Experimental Stress Analysis

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Lecture No. # 01
Overview of Experimental Stress Analysis

This lecture is an Overview of Experimental Stress Analysis.

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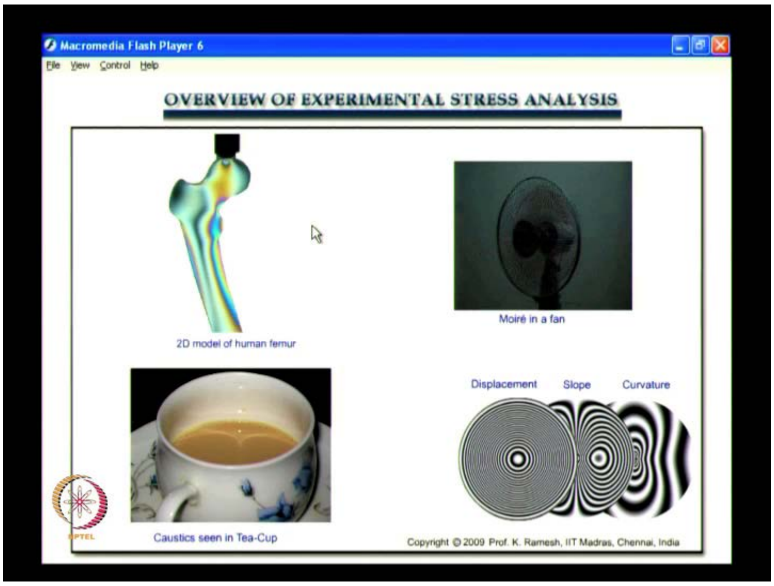

And these slide shows in nutshell what experimental analysis is all about. And what we see here is (Refer Slide Time: 00:26) stress patterns observed in a 2D model of a human femur. So you get stress information and stress analysis and you also get displacement information in stress analysis.

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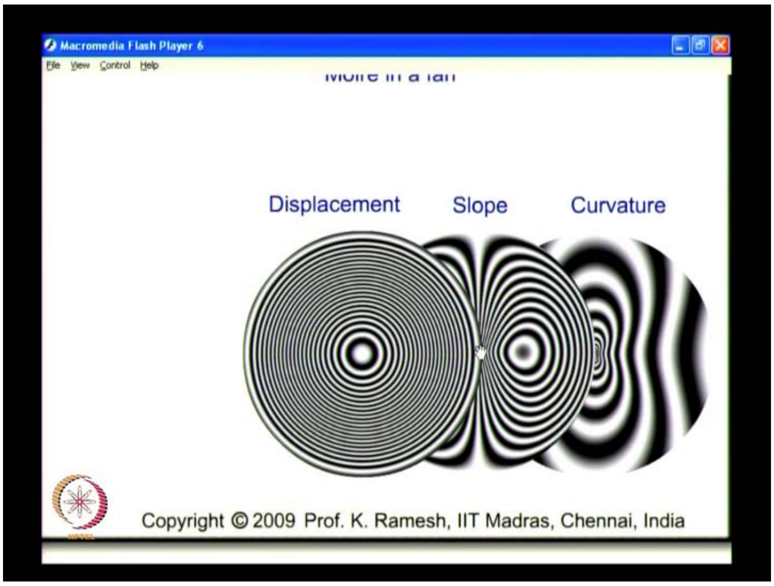

And what you find here is for a circular plate clamped at the boundary with a central load, you get the displacements. And you can also have the slope, you can also get curvature but, what you will have to appreciate here is, for each of this information, you need to use a specific optical arrangement. You would not get them in one shot but, you have to have effort to do that.

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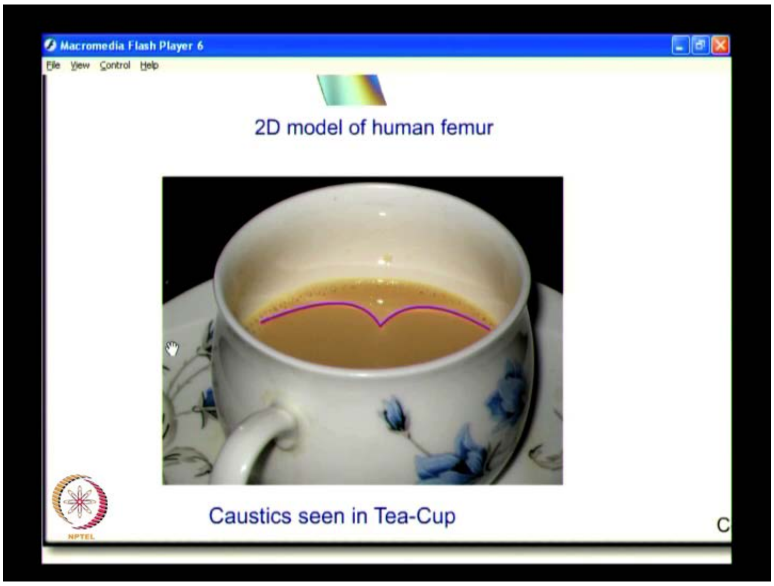

And what you see on these two corners show that you need to use physics in applying experimental techniques. So, what is done is any physical information which could be exploited for measurement is identified and that is translated into an experimental technique. And what you see here is a cusp in a tea cup, and this you see as a silver line, what happens is one light gets reflected on the curved surface, it gets reinforced and you have a cusp. And this can be same on any shallow filled containers with appropriate lighting and this phenomenon is called caustics. And this physical information is exploited in a technique called method of caustics, which is used for measurement of high stress concentration.

