will say a product is having a very good value or a very significant value for the customer if, it is providing the intended function at the minimum possible cost and, how it is going to provide the function that the designer has to decide.

When the product is being designed, the designer has to take a call that what are the essential functions, what are the basic functions, what are the secondary functions, what are the tertiary functions that he must include in the product during the design stage. And, if you recall in our previous session we have seen types of product functions in which we have defined the primary, secondary and tertiary functions. Also, we have taken examples of use and esteem functions. So, once we are able to properly understand the function for which the product is being designed, we will be able to come up with n

number of alternatives to satisfy that function. And, we have taken an example in the previous session also that once we are able to define the function. For example, show time, so, we have identified that the product that we are conceptualizing that we want to design, the basic function of that product is to show time.

Now, we have to see that how that show time function can be achieved by the product or can be modify design provide a facility which can tell the customer the time whenever he or she wants to see the time or to know about the time. So, identification of the basic function is the primary job of the designer.

And, once the functions have been identified the designer has to provide then means and mechanisms to achieve that function or to provide that function to the customer in the most reliable, efficient and effective manner. So, with this background and the revision of what we have already covered, we will carry forward our discussion in the next phase that is the Functional Analysis.

So, in functional analysis, we will try to identify the function which we have already seen in the form of a verb and noun and, then we will try to blast the function or the functional blasting of the product. For example, if you take an example of a overhead projector; in overhead projector there will be so, many different parts. So, what in functional blasting what we will do, we will blast the product not explosively, but maybe fundamentally.

We will try to see that what are the various parts that are being assembled or which have been assembled together to make overhead projector. There can be a mirror arrangement or optical arrangement, there can be a stand, there can be a platform on which we will put over transparencies, there can be a bulb for illuminating the transparency, there can be a focusing knob.

So, each and every part of the overhead projector we will blast it into the individual components, and then try to find out that what is the function of each and every component which is being used for assembly of that overhead projector. And, once we have done that then we will see that what are the interacting functions, what are the two functions which can be combined together, what are the unnecessary functions which can be easily eliminated. So, all these type of analysis will come under the functional analysis. Once we are done with that so, we will blast or functionally blast the part into

the individual components. For each component, we will try to identify whether it is satisfying the basic function or it is helping us to accomplish the secondary function.

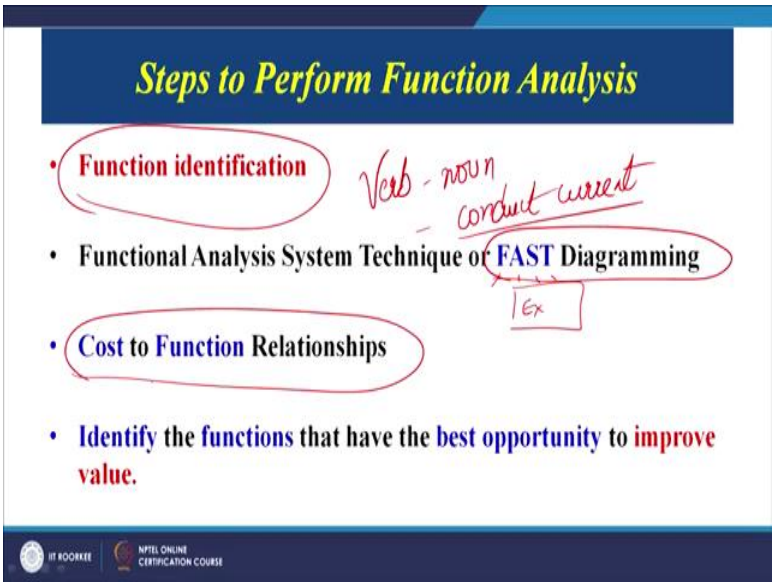
So, for each component we will try to do basic or secondary and then we will try to create that is identifying the functions which are necessary, eliminating the unnecessary functions, combining the functions which can be easily combined. Though that will be creating a new design which is different from the existing design, but without compromising the performance, quality, reliability of the product. So, we in creation phase we will try to create new and new alternatives of the existing product which satisfy the primary function or the basic function of the product; then we will refine these alternatives.

