Experimental Stress Analysis
Prof. K. Ramesh
Department of Applied Mechanics
Indian Institute of Technology – Madras

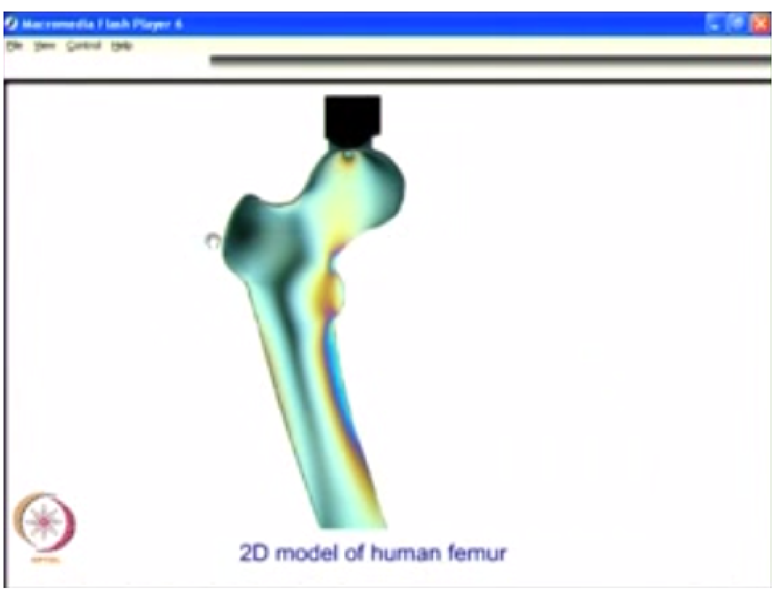
Lecture – 01
Overview of Experimental Stress Analysis

This lecture is on overview of experimental stress analysis.

(Refer Slide Time: 00:16)

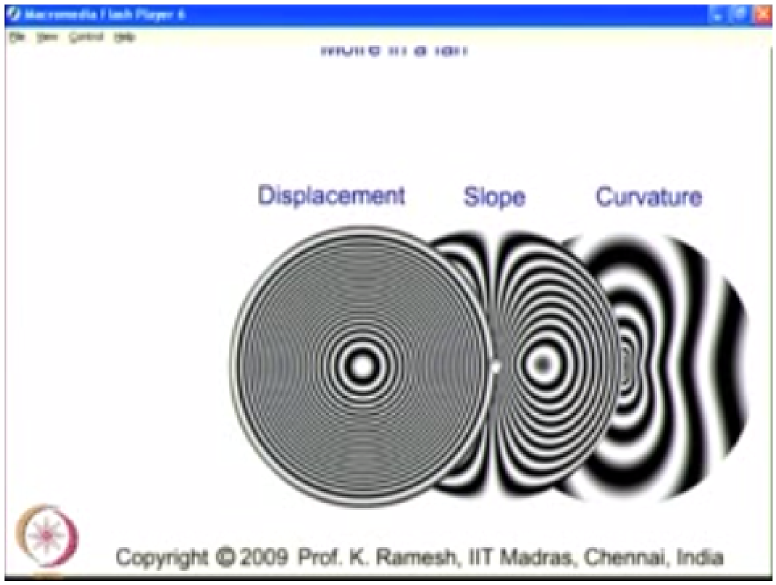
This light shows a nutshell what experimental stress analysis is all about.

(Refer Slide Time: 00:24)



What we see here is stress patterns observed in a 2D model of a human femur. So, you get stress information and stress analysis and you also get displacement information in stress analysis.

(Refer Slide Time: 00:40)



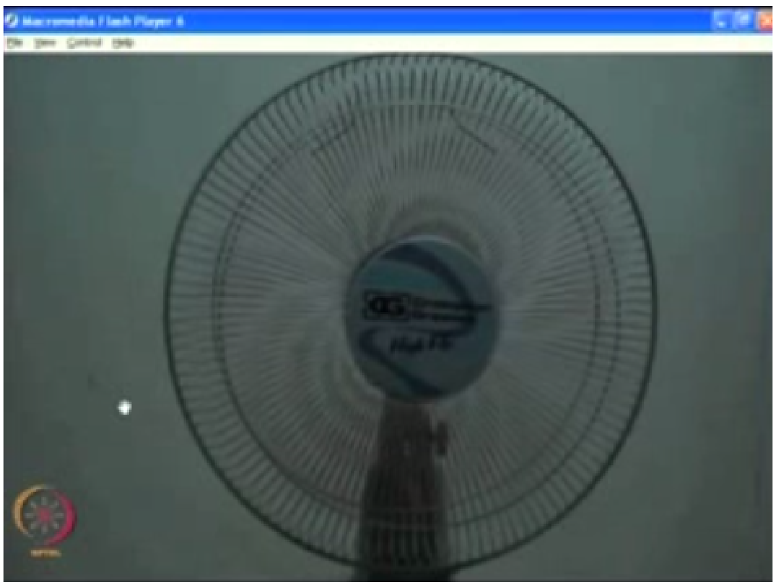
What you find here is for a circular plate clamped at the boundary with a central load you get the displacement and you can also have the slope, you can also get curvature. But will I had appreciated here is for each of these information you need to use a specific optical arrangement. You do not get them in one shot but you have to have effort to do that and you see on these 2 corners show that you need to use physics in applying experimental techniques.

(Refer Slide Time: 01:17)

So, what is done is any physical information which could be exploited formation and is identified and that is translated into an experimental technique and what you see here is a cusp in a teacup and this you see as a silver line. What happens is when light gets reflected on the curved surface it gets reinforced and you will have a cusp and this can be seen on any shallow filled containers with appropriate lighting and this phenomenon is called caustics.

This physical information is exploited in a technique called method of caustics which is used for measurement of high stress concentration. How it is done, we will see as part of the course.