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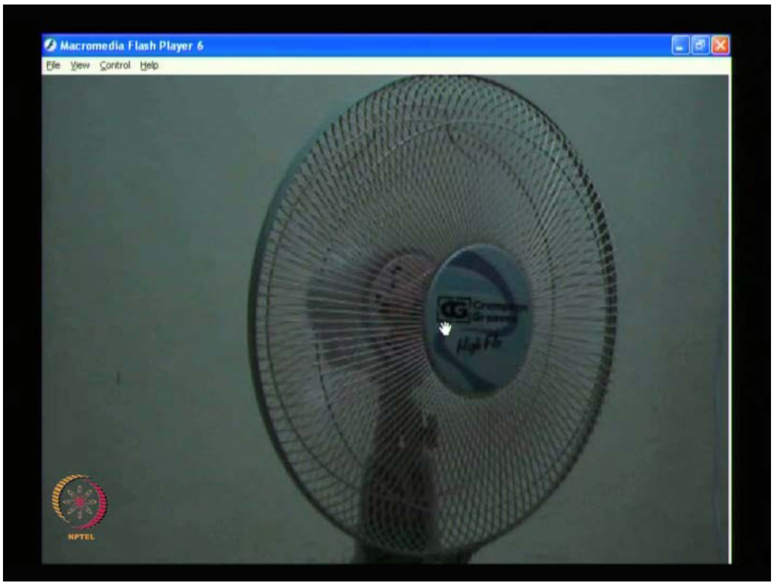

How it is done, we will see as part of the course. And what you see here is another down to earth example, where you see in the case of a fan when you have two grids super imposed, you see a nice moving patterns and this is called moire. And this is used for measurement of in plane displacements, out of plane displacement and so on. So, what is emphasize here is, when you have experimental stress analysis I can measure stress information, I can measure displacement information, I can also measures strain information though it is not shown here. And what is emphasize here is, for each of the experimental technique, there is a 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.

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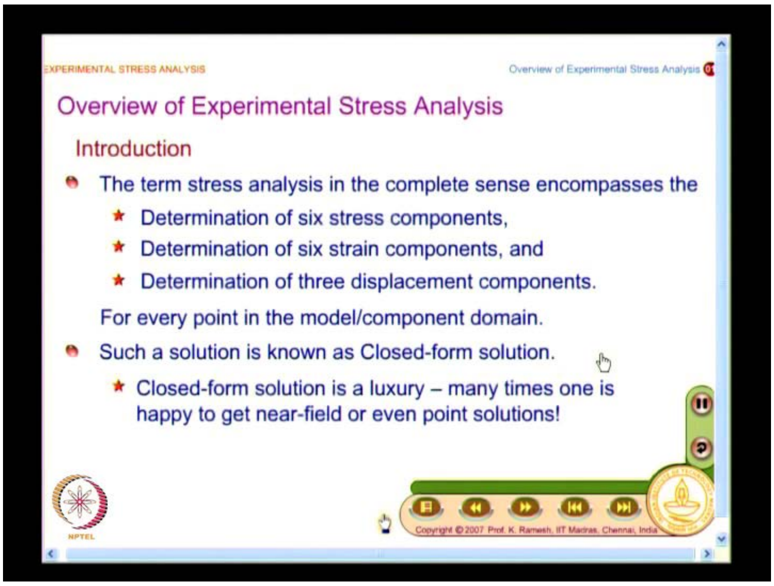

So, the term stress analysis, in the complete sense encompasses the determination of six stress components. Why they are six, why we are say that you have six stress components? Suppose suppose I take a member like this and then apply a tension, you all know the stresses are developed and what is the value of stress? Someone can answer, suppose apply the load as b and area of cross section is a, what is the value of stress?

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Where are six components? You are only say only one and what you have in the simple example problem is, stress is a tenser of rank 2.

So, you have nine components, of the nine components, because of symmetry you have only six independent components. So, in a simple tension test like what you do on a slender member, you evaluate stress on it appears to be scalar, b by a appears to be scalar and that is what we are learnt in a simple course in strength of materials. But, what you should change your thinking is go back and fill in the components in the stress sensor. So, what do you find is, I will find one stress component all other stress components are 0.

So, actually you have, because stress is a tensor of rank 2, you have six independent components. So, when is a stress analysis I should know stress components, then I also need to know, strain components and strain components are again six, because strain is also a tensor of rank 2 (Refer Slide Time: 04:47).

So, I need to get stress components, I need to get six strain components and it also desirable that I get displacement components and displacement components are 3. And 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 these information.