Suppose, we have now 10 alternatives designs available with us which are satisfying the primary function; we will scrutinize these designs based on certain criteria which is relevant to our example of overhead projector. And, then once we are able to fine tune our idea to maybe one or two best ideas, we will try to implement those ideas. So, in functional analysis our target is to basically analyze the primary and the secondary functions of the product. And, try to create new and new solutions to the existing design or different alternatives to the existing design then, analyze that design based on the certain criteria.

So, in today's session, we have tried to include two or three case studies where the function has been identified and then that function has been achieved at a reasonably lower cost. Maybe in our next session, we will try to focus on a very systematic technique which we normally call as the functional analysis system technique.

With the help of an example we will try to see that whatever, we are trying to understand today in an abstract manner, in a subjective manner, we will try to make it more objective in the next session. So, let us today see the basic aspects of functional analysis with the help of an example. So, we will try to take two or three examples today.

(Refer Slide Time: 08:29)



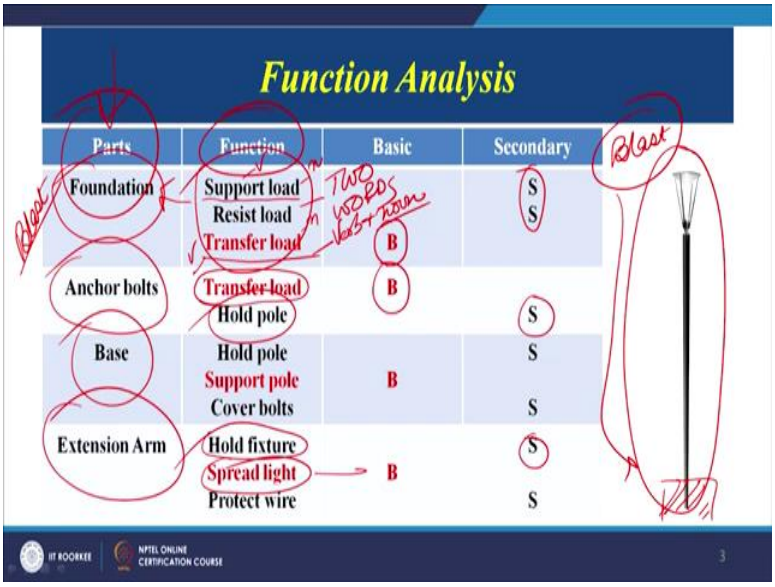
So, four steps to perform the functional analysis as we have already discussed in the previous session first thing is function identification. So, normally we do it in the form of verb and a noun, and we can take an example in the form of conduct current. So, this is the basic example. So, first we have to identify the function and a second thing is the functional analysis system technique that is FAST diagramming which we are going to study in the next session. We will try to understand the Functional Analysis System Technique with the help of an example.

Then the next stage in our discussion will be that cost to function relationship. Because, we have seen that the value of a product as per value engineering is dependent upon two important things that is the function as well as the cost. So, there must be a relationship between function and cost. We will try to understand this functional cost relationship with the help of few case studies in our subsequent sessions.

Finally, once we have established this functional cost relationship, we will try to identify the functions that have best opportunity to improve the value. We will try to establish a value gap, this is the value gap existing. This function can be satisfied in x amount of money or we can say, if we take rupees as our currency we can say that this function must be achieved in rupees 10. But currently to satisfy that function; suppose we are spending rupees 12.