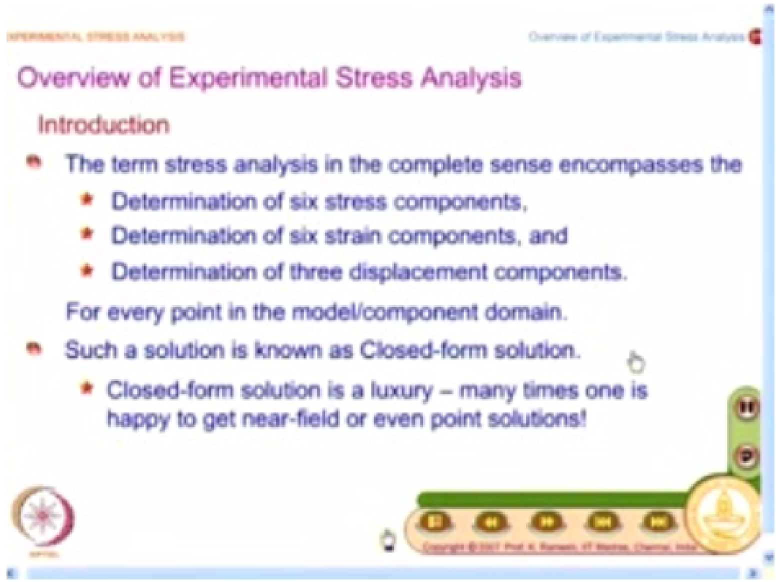
(Refer Slide Time: 02:16)



What you see here is another down to earth example where you see in the case of a fan when you have 2 grid superimposed you see a nice is moving pattern and this is called Moire and this is used for measurement of in-plane displacements, out of plain displacement and so on. So, what is emphasised here is when you have experimental stress analysis, I can measure stress information, I can measure displacement information, I can also measure strain information thought it is not shown here.

What is emphasised here is for each of the experimental technique, there is physics behind it. So, you need to appreciate the physics, understand how this physical information is exploited and that is what we are going to see in the lectures to follow but before we proceed further, we need to know what is stress analysis all about.

(Refer Slide Time: 03:13)



So, the term stress analysis in the complete sense encompasses the determination of 6 stress components. Why they are 6. Why do I say that you have 6 stress components?

"Professor - student conversation starts" Suppose I take a number like this and then apply tension, you all know the stresses are developed and what is the value of stress. Someone can answer. Suppose I apply the lower as P and area of cross section is A, what is the value of stress. (()) (03:51) Where are 6 components. You are only saying only one and what you have in this simple example problem is stresses are tensor of rank 2, so you have nine components. **"Professor - student conversation ends".**

Of the nine components because of symmetry, you have only 6 independent components. So, in a simple tension test like what you do on a slender member, you evaluate stress and it appears to be a scalar, P/A appears to be scalar and that is what you have learned in a question strength of materials, but you should change your thinking is go back and fill in the components in the stress.

So, what you find is I find one stress component, all other stress components are 0. So, that is why you have because stresses are tensor of rank 2, you have 6 independent components. So, when I say stress analysis, I should know stress components. Then, I also need to know strain components and strain components are again 6 because strain is also a tensor of rank 2. So, I need to get stress components, I need to get 6 strain components and it is also desirable that I get displacement components and displacement components are 3.

In what way I want this information. Suppose I take this rod and I pull it, I want this information at every point in the model. So, what I want to do is for every point in the model or component, I want all of this information and in this simple case, the stress component is only one I keep it at sigma Y, if I keep it horizontal you will label it at sigma X. If you have X and Y as and vertical, you will have this as sigma X stress component or you will put it as sigma X stress component.

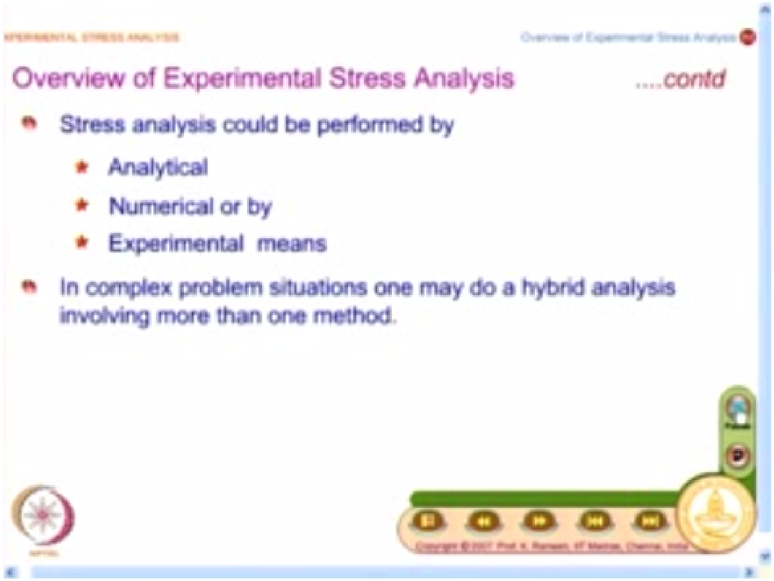
So, what you need to understand is stress is a tensor of rank 2. So, whatever the kind of loads that you apply, you should be able to identify the components and what I want is I want this information for every point in the body. Right now, let us not worry about the values of these near the place where I hold them, where I grip them do it away from the point of loading, we will worry about it, and when you say this P/A I know it at everywhere and it is constant and such a solution if I give the XY location and I am able to find out the values of stress, I call that as closed form solution.

Because at every point which I want to find out, I have the answer. Can you get closed form solution for all problems? It is not so; it is only a luxury. For certain problems, you are able to get all the 6 stress components, 6 strain components and displacements and in certain class of problems, you are satisfied with near-field solution. Particularly, in the case of problems with crack where fracture mechanics is focusing this, you get analytically solution close to the vicinity of the cracked; and from a design point of view, you are happy with even point solutions.

You would like to know where is the maximum stress when you want to find out stress concentration, when you want to go for the optimization, you also want to know where is the minimum stress because from there I can scoop out the material. So, what you have to understand is the term stress analysis in its complete sense encompasses determination of 6 stress components, 6 strain components and 3 displacement components and it is a luxury.

So, we have to go for that kind of solution which you require for a problem on hand. Always you do not require all these 15 components.

(Refer Slide Time: 07:55)

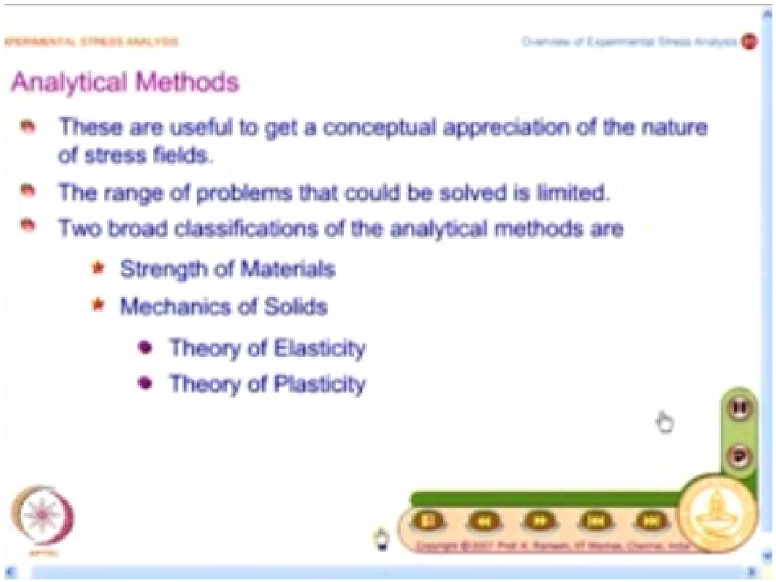


How this stress analysis can be carried out. You could do this by analytical methods, you could do by numerical methods or you can also do by experimental methods. Can you take a view that I will always use analytical method? or I will always go with the numerical method or being an experimentalist, I will use only experiment method. We cannot take that kind of prejudiced review. Each approach has certain characteristics that could be effectively exploited.