And in simple case the stress component is only 1, if I keep it sigma y, if I keep it horizontal you label as sigma x. If you have x and y as horizontal and vertical, you will have this as sigma stress components or you will put it sigma y stress component. So, what do you need to understand is stress is a tensor of rank 2, so whatever the kind of load that you apply, you should able 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 hole them, where I grip them and do it, away from the point of loading will worry about it. And when you say this b by a, I know it at everywhere and it is constant. And such a solution if I give the x y location and I am able to find out values of stress, I called at as close form solution. Because at every point which I want to find out, I have be answer can you get close form solution for all problems is not so.

It is only a luxury, for certain problems you are able to get all these six stress components, six strain components and displacements. And in certain class of problems, you are satisfied with near field solutions. Particularly in the case of problems with crack, where fraction mechanics is focusing this, you get analytically solution close to the vicinity of the crack.

And from a design point of view, you are happy with even point solution. 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 scope out the material.

So, what you have to understand is, the term stress analysis in its completes sense encompasses, determination of six stress components, six strain components and three displacement components and it is a luxury. So, we have to go for that kind of solution, which you required for a problem on hand, always you do not required all these fifteen components.

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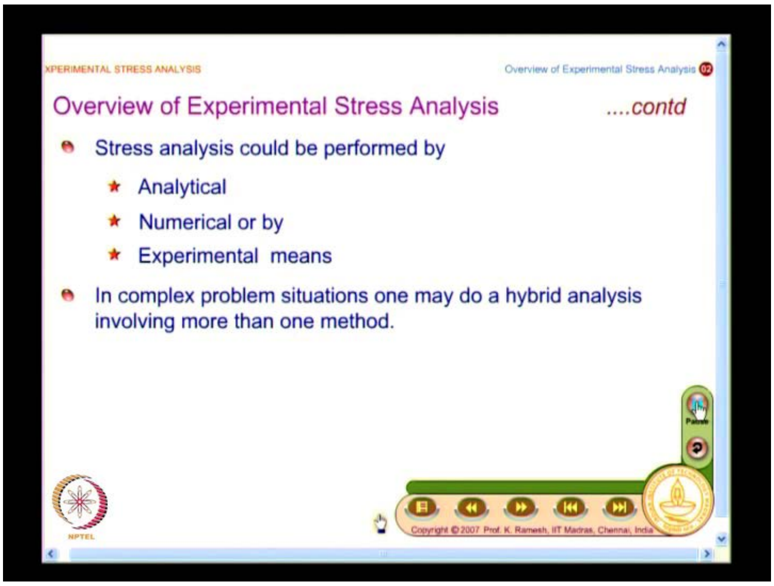

And how these stress analysis stress analysis can be carried out, you could do this by analytical methods, you could do by numerical methods or you can also do by experimental methods. Can you take a view that I will always use the analytical method or I will always go to numerical method or being an experimentalist I will use only experimental methods. We cannot that kind of a prejudice review; each approach has certain characteristic that could be effectively exploited.

Few of this you 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 an analysis is known as hybrid analysis. And what we are going to do now is, you will see one by one what analytical methods, for which class of problems, why do you do analytical methods and what is the advantage of numerical technique. And when you go to experiment in which class of problems, experimental methods are ideally suitable, that is what we will see now.

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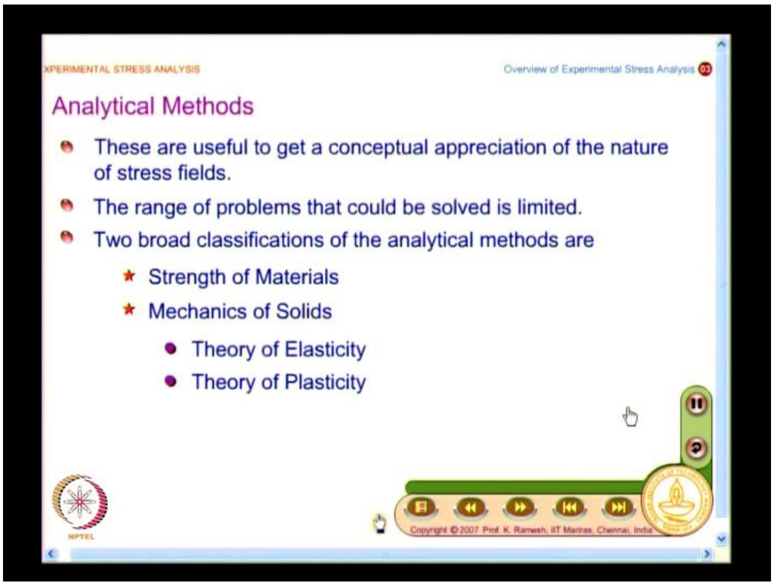

And once you come the analytical methods, what is the advantage here? These are useful to get a conceptual appreciation of the nature of stress fields. If I want to know I take a member and I pull it I know that it subject to tension and I do the bending and I want to know how the stresses are developed 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.

And the broad classifications of the analytical methods, we call them as strength of materials 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 at could be solved is limited. And you are all done a preliminary course and strength of materials and we know in strength of materials what is the basic assumption that has been used in solving the problem on one hand; can anyone of you answer?

Plane sections remain plane before and after loading.

You remember that that has been taught in a earlier course

No

The basic, what you want to know is the basic information that used for attacking the problems.