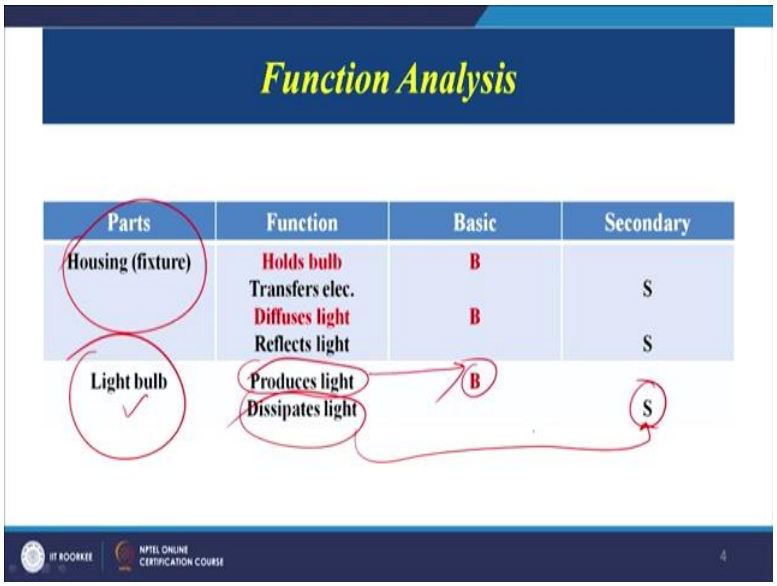
So, we can establish a value gap that in the current design, the function is being achieved at rupees 12, actual worth of this function is rupees 10. So, there exists a value gap of rupees 2 which means that now we must try to create the alternatives which can help us to achieve the desired function reliably at a cost of rupees 10. So, that kind of value gap we can start looking for once, we establish the cost to function relationship. But, today our target will be the function identification, and then trying to develop different alternatives to satisfy the desired function.

(Refer Slide Time: 11:09)



Now, let us take the functional analysis here this is a lamp post you can see. So, we can have a foundation here for this lamp post. So, we have seen first we have to blast the product which is a lamp post into the individual components. So, here you can see one of the important parts or components of this product is the foundation, then there are anchor bolts, then there is a base, then there is an extension arm, then there is housing or a fixture and then there is a light bulb.

(Refer Slide Time: 11:39)



So, this is a lamp post where we have fixed up a light for illuminating the neighborhood or illuminating the street. So, that is the first thing that we have seen here, the first column is giving us the various parts. So, this we can say we have blasted the product into its constituent components.

So, there are six or seven component that is the first stage, then we try to define the functional definition. And, in functional definition, you will see that we are using two words only. And what are these two words? The two words are a verb and a noun and you can see here foundation. What is the function? It is to support the load, support is a verb and load is a noun; similarly transfer the load, transfer is a verb and load is a noun.

So, there are three functions basically being achieved through the foundation, and here we can see that which one is the basic function and which all are the secondary function. So, to support the load and resistance load are the secondary function and transfer the load maybe the basic function. So, we are not going to get into the technicalities or we can say nitty gritty of the situation, we are trying to see that how we actually do the functional analysis.

So, first we divide the component or a complex intricate product into its individual components and then for each component, we try to list down the functions that particular component is delivering. And, here we can see similarly, the anchor bolts again the transfer load is the basic function and hold the pole is a secondary function.

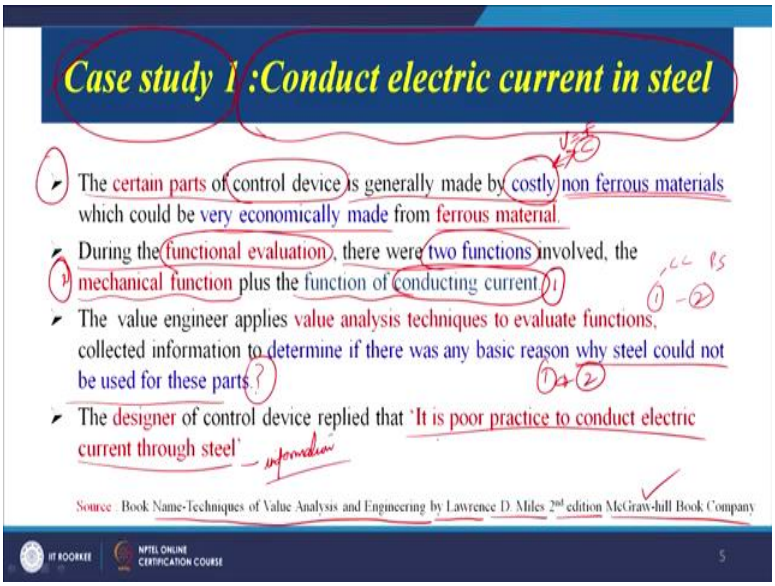
Similarly for the base, for the extension arm we can see holding the fixture is a secondary function for this, but spreading the light is a basic function for the extension arm. Similarly for light bulb produce light and dissipate the light.