Few of this we will see as we go by. In a very complex problem situation, you know one technique may not be sufficient. You may have to use a combination of analytical, numerical or numerical and experimental and that analysis is known as hybrid analysis and what we are going to do now is we will see one by one what analytical methods, for which class of problems?

Why do you do analytical methods and what are the advantage of numerical techniques; and when you go to experiment, in which class of problems experiment methods are ideally suitable, that is what we will see now.

(Refer Slide Time: 09:23)

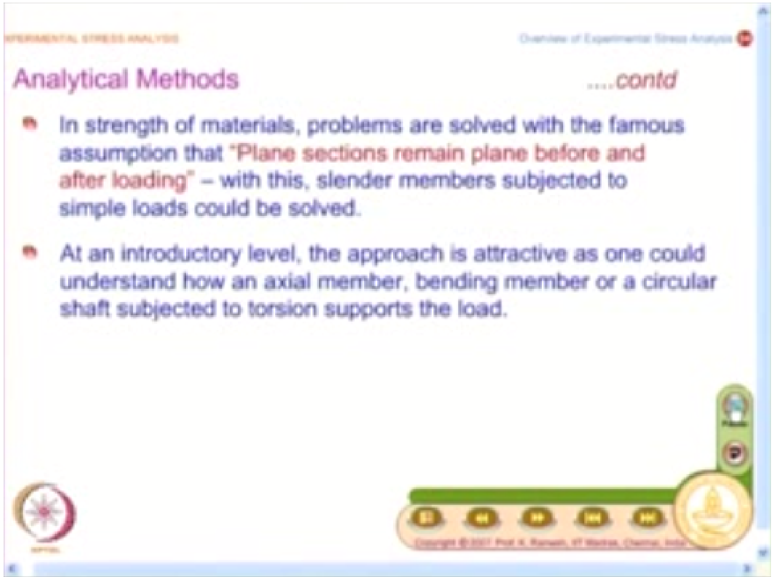


Once you come to analytical methods what the advantage here. These are useful to get a conceptual appreciation of the nature of stress fields. If I want to know, I take a member and I pull it, I know that it is subjected to tension and I do the bending and I want to know how the stresses are developed in bending. But when you look at whether it is strength of materials or theory of elasticity, the range of problems that could be solved is limited.

The broad classification of analytical methods we call them as strength of material and mechanics of solids and in mechanics of solids, you could classify that as theory of elasticity and theory of plasticity and what we see here, they are very useful in getting a conceptual appreciation of the nature of stress fields but the range of problems that could be solved is limited.

“Professor - student conversation starts” You have all done preliminary course in strength of materials and the do you know in strength of materials what is the basic assumption that has been used in solving the problem on hand. Can anyone of you answer. Plane sections remain plane before and after loading. You remember that has been taught in your earlier course. Yes. Okay. (()) (10:56) No, what you want to know is the basic information that is used for attacking the problem. **“Professor - student conversation ends”.**

(Refer Slide Time: 11:10)

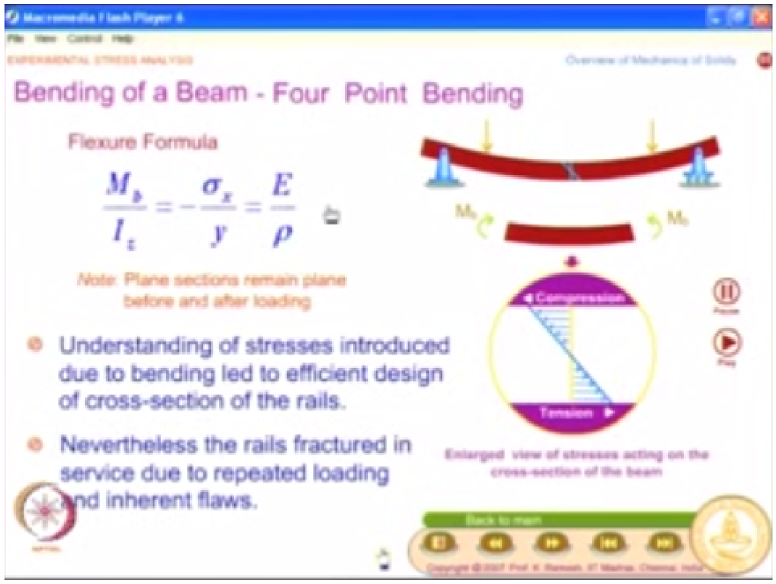


What you find here is the basic assumption is plane sections remain plane before and after loading and with this what you have solved. You have solved large number of problems which are slender in nature. It is very-very important. Suppose, I take a plate and then stretch it like this, I have no problem. Suppose I put a hole there, I cannot do it with strength of materials.

The moment I put a hole, the assumption plane sections remain plane before and after loading no longer exists. So, I have to be careful. So, that is why you always solve problems that are solvable. So, in a strength of materials course, what you get is you understand how an axial member, a bending member or circular shaft subjected to torsion supports the load. In the case of axial member what do you understand. Suppose I take the cross-section A and suppose I apply the load P, how the force is distributed.

It is uniform the entire cross-section participates in the loading shedding. On the other hand, if we go to (()) (12:20) what happens. What is the difference between axial member and a member that bends?

(Refer Slide Time: 12:33)



So, this is where you have the answer. So, what you have here is I have a member which bends and I find that stresses are varying linearly over the depth and what you find this is a very famous flexure formula and what you did, you never went and solved differential equations. You cleverly avoided solving differential equations and you hide behind the assumption plane sections remain plane before and after loading.

If you watched this problem, this is also very clearly shown that you have the end loads here but you are only looking at the region which is inferior to that where you have only pure bending is applied and the discussion is confined to pure bending. If I go to cantilever, I have a sheer and plane sections do not remain plane before and after loading. They are not couple so you are able to still live with flexure formula and it go for deep beams, you have to bring in sheer effects.