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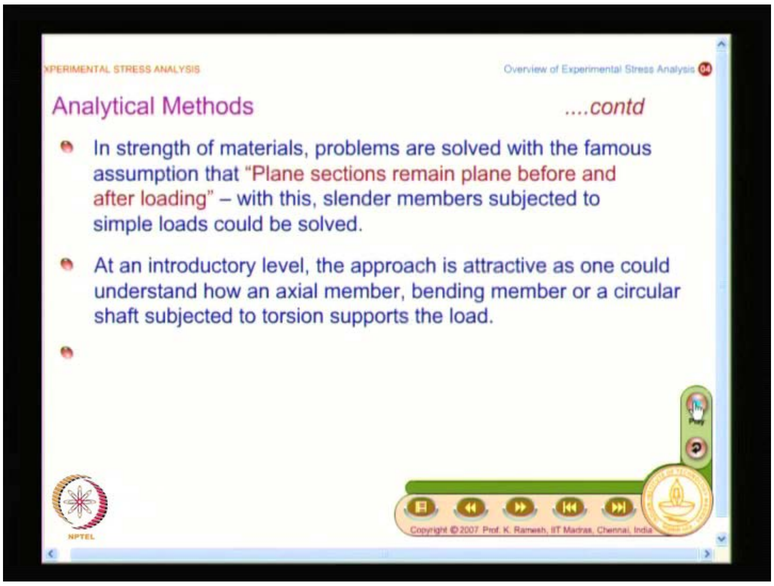

And what you find here is, so one of the basic assumption is plane sections remain plane before and after loading. And with this what we are solve? We are solved at large number of problems, which are slender in nature, very very it important, suppose I take a plate and then, stretch it like this, I have no problem. Suppose, I put up hole their I cannot do it strength of materials, the moment I put a hole the assumption plane section remain plane before and after loading no longer exists.

So, I had been careful, so that is why you always solve problems at all solvable. So, in strength of material course, what you get is you understand how an axial member, a bending member or a circular shaft subject to torsion supports the load. In a case, of axial member what do you understand suppose I take the transaction A, suppose I apply the load P, how the force is distributed. It is uniform the entire transaction participates in the load sharing, on the other hand if you go to beam at bending what happens, what is the difference between axial member and the member that bends.

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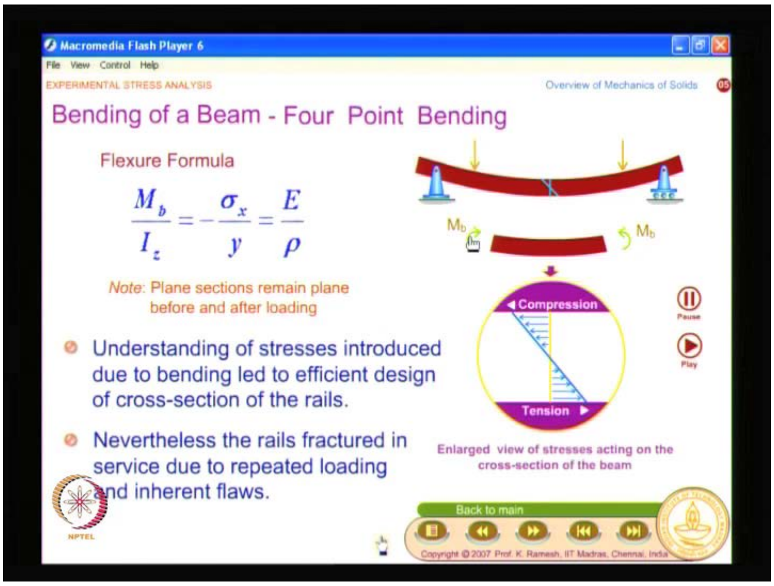

So, this is value, having answer; so, what you have here is I have the member which bends, and I find that stresses are varying linearly over the dense. And what you find this is a very famous flexure formula and what they you did it, you never went in solve a differential equations, you cleverly avoided solving differential equations and you hide behind the assumption plane section remain plane before and after loading. And if you watch this problem this is also very very clearly shown that you have the end loads here but, you are only looking at a regeneration interior to that, where you have only pure bending is applied.

And the discussion is confine to pure bending, if I go to cantilever I have a shear and plane section do not remain plane before and after loading. They are not couple, so you are able to still live with flexure formula, and if you go for deep beams, you have to bring in shear affects. So, in a first level course you learn how an axial members supports low, that is why you have lot of stresses that is mean used for in stadiums and very large halls. So, you effectively utilize role of material completely, because all the material contributes to load sharing.

The moment you come to bending, you understand that stress is varying linearly, so the inner core is contributing to load sharing. And what is seen, when you go to how this is used in design, so if you go and seen a rail cross section, you do not have a square block, because you know that this is subjected to load on the top phase. And you know it is essentially transmitting a bending load; since the inner core is not participating you have to move the material.

So, what you have done is your analytical approach to problem, you are not solve of the problem of rail to start with. But, you are bending understanding that, what you have the stresses very linearly and inner core is not contributing is effectively utilized in arriving at a shape of the rails.

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And 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 to torsion supports the load.