So, the light bulb, basic function is to produce the light and dissipation it can be the secondary function. So, here we can see in functional analysis, first and foremost what we have to do for any product we have to divide that product into its individual components. And, for each component we have to write down a two word functional definition or a verb noun definition of the functions that particular component of the product is delivering.

Then, we have to identify that which of these functions are the primary functions of the components, which all are the secondary functions of the component. So, this is a first stage of our functional analysis. Then what will be the next stage? The next stage will be that we can try to put all this information or plot all this information in the form of a fast diagram that is functional analysis and system technique. Thereafter, the other component that is the cost component will come into picture where we will try to see that, what the cost of satisfying the secondary function.

What is the cost of satisfying this basic function, what is the cost associated with satisfying the reflecting light secondary function. And, then we will try to eliminate, combine or remove certain functions which are not relevant or which are unnecessarily adding cost to the product, but are not satisfying any of the defined needs and requirements of the customer. So, that kind of analysis we will have to do once the cost also comes into picture. So, this is the first stage of functional analysis.

(Refer Slide Time: 15:57)



Now, let us try, to understand the concept with the help of two case studies. So, this is case study number 1 that is conduct the current in steel and it has been taken from a very good book. The name of the book is Techniques of Value Analysis and Engineering by Lawrence D Miles 2nd edition McGraw - hill Book Company. So, this is a source for this case study. Why I am highlighting the source? Because, there are a number of other similar case studies which have been given, and you can refer to the book to have even deeper understanding of the topic of value engineering.

So, which is much more relevant to the overall product design process; so therefore, we have a time constraint of 20 sessions of half an hour each, the course is designed for 10 hours only. So therefore, I would advise all the learners to have a copy of this book and have a go at the case studies especially because the concepts we are trying to understand to discuss to deliberate. But, the case studies will help you to further understand the applicability or the application part of the concept of value engineering.

So, in this case study that is conduct the electric current in steel but basically is done. Majorly, whenever the current has to be conducted the first material that comes to our mind is copper. So, here the designers have tried to experiment and try to conduct the current through steel. Why? Because, in the specific application the strength, the hardness, the mechanical properties of the component were equally important as the current carrying capability of the wire. So therefore, when you require this type of a

specific combination where strength is also equally important that current also has to be carried or conducted in that case maybe copper may not be the best alternative.

So therefore, we have to look for the alternatives and find out the best alternative which satisfies our functional requirement. So, here for example, we take the product and in that product there are two basic functions that have to be achieved. The first function is conduct current, the second function is provide strength maybe or provide mechanical properties.

So, we have to see that whatever, material we choose must be able to satisfy these two functions that is it must be able to conduct the current, and it must be able to provide the mechanical properties that are desirable for the safe and reliable operation of the component or the product.

So, let us now whatever I have tried to explain has been jotted down, has been listed down in the presentation for easy explanation. So, I will read it for you so, that we are able to revise what I have already said, the certain parts of a control device. So, what is our product? The product is our control device is generally made by costly as we know value engineering is function by cost. So, cost is much relevant here. So, whatever parts or control device we are making with costly non-ferrous materials which could be very economically made from ferrous materials.