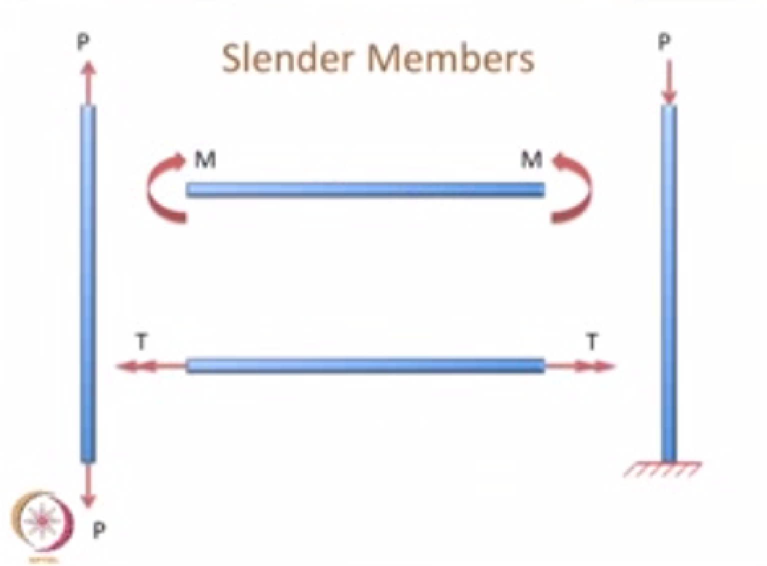
So, in a first level course you learn how an axial member supports load that is why you have lot of (()) (13:53) that is being used in stadiums and very large halls. So, you effectively utilize role of material completely because all the material contributes to load shedding. The moment you come to bending you understand that stress is varying linearly, so the inner core is not contributing to load shedding and what is seen how this is used in design.

So, if you go and see rail cross-section, you do not have a square block because you know that this is subjected to load on the top face and you know it is essentially transmitting a bending load since the inner core is not participating, you have removed the material. So, what you have done is your analytical approach to problem, you have not solved the problem of rail to start with but your bending understanding that what you have the stresses very linearly and inner core is not contributing is effectively utilized in arriving at the shape of the rails, okay.

(Refer Slide Time: 15:04)

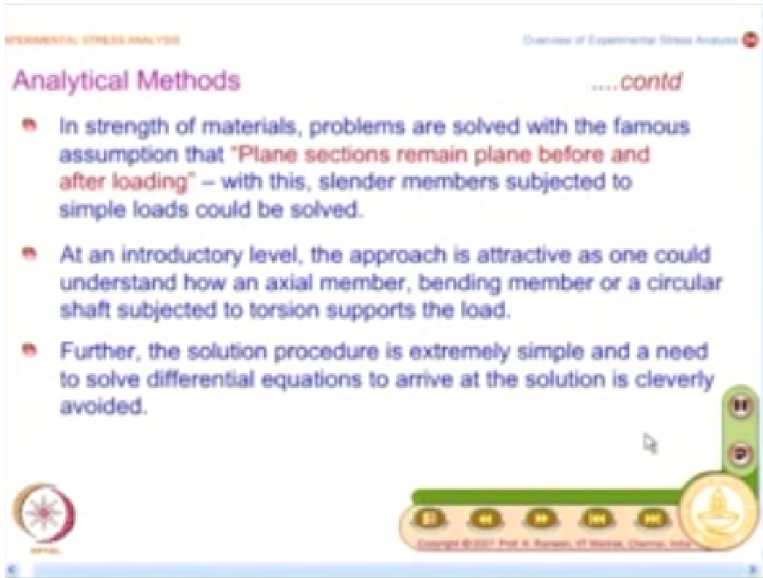
Now, what will see is the introductory level the approach is attractive as one could understand how an axial member, bending member or a circular shaft subject to torsion supports the load.

(Refer Slide Time: 15:18)



Once you come to the circular shaft, you all know people use hollow shaft very similar to bending there the sheer varies linearly. So, in pure torsion you only talk of a circular shafts subjected to torsion. Suppose you have a rectangular shaft subjected to torsion that is shifted to the next course. It is not taught in the first level course.

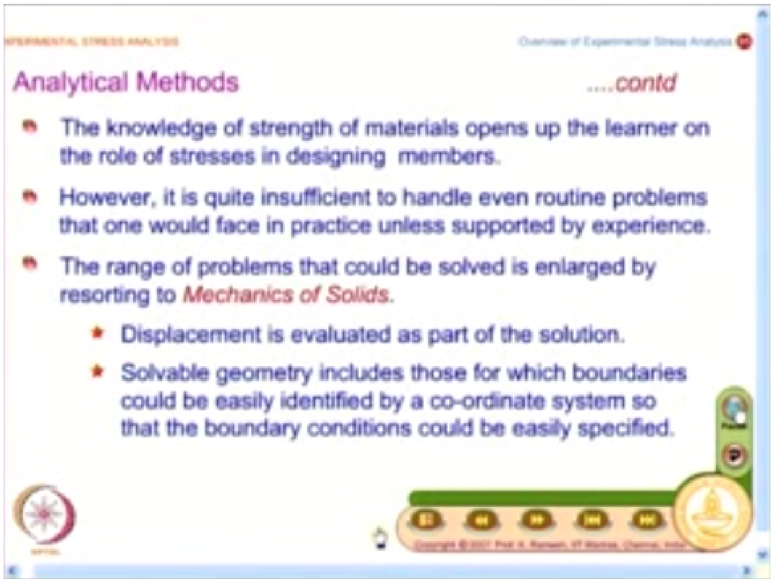
(Refer Slide Time: 15:41)



Because we always want to have a very simplified approach to problem-solving and we have cleverly avoided solving differential equations, but nevertheless we have understood how an axial member supports load, what happens in the case of bending, what happens in the case of torsion. So, analytical methods are very crucial in giving a conceptual appreciation on very simple problems but you will restrict to class of slender members.

You will not go to any other class of problems and this is very effectively used in design.

(Refer Slide Time: 16:21)



If we go to the second level course, you always use a design based on very simple idealisation based on strength of materials. So, what we find here is the knowledge of strength of material opens up the learner on the role of stressors in designing members. Like I have shown you that you have the rail where you have removed the material from the central portion because it takes the load only on the top and bottom fibre maximum, whether you have understood or nature also has understood solid mechanics.

If you go and see you have bones. Bones are hollow. The inner core is where you have bone marrow, where the haemoglobin is developed and that has to be protected so you have a hard shell. If you take your thigh bones it is subjected to bending and in appropriate loading, it will also have some level of torsion. So, nature has already understood that when it has to resist bending or torsional loads, it can optimise its structures beautifully.

Because the bone marrow is a very soft material and if you really go and look at bone, people now say that it is functionally graded material. It is not even just a hard and soft. It is a functionally graded and they say tooth is also functionally graded. So, nature has understood all these solid mechanics and utilized it in many of its structures and as humans, we go try to unravel it and embed it in the form of mathematics and develop as engineering tools, okay.