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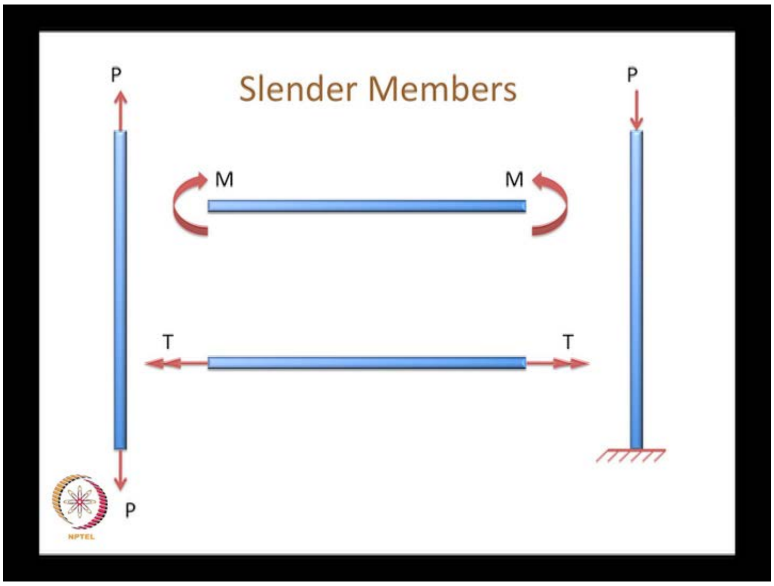

And once you come the circular shaft, you all know, people use hallow shaft very similar to bending where the shear wave is linear. So, in pure torsion, you only talk of a circular shaft subject to torsion. Suppose, you have a rectangle shaft subject to torsion that is a shift of the next course, is not taught in the first level course. Because, we always moment to have a very simplified approach to problem solving.

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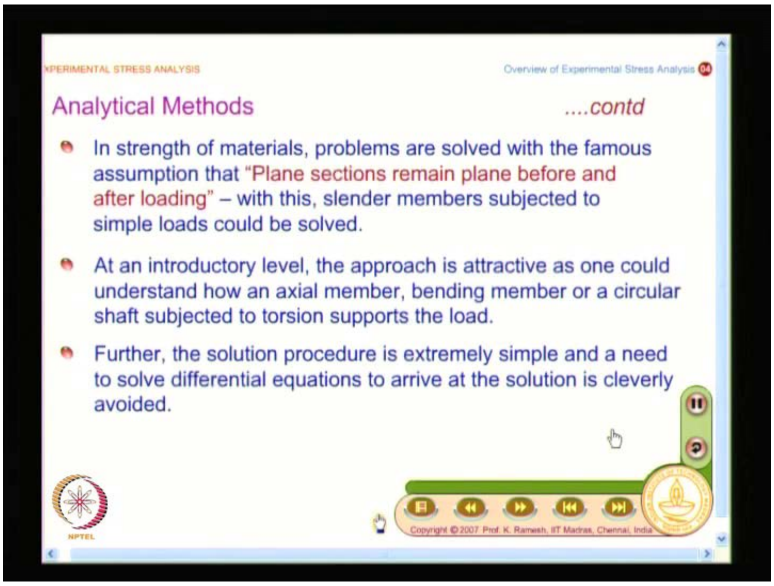

And we have cleverly avoided solving differential equations, but nevertheless you understood how an axial member supports to what happens in the case of a bending, what happens in the case of torsion. So, analytical methods are very crucial, in giving a conceptual appreciation on very simple problems 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 design.

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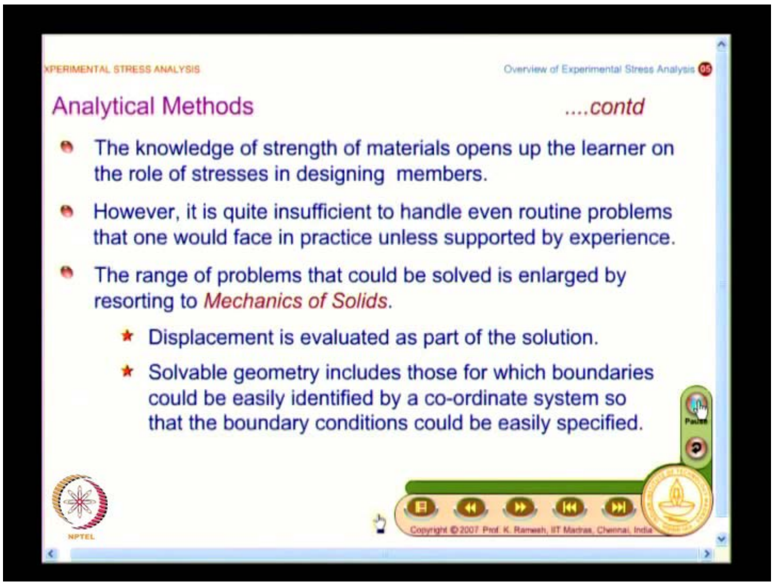

If you go to the second level course, you always use a design based on very simple idealization based on strength of materials. So what you find here is, the knowledge of strength of materials opens up the learner, on the role of stresses in designing members like I have shown you that you have the rail, where you have removed the material from the central portion, because it takes the load only on the top and bottom fiber maximum.