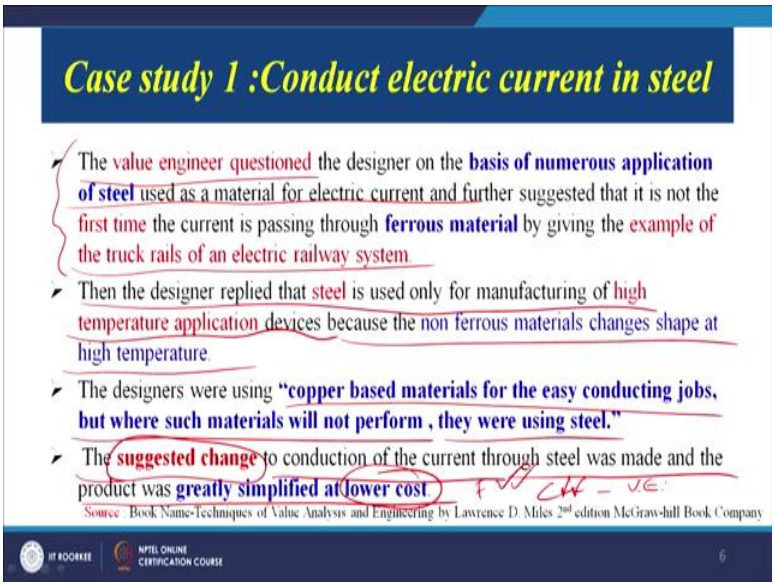
So, some of the parts we are unnecessarily making by costly non-ferrous materials, but these can easily be made economically from the ferrous material. So, this is you can say the crux of the whole case study. During the functional evaluation as we are trying to understand the functional analysis, there were two functions. What are these two functions which I have already explained? The two functions are the mechanical function plus the function of conducting the current. So, conducting the current maybe function number 1 and the mechanical properties desirable is the function number 2.

The value engineer applies value analysis techniques to evaluate the functions which functions, function number 1 that is conduct current and function number 2 that is provide strength or the mechanical properties. The value engineer applies value analysis techniques to evaluate these functions, collects the information to determine if there was any basic reason why steel could not be used for these parts. This is the first question that the value engineer tries to address that why steel cannot be used to satisfy both the

function, that is function number 1 and function number 2 for conducting the current as well as for providing the mechanical strength. The designer of control device replied that it is poor practice to conduct electric current through steel.

So, this type of information or maybe a prejudice that normally that designers carry is harmful to the successful implementation of the techniques of value engineering. So, it is a poor practice to conduct electric current through steel. So, that is basic hindrance towards answering the question that why current cannot be conducted through steel. Now, this has to be challenged and the value engineer questioned the designer. Now, the designer is saying that steel is never used or very rarely used for conducting the current.

(Refer Slide Time: 21:51)



But the value engineering questioned the designer on the basis of numerous applications of steel used as a material for electric current. So, value engineer must have a lot of information I must say because, he had this particular case study the value engineer had this idea that steel has been used for electric current or power conducting the electric current. And, further suggested that it is not the first time that current is passing through the ferrous material by giving the example of a track rails of an electric railway system. So, it is not for the first time that the value engineer is trying to conduct the current through a ferrous material.

He has already given a precedence or an example where the current has been carried through ferrous material. And, the designer is prejudiced that ferrous materials cannot be

used or are not widely used for conducting the current. So, then, there is a conflict thoughts. Value engineer has a special thought that yes there are examples, where ferrous materials have been used for conducting the current. Whereas, the designer feels that ferrous materials are not the right materials for conducting the current. Now, we have to somehow take a decision and try to find out the solution to the existing problem.

That we have to satisfy two functions, how these two functions will be satisfied we can see ahead. Then the designer replied that steel is used only for manufacturing of high temperature application devices because, a non-ferrous material changes the shape at high temperature. So, the designer has his own application spectrum for ferrous materials. He says that the ferrous materials are usually used for making high temperature devices where, the non-ferrous materials changes shape. Then, the designers were using copper based materials for easy conducting job, but where such materials will not perform, they were using steel.

So, which means that steel can be used for conducting the current, but they were not using it in all the applications. They were only using steel where the non-ferrous materials will not be used or cannot be used. So, copper based materials for easy conducting jobs, but where such materials will not perform, they were using steel. So, the suggested change.