Now what happens the basic restriction is I assume displacements in the case of strength of materials and you cannot live with that. If you go to fluid mechanic's course, they start with differential equations.

They do not have any problem where they avoid differential equations. Only in solid mechanics what we find is you can have one full course without touching differential questions and only in the second level course you relax this, you do not make assumption on the displacement but you evaluate displacement as part of the solution and this is what you have it in mechanics of solids. By relaxing this if you find whether you have been able to solve all problems on hand which is not so.

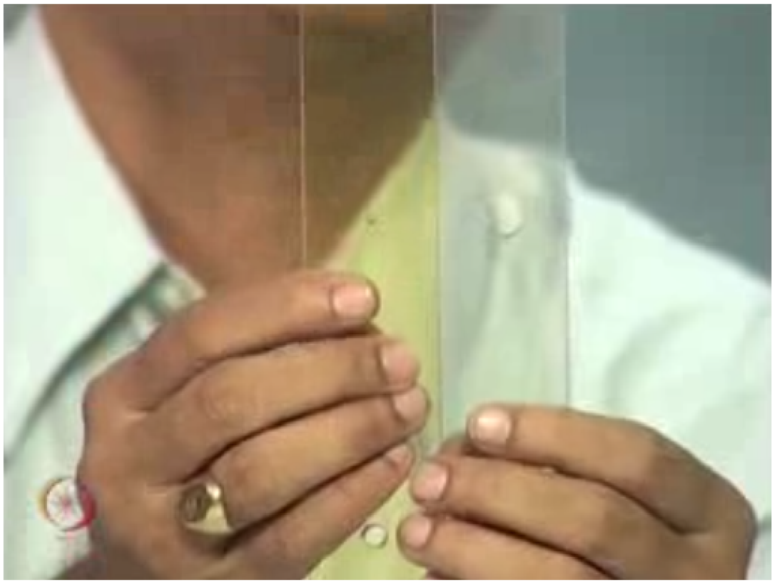
The solvable geometry includes those for which boundaries could be easily identified by a co-ordinate system so that the boundary condition could be easily specified.

(Refer Slide Time: 19:23)

Now, I have shown that you have a plate with a hole, I cannot solve plate with a hole by theory of elasticity unless the hole is sufficiently small and what you have here is, here is for elastic model and here you have a plate with a hole and plate with a very small hole. From a mathematical point of view, it is possible to assume or idealise that this is a small hole in an finite plate.

Physically, it is finite but mathematically it could be modelled as infinite and you would be able to find out analytical solution for this using theory of elasticity.

(Refer Slide Time: 19:54)



On the other hand, if I take a model with a slightly larger hole, then this solution is no longer valid. I have the same width. The width is same. In one case, there is very small hole. In another case, the hole is about 10 to 12 mm and this is comparable to the width. So, this becomes a finite body problem. So, when I go to theory of elasticity where I am to idealise. I look at a situation where I remove the restriction on displacements and I evaluate displacement as part of the solution.

Even there I need to have infinite boundaries for a problem like this, only then I will be able to solve. Mathematically, the distance is far away but physically it could be a very small hole, this closely resembles and the solution is possible and plate with a hole is a very-very important problem. You all learn, see in many one of your bad design courses when I have reverted joints, I have a series of holes.

So, the idea here is an analytical method you have been able to find out the presence of a hole, how does it influences the stress field near the hole. You are able to get an analytical expression and this will be a function of X and Y, so as we plug in X and Y, you will be able to find out the solution at every point in the domain, okay which is not the case when I take a finite geometry. This finite geometry, it is not possible to solve by theory of elasticity.

(Refer Slide Time: 21:34)

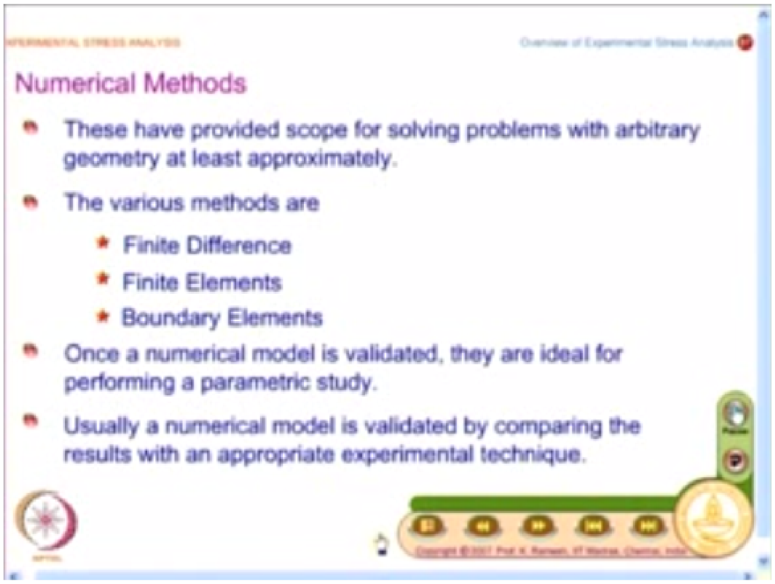
On the other hand, other geometries like suppose I have a circular disc and a diameter compression, this you get closed form solution from theory of elasticity. In compare, I have an axial member. I pull it, I can do it by strength of materials but the same axial member suppose I have a hole, I cannot solid (()) (21:56) materials. I have to depend on theory of elasticity. Even in theory of elasticity, the hole should be as small as possible, okay.

On the other hand, even if you have changed the geometry, you cannot do it. I do not have a hole here but the geometry has changed because the way I apply the load, plane sections do not remain plane before and after loading. So, if you look at when I move from strength of materials to theory of elasticity, I have enlarged my domain of solving problems. Strength of materials has given me a very good approach wherein without solving differential equations, I could understand axial member, bending and torsion.

When I go to theory of elasticity, I could find out what is the meaning of stress concentration and I can also solve a class of small problems where I am able to find out the boundary conditions and then apply it carefully. So, you have a large class of 2-dimensional problems I did not solve. I have a disc that you have a solution but if you look at a 3-dimensional problem and if you want to approach and find out whether you have analytical solution, those problems you can count them in fingers.

They are very-very few. So, the problem is very complex and I want to find out, I want to take a spanner and I want to tighten a nut, because this has arbitrary geometry. I cannot approach it from theory of elasticity and get the solution and this is what we do day in and day out.