Whether, you have understood or nature also understood solid mechanics, in if you go and see if you have bones, bones are hallow, the inner core is where you have bone marrow, where you have hemoglobin is developed. And that has to be protected so you have a hot shell and your bones if you take a thigh bone it is subjected to bending, on in as appropriate loading is also have some level of torsion.

So, nature has already understood but, when it has to resist bending or torsion loads it can optimized structures beautifully. Because, in bone narrow is very soft material and if you really go look at bone people now say, that it is a functionally graded materials, it is not even just hard and soft, it is a functionally graded. And they say tooth is also functionally graded, so nature has understood all these mechanics solid mechanics and utilized it in many of it is structures and as humans, we go try to unravel in an embedded in mathematics and developed as engineering tools.

Now, what happens suppose I 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 mechanics course they start with differential equations, they do not have any problem, where they avoid differential equations. And only in solid mechanics where to find is you can have one full course without touching differential equations.

And only in the second level course you relax this, you do not make assumption of 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 the coordinate system; so that the boundary condition should be easily specified.

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 mod elastic model and here you have a plate with a hole and plate with the very small hole. From a mathematical point of view, it is possible to assume or idealize this is the small hole in an infinite plate. Physically it is finite but, mathematically could be modeled as infinite and would be able to find out analytical solution for this using theory of elasticity.

On the other hand, if I take a model with a slightly larger hole, then the solution is no longer value. I have the same width, the width is same in one case is very small hole, in another case the hole is about 10 to 12 millimeters and this is comparable to the width. So, these becomes a finite body problem, so when I go to theory of elasticity, where I am able to idealize, I look at a situation, where I remove the restriction on displacements and 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 it.

Mathematically, the distance are for away but, physically it could be a very small hole this closely resembles and this solution is possible. And plate with a hole is a very very important problem, you all learn see in many one of your design courses, when I have a reverted joins I have a series of holes. So, the idea here is as an analytical method, you have been able to find out the presence of a hole, how does the influence as the stress field near the hole.

You are able to get up analytical expression and this will be a function of x and y, so is plug in x and y, you will be able to find out the solution, you will be able to find out solution at every point in the domain; which is not the case when it take a finite geometry. This finite geometry it is not possible by theory of elasticity. On the other hand other geometries like, suppose I have a circular disk and the diameter compression, this you you get close solution from theory of elasticity.

And compare I have a axial member, I pull it, I can do by strength of materials but, the same axial member. Suppose, I have a hole I cannot solve it by strength of materials, I have it depend on theory of elasticity, even in theory of elasticity, the hole should be as small as possible. And on the other hand, even if you change the geometry you can do it I do not have a hole here but, the geometry is changed, because the way I apply the load the plane section do not remain plane before after loading.

So, if you look at the moves from strength of material to theory of elasticity, I have enlarge my domain of solving problems, strength of materials has given me 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 two dimensional problems as in solve, I have a disk, you have a solution but, if you look at a three 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 tight in a net, 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.

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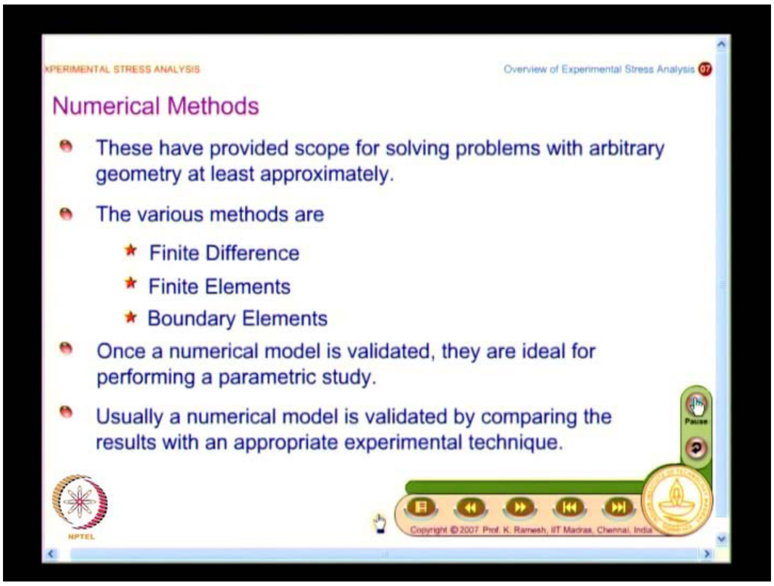

So, what you find here is, even though you have methods, which provide the conceptual understanding if I go for arbitrary shape, numerical methods, come they handling. And you are able to get the solution at least approximately, for arbitrary geometry, so that is where you find the numerical methods 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 attract the problems. And you also have boundary elements and very recently you have Meshrie method let us come, and what you find is when I am having a numerical approach to problem, the numerical model has to be validated. Once, unless numerical model is validated 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 that the greatest advantage of numerical method is once the procedure is validated, it is an ideal way to the parametrical analysis. In a design, if you have several geometry factors, you would like to vary them or you like to change the load case and find out how the system is going to behave, conducting experiments for each one of the concentration be difficult. So, you do an experiment verify the discretization, verify the boundary condition then do you parametrical analysis by in medical approach.