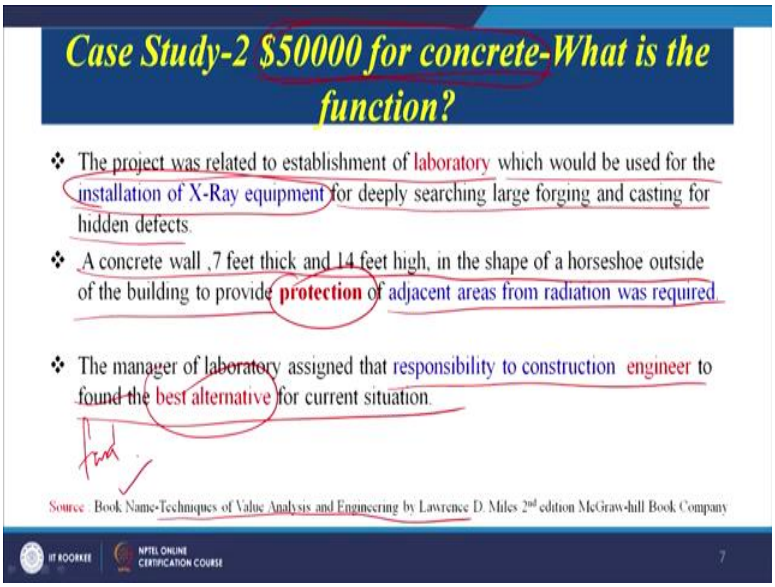
So, what is the changes suggested? To conduct the current through steel was made and the product was greatly simplified at lower cost. So, here, we can see that the designers had this knowledge that the current can be conducted through the ferrous material, but they were not using that knowledge.

Because, they were having a prejudice that the steel is not commonly used for carrying the current, but that prejudice was taken care of by the value engineer. And, it was reported that we can easily conduct the current through steel, the amount of current definitely is you can say less as compared to copper. But, as per the functional requirement it was ok and then even the ferrous material is providing better strength at elevated temperature even better strength for the specific application.

So, both the functions conducting the current and the mechanical action or the mechanical function both are satisfied by selecting steel as a material of choice or steel as a material for conducting the current. So, the product was easily you can say

fabricated at a lower cost. So, we can see that the functions are also, ok, we are able to get both the function, the cost is also lower. So, we can say it is a good example of application of the techniques of value engineering.

(Refer Slide Time: 26:03)



Now, in the second case study, very quickly we will try to go through this case study; dollar 50,000 for concrete wall; this case study is also from the same book Techniques of Value Analysis and Engineering by Lawrence D Miles. So, in this case study 50,000 rupees was to be spent for making a concrete wall.

So, what is the purpose of this wall or the function of this wall? The project was related to establishment of a laboratory which would be used for installation of X-ray equipment. So, there is extra equipment to be installed and what is the purpose of this equipment? It will be used for searching large forging and casting defects. I think the problem is absolutely clear.

In a laboratory X-ray testing equipment has to be installed, it is to be used for finding out defects in castings and forging. Now, because in order to avoid the effects of harmful X-rays for the staff, for the student, for the faculty members of the university or wherever the laboratory is established a concrete wall 7 feet thick and 14 feet high in the shape of a horseshoe outside of the building to protect of adjacent areas from the radiation was required. Now, a lab has to be established and a horseshoe type of a concrete wall of the thickness 7 feet thick and 14 feet highs has to be erected or constructed all around the in

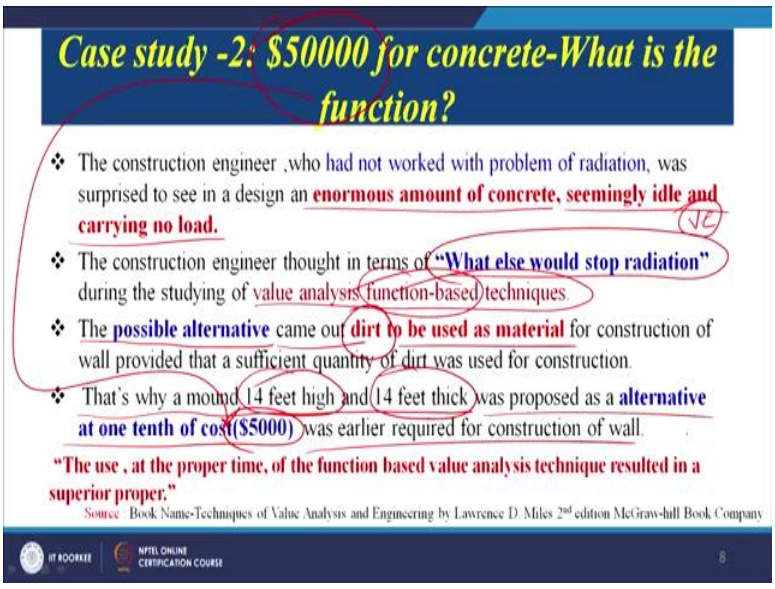
a horseshoe shape around the laboratory to protect the adjoining areas from harmful X-ray radiation.