(Refer Slide Time: 23:48)



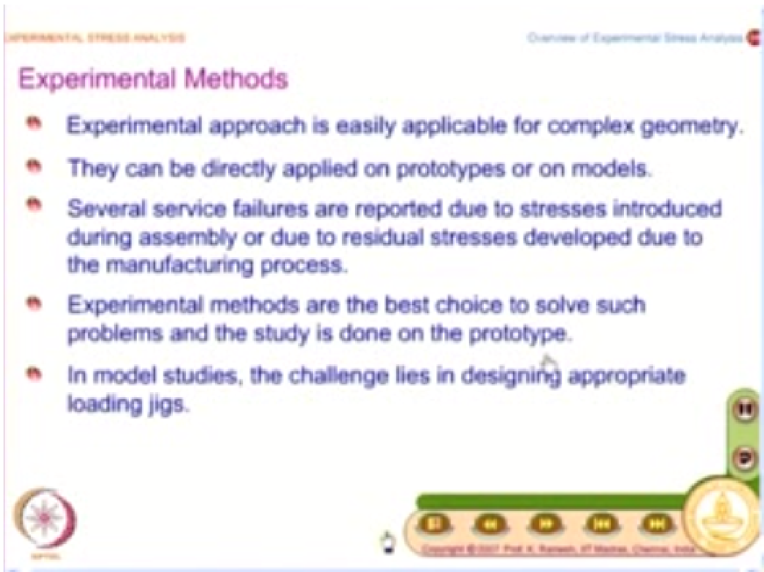
So, what you find here is even though you have methods which provide you conceptual understanding, if I go for arbitrary shape, numerical methods come very handy and you are able to get the solution at least approximately for arbitrary geometry. So, that is where you find the numerical method as very attractive and you have many numerical methods. Many of you might have done finite difference. Then, you have most versatile finite elements.

You have very many packages available for you to attack a problem and you also have boundary elements and very recently you have measured methods that have come; and what you find is when I am having a numerical approach to problem, the numerical model has to be validated. Unless numerical model is validated, if the boundary conditions are not verified, you are solving a different problem.

So, for any numerical approach you have to validate whether the procedure is alright, but the greatest advantage of numerical method is once the procedure is validated, it is an ideal way to do a parametric analysis. In a design if you have several geometry factors, you would like to vary them or you would like to change the load case and find out how the system is going to behave, conducting experiments for each one of the configuration would be difficult.

So, you do an experiment, verify the discretization, verify the boundary condition and then do a parametric analysis by a numerical approach.

(Refer Slide Time: 25:24)



Once you come to experiments, what do you see. Very similar to numerical methods, experimental method is applicable for complex geometry, absolutely no problem and once you come to experiment you will also have to look at 2 different things, am I working on a model or am I working on a prototype. So, you can do the experimental approach on prototypes or on models. Another area where experiment methods are the ideal choice is in the area where you have assembly stresses or residual stresses.

(Refer Slide Time: 26:10)

Now, I take a very simple example of a chain and this you have it in your bicycle. This is also used in power transmission; and in practice what you have, you have 2 sprockets on either side and this is subjected to essentially tension in actual service, okay.

“Professor - student conversation starts” Now, what I have here is I have an element taken out of this chain. I am just holding it. Are there any stresses in this chain? No. How many of you say no, how many of you say yes? There is one person who says this is stress, the rest of the class say it has no stresses. **“Professor - student conversation ends.”**

So, you have to know how this component is fabricated. Suppose I take a block of material and then I go to CNC machining and then machine out this, that is one thing and how it is done is, you have essentially plates and these plates are brought together by putting the appropriate bush and the bush has to stay in place, so you have an oversized bush and this has been to be inserted. So, this is done with an interference fit.

So, apparently I do not have any external load on this chain-link but because of the way it is manufactured, you have stresses developed, you have a bush here, you have stresses developed very prominently here and it is comparable to the service load. The stresses developed are not small in value, they are comparable to the service load. So, what you need to understand here is it is a very complex problem and this is where many service failures are reported.

Service failure in the field are reported because of residual stresses and also assembly stresses, and experimental methods come in very handy for solving problems of this complex nature because many issues that go into this, you have the bush and bush may not be perfectly cylindrical and another one is, this is a body which has finite geometry. You have a finite geometry and this is an arbitrary shape.

Finite geometry I cannot go and approach by finite element by theory of elasticity, definitely I can approach it by finite elements, absolutely no problem but that I have to apply the boundary conditions. What information I may not know from a production shop is this may not be perfectly cylindrical. There is lot of variation. So, suppose I put it and then do expert analysis on this component directly which actually is a prototype, then I capture all the manufacturing variations that have gone into the fabrication of this.

Whereas, if I do a numerical analysis, I would take this as a slender, I would not have modeled if there are any fine undulations on the surface of it and such variations do exist in actual practice. So, what you find here is for conceptual understanding, analytical methods are needed. For complex geometry, you have to go in for numerical method, but to know the truth, you always have to depend on experimental methods, okay.

So, experimental methods are the best choice to solve such problems and the studies done on the prototype. In model studies, you have difficulty because in model studies the challenge lies in designing appropriate loading jigs. So, if I do not design the loading jig appropriately, then I am not solving the problem that I have to solve even by experiments. I said in numerical techniques if you do not specify the boundary conditions, you are not solving the problem that you have to solve.

The same defect exists even in the case of experimental methods when you have to work on models. When you have to work on prototypes, the approximation is as close as possible to reality, but when you have to work on models you have to load the model.

(Refer Slide Time: 30:49)

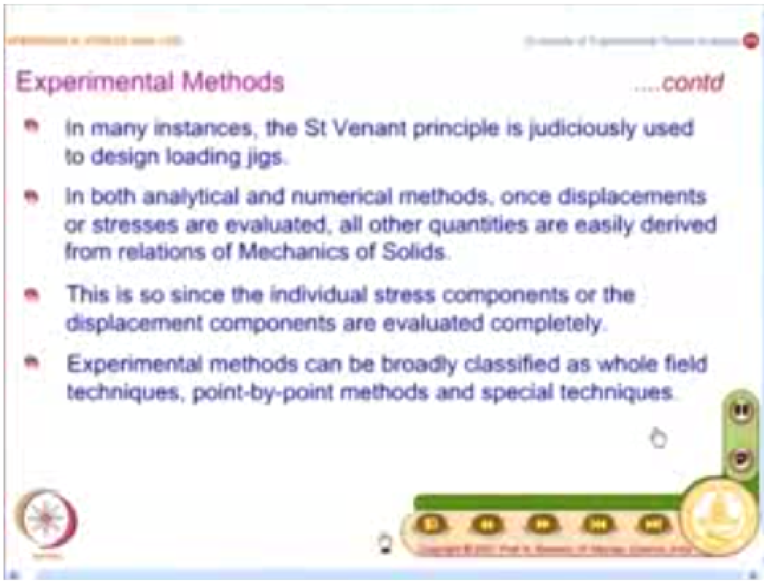
Now, let us see one simple example. I have this rod and I want to pull this. I can pull it by grips. I can have solid grips and then pull the rod.