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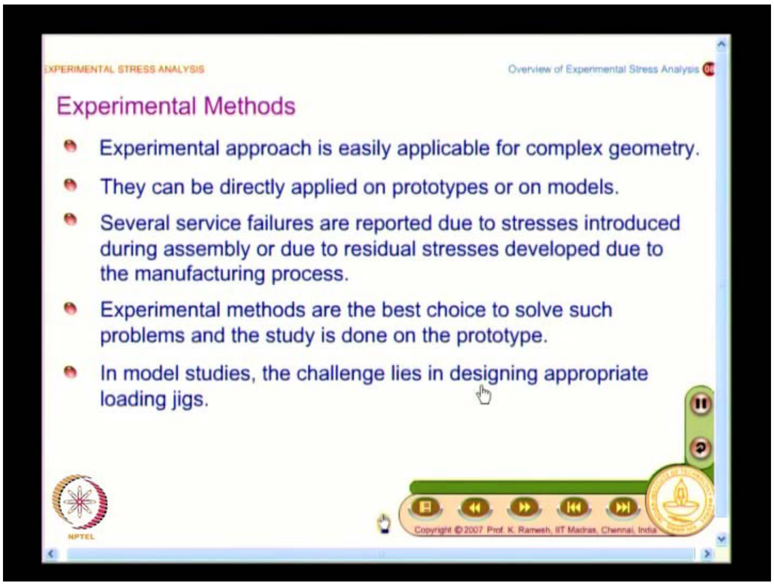

And once you come to experiments, what you see? Very similar to numerical methods, experimental method is applicable for complex geometry absolutely no problem. And once you come to a experiment also have to look up two different things, I may working on a model or I may working on prototype. So, you can do the experimental approach on prototypes or on models. On another area, where experimental methods are ideal choice, is in the area, where you have assembly stresses or reusable stresses. Now, I take very simple example, of a of a chain and this you have it in your bicycle, this also used in a power transmission and in practice what you have you two progress on either two side.

And this is subjected to essentially tension in actual surface, and now what I have here is I have an element taken out of this chain, I not I am just holding it other any stresses in this chain, how many of you say no, how many of say yes. There one person says you stress, the rest of the class it has no stresses, say, you have to know this component is fabricated. Suppose, I take a block of material and then I go to seen the machining and then machine out this that is one thing. And how it is done is you have essentially plates essentially plates and these plates are brought together by putting the appropriate bush and then bush has to strain plates.

So, you have an oversized bush and this has been inserted, so this is done with the interference width. So, apparently I do not have any external load on this chain link but, because of the way it is manufactured you have stresses develop, you have a bush here, you have stresses develop very prominently here.

And it is comparable to the service loads the stresses developed or not small in value 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 failures 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 going to this, you have the bush and bush bush may be may not be perfectly cylindrical. And another one is this is body which has the finite geometry you have a finite geometry. And this is an arbitrary shape, finite geometry I cannot go an approach by finite element by theory of elasticity, definitely I can approach finite element observably no problem.

But, there I have the applied boundary conditions, what the information I may not know from the production shop is this may not be perfectly cylindrical, we will have the variation. So, suppose I put is and then do experimental analysis on this component directly which acts like a prototype, when I capture all the manufacturing variations that has gone into the fabrication of this.

Whereas, we do a numerical analysis, I would take this is a perfect cylinder, I do not a model is there are any fine undulations on the surface of a run the such variations do exists in actual practice. So, what do you find here is for conceptual understanding, numerical analytical methods are needed. For complex geometry you have to going to for numerical methods but, to know the truth you will always have depend on experimental methods.

So, experimental methods are the best choice to solve such problems and studies done on the prototype. And in model studies you have a difficulty, because in model studies the challenge lies in designing appropriate loading jigs. So, if I do not design the loading jigs 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. Now, let us say one simple example, I have this rod and I want pull this, I can pull it by grips, I can have solid grips and then pull the rod and I can also pull the rod by another method which is what usually do, what you do is you have a slink, you have a pin. So you pull it with the 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 two are different. But, our interest is I want to have axial force in this number which could be done by numerous numerous ways and one they are doing it is putting a pin and string and then pull it, another put a grip and do it. So, I am not really solving the problem that I have to do, what I have in actual practice and this is where you have this famous in a St Venant principle that is required.