Now, there was a question; when this went for a financial approval, there was a serious question that was asked that if the laboratory has to be shifted from location from its current location to any other location inside the university, will the concrete wall also travel along with the university or the concrete wall will have to be demolished? So, why to make such an investment?

What is the basic function here? The basic function is to provide protection. So, that protection has to be provided why only a concrete wall can satisfy that function. There must be some other alternatives which can satisfy the same function of providing protection from X-rays.

And, then team was established, brainstorming was done; it was found out that there can be better alternatives which satisfy the same function at a reasonably lower cost. So, the manager of that laboratory assigned that responsibility to construction engineer to found the best alternative, to find the best alternative for the current situation. Now, really we will see that which is the best alternative.

(Refer Slide Time: 28:57)



The construction engineer who had not worked with the problem of radiation was surprised to see in a design an enormous amount of concrete seemingly idle and carrying

no load. So, a construction engineer was surprised that what is the need of constructing this 7 feet thick wall, 14 feet high evolved in that laboratory. So, you can see 7 feet thick 14 feet high wall wide is required. So, you can say, why there is a requirement? The construction engineer thought in terms of what else would stop the radiation, one of the key principles of value engineering, we have to keep on looking for situations for different alternatives.

So, what else can stop the radiation during the studying of the value analysis function based techniques. So, we are also trying to understand the functional analysis or the basic function here is to stop radiation or to protect from radiation. The possible alternative now, we are coming to the solution, the problem all of you have understood.

The possible alternative came out in the form of dirt to be used as a material for construction of wall provided that a sufficient quantity of dirt was used for construction. So, it was found out that we can make a mound or a heap of a dirt all around the X-ray laboratory. So, that the function can be achieved, the protection from X-rays can be provided to the people who are all around the laboratory and the cost can also be reduced.

So, an alternative solution was found out that is why a mound of 14 feet high and 14 feet thick you can see, the height remains the same. But, because now, we are using loose dirt, lose soil, the thickness was increased to 14 feet and it was proposed as an alternative at one-tenth of the cost. So, earlier 50,000 USD and then, the cost has reduced to 5000 USD.

And, it was better than construction of a wall because the loose dirt or the soil you can take from one place to another place very easily. And, concrete wall, we can say a dead investment which cannot be transported from one place to another place along with the laboratory. So, we can say the use at proper time of the function based value analysis technique resulted in a superior alternative.

So, we can say that when we are applying the functional analysis technique in both the case studies as given by Lawrence D Miles. You can see that once we are applying the basic functional analysis technique, our target is to focus on the desired function without getting prejudiced by the existing solutions that are already available. So, in both cases; in first case copper or a non-ferrous material was an existing solution for conducting

current. But, final solution was a ferrous material because it provides the additional strength also. And, in second case, the concrete wall protection was a standard solution, but then, the alternative was better although it was thicker by 7 feet, but still it reduced that cost by approximately USD or dollar 45,000.

So, it was a low cost solution satisfying the desired function reliably and therefore, it was implemented. So, with this we conclude the today's session as we in the today's session we have tried to understand the basic aspect of functional analysis with the help of case studies. In our next session we will try to learn a more systematic approach of functional analysis,that is a functional analysis system technique. And, thereafter we will focus on the cost implications of functional analysis also with the help of case studies, where we will try to understand the functional cost relationships.

Thank you.