(Refer Slide Time: 31:00)

I can also pull the rod by another method which is what usually do. What you do is you have a sling, you have a pin. So, you pull it with a pin. It also has a certain level of self alignment and if you really look at what is the stress distribution near the close vicinity of the hole and the way I grip it, these 2 are different but our interest is I want to have axial force on this member which could be done by numerous ways and one way of doing it is putting a pin and sling and then pull it. Another is put a grip and do it.

So, I am not really solving a problem that I have to do what I have in actual practice.

(Refer Slide Time: 31:50)



This is where you have this famous St. Venant principle that is required. So, in many instances in designing load jigs, you use St. Venant principle. What it says is at distances away from the point of loading, the distribution is similar to want we finally want. So, you will have to use St. Venant principle and design your loading jig appropriately so that it simulates service load condition as closely as possible.

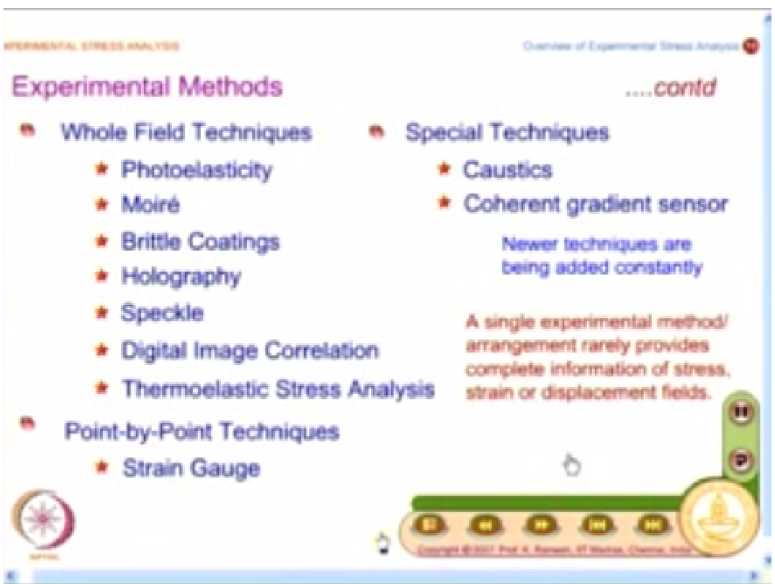
Then, what you have. There is also another difference. See in the first I showed axial member pull, you have P/A, you have the stress component. Rest of the stress components are 0. If you want to find out strength you can easily find out because you have readily available mechanics of solids equations, you have stress-strain relation, strain displacement relation. So, once I find out stress components, I can find out the strain, I can find out the displacements both in analytical and numerical methods.

This is primarily because I know all the stress components by analytical method, then I proceed. In a numerical method also when I solve, I get all the stress components evaluated, then I go for strain and displacement which is not the case in the case of experimental technique, because experimental technique exploits the physical principle for measurement. So, that physical principle imposes certain restrictions what you can measure in experimental technique.

Suppose, I measure stress, I cannot measure all 6 stress components. I can measure only a particular stress component or a combination of them which is dictated by the physical principle employed in the technique. On the other hand, you have an advantage. It can work on prototype; it can work on arbitrary geometry. It can find out (()) (34:01). It can find out assembly stresses, but the restriction is I do not get all information in one go.

So, this is one restriction that you have to live with and once you come to experimental methods, there are many experimental methods available. They are broadly classified as whole field techniques and point-by-point methods and if you look at whole field techniques, they are essentially optical techniques and you have great many of them and newer techniques are also being developed day after day.

(Refer Slide Time: 34:40)



When you look whole field techniques, one of the very popular and widely used experimental method is technique of photoelasticity and we would see later what these experimental techniques give directly the information, what information it can give directly. Essentially, photoelasticity gives sigma 1-sigma 2 contours and you have Moire that essentially gives displacement and you have brittle coatings that gives direction of principle stress.

So, for each one of the experimental techniques, you get a particular kind of information and even if we are going to use that particular experimental technique if it gives more than (()) (35:32) information, you should use different optical arrangements to get it. So, you do not get anything free. You know, you have some advantage, some disadvantage that they go together. So, it is a user who has to decide what aspect he will exploit and then find out which combination you will try to use for solving a problem on hand.

You have holography, many of us have seen holography as a sticker on many of the products. It is used for mostly as a security device but it is also a very good experimental technique and you would essentially get the displacement vector and you have speckle method which is a variation of holography and one of the very recent experimental technique is digital image correlation. This is our advantage of working at multi-scale. Specimen preparation is very simple.

Surface preparation is very simple and it exploits the computers to the fullest extent for measurement of displacement. Then, you also have a technique called thermoelastic stress analysis and what you have is when you have model and when I put a cyclical load, the temperature changes. The temperature change is very-very small and those are measured by a non-contact approach and you have thermoelastic stress analysis and you have a point-by-point technique.

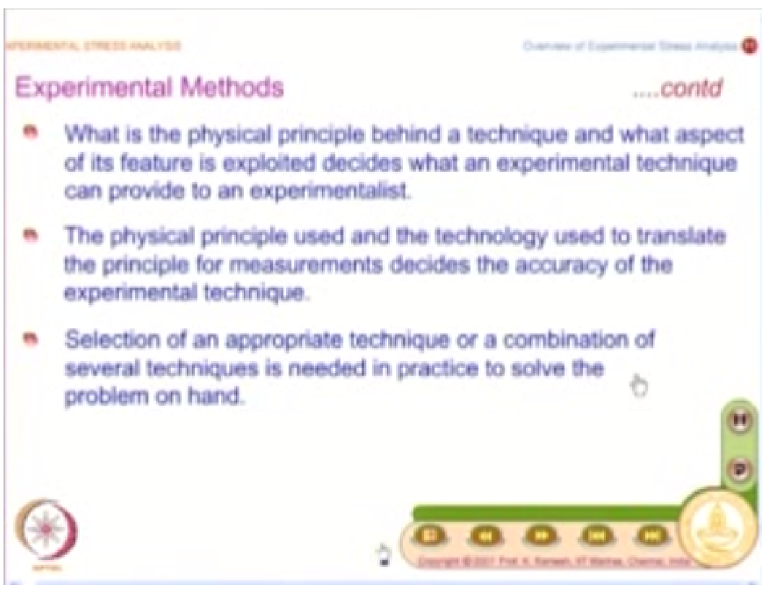
What you have here is the widely used strain gauges, eye sight is widely used. I also caution is a widely abused technique because in a strain gauge, people have to pace the strain gauge and pacing a strain gauge is such a boring exercise and you have to be trained in pacing strain gauges. We do not pace the strain gauge as properly; you measure anything under the sun. So, you do not really measure what the system shows.

You have error sources, so unless you handle the technology behind strain gauge instrumentation right from pasting onwards, you would not measure the quantity that has to be measured correctly and you also have a special technique. As I mentioned in the beginning of the class, we saw there is an optical phenomenon where light gets reinforced and you get a silver line, you have this as phenomenon of caustics which is uses in high stress bearing problems like when I want to find out what are the stresses in the vicinity of a crack.

This is a very useful technique and because of portion effects, the specimen behaves like a divergent lens. Caustics can be classified as a point-by-point technique because it gives only one information and you have field information coherent gradient sensor which is a variation of caustics. You should also appreciate that newer techniques are constantly added and as I said earlier, a single experimental method or arrangement rarely provides complete information of stress, strain or displacement fields. It may give a particular kind of information.

If you are satisfied that that information is good enough, then one experiment is sufficient for you to get the answer you wanted. If not, you may have to use a combination of different experimental techniques and go and evaluate the parameters that you want to do it for you analysis.

(Refer Slide Time: 39:42)



As I mentioned earlier also, what is the physical principle behind the technique and what aspect of its feature is exploited decides what an experimental can given. So, I need to know the physics behind it. Another aspect is what is the physical principle used and the technology used to translate the principle of measurements decides the accuracy of the experimental technique because if you go to photoelasticity. Earlier we were making measurements manually, now you have image processing techniques available.

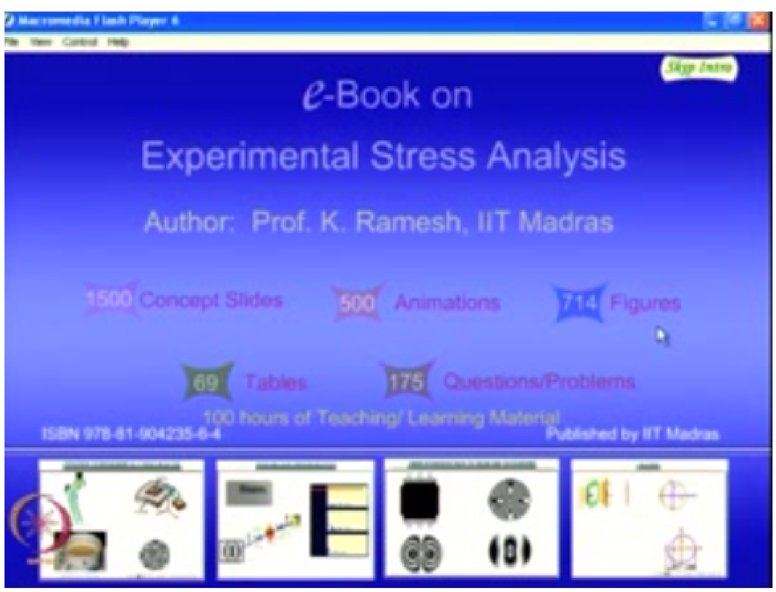
So, with the technology I can refine the measurements for it. So, you need to know what is the physics behind it. Suppose, I got the image correlation, the size of the speckles matters and there is an inherent difficulty when you want to go for very low value of strain measurement. So, you have the physics. What is the physics that is used? and what is the technology that is used to exploit this? Both have to be in synchronization for you to arrive at accuracy of particular kind.

Suppose I want to measure the length of this room, I can go and take a tap and measure it. When I take a tape and measure it, I am going to say so many centimetres. On the other hand, if I want to have very fine measurement, then I can go for laser based measurement technique where I will say in terms of nanometers the accuracy of the length.

Same length measurement by depending on whether you use a scale, whether you use a tape or whether you use a veneer or whether you use a screw gauge or whether you got optical method, the level of accuracy is inherent in the measurement approach and also the tool that you used for it. So, as a stress analyst, you have to decide whether you want all the 6 stress components, all the 6 strain components.

All the 3 displacement components at every point in the model or only a particular kind of information at few locations. So, this decides the selection of an experimental technique.

(Refer Slide Time: 42:04)



For this course, I would essentially use my e-book on experimental stress analysis. This has been developed at IIT Madras and published by IIT Madras and this contains more than 100 hours of teaching and learning materials.

(Refer Slide Time: 42:23)

This book is dedicated by Lineage of Teachers and Pioneers in Experimental Mechanics across the whole and this will be the core book that I will be following it and other books that you require for self reading and reference, I would give you as we go by in the course. Are you clear that what is the fundamental difference between analytical approach, numerical approach and experimental approach?

Analytical approach provides you conceptual appreciation of what is axial load supporting members, how do they behave. In bending, how the stresses vary over the depth. In sheer, how the stresses vary, that understanding is very crucial. In translating many of the design what you see across, they could be simplified to any one of the slender member as a first approximation and you can get some insight what is happening.

But if you want to get a detailed solution, you have to go to theory of elasticity where you do not have the restriction on the displacements. You have simply connected and multiply connected. In multiple connected problems, you have to bring in uniqueness of displacement as an input, otherwise you cannot solve the problem, but leaving that apart you do not put any restriction on displacement. You evaluate by solving differential equations.

When I have a complex geometry, I can always go and attack the problems of numerical approach where numerical approach has to be handled very carefully because you may go wrong in understanding and implementing the boundary conditions. So, any numerically approach has be validated by experimental inputs. Once you validate the numerical approach, they are the ideal choice for a parametric analysis.

On the other hand, when you come to experiment, if you use the technique very carefully you really get the truth and you can work on prototypes, you can work on models and when you work on prototypes you are very closer to reality. In model studies, you have to be very careful in designing the loading jigs. If they are not designed properly, you may not really simulate the actual service load, so that will also be erroneous, but you need both.

You need to have prototype studies, you also need to have model studies and you also have to look at whether a particular experimental technique can be applied for both prototype and model studies because if you look at photoelasticity, one version of it can be applied of models, a variation of that can be applied on prototypes. So, the techniques can be applied both on models as well as prototypes.

So, you have to choose depending on the problem on hand what is the way that you would go and select these experimental techniques and an experimental technique by itself will not give all the information of what the basic stress analysis. It will not give all the 15 components. What competent I get is dictated by the physics behind the experimental techniques. So, in this course we would pay attention on what is the physics behind each of these experimental technique.

How these has been exploited, what is the technology used and what is do’s and do not’s in employing the experimental techniques, that is what we are going to see in the classes to come.