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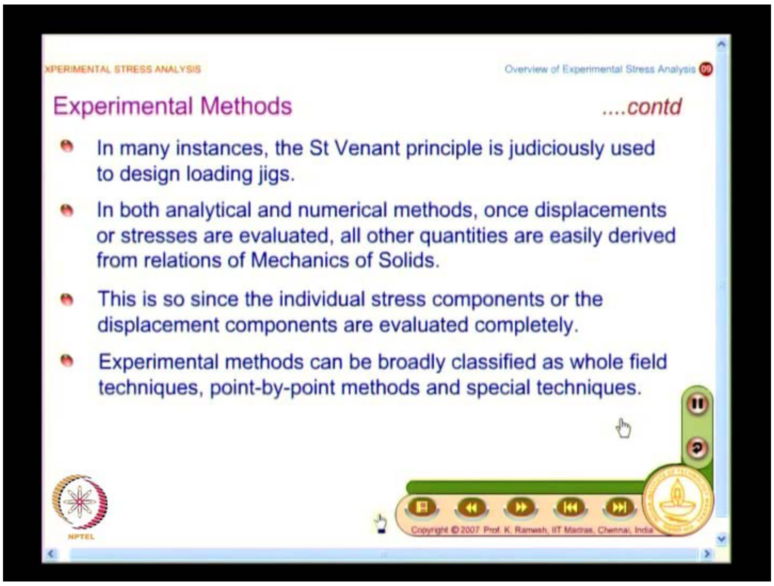

So you, many instances in designing, loading jigs, you will see in a principle. What it says is and distances away from the point of loading, the distribution is similar to what we finally want. So, you will have to use St Venant principle and decide design your loading jigs appropriately, so that it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

Then what you have, there is also another difference see in the first I showed a axial member pull, you have p by a, you have the stress component, rest of the stress components are zero. If you want to find out strength, then easily find out, those you have this you have you have readily available mechanics of solids equations. You have a stress strain relations, strain displacement relations.

So, once I find out stress components I can find out the strain, I can find out the displacements, both in analytical and numerical method. This is primarily because, I know all the stress components by analytical method then I proceed. In a numerical method also when I solve 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, exploit the physical principle for measurements.

So, that physical principle imposes at a restriction, what you can measure is experimental technique. Suppose, I measure stress I cannot measure all six stress components, I can measure only a 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 residual stresses, it can find out assembly stresses.

But, the restriction is I do not get all information is in one component; so this is one restriction that you have to leave it. And once you come to experimental methods the many experimental methods available, they are broadly classified as whole field techniques and point by point methods. And if you look at the full field techniques, there essentially optical techniques.

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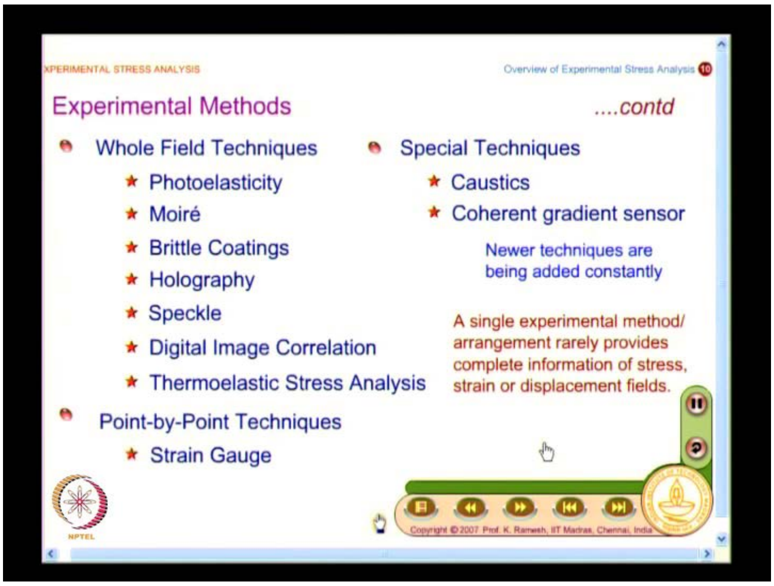

And you have great many of them and newer techniques also being developed, day after day. And when you look at whole field techniques one of the very popular widely used experimental method is technique of photo elasticity. And you would see later what gives experimental techniques, give directly the information, what information can give directly. And essentially photo elasticity gives sigma 1 minus sigma 2 contours; and you have moire that essentially gives displacements and you have a brittle coating, that gives you direction of principles stresses.

So, for each one of the experimental technique you get a particular kind of information and even if you used that the particular experimental technique if it gives more than one information, you should use different optical arrangements to get it. So, you do not get anything free no, you have some advantage, some disadvantage that they go together. So, it is the user has to decide what aspects you will exploit and then, find out which combination you will try to use for solving a problem on hand. And you have holography many of them has seen holography as a sticker on many one of the products, it used for mostly as a security device but, it also is a very good experimental technique.

And you would essentially get displacement vector and you spectral methods, which is the variation of holography. And one of the very recent experimental techniques is digital image correlation, this has a advantage of working at multi scale specimen preparation is very simple, surface preparation is very simple. And it exploits the computers the full as extent for measurement of displacement.

Then, you also have a technique called thermo elastic, stress analysis and what you have this when you have a model and then put a load, when a 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 a thermo elastic stress analysis. And you have a point by point technique and what you have here is the widely used strain gauges, I said widely used I also caution is a widely abused. Because, you know people in a strain gauge people have to place a strain gauge and pasting the strain gauge is such a boring exercise. And you have to been trained in pasting the strain gauges, we do not paste the strain gauges properly, you measure anything of the sum.

So, you do not you do not really measure what the system shows, you have error sources unless you handle the technology behind strain gauge instrumentation right from pasting onwards you would not measure the quantity has to measured correctly. And also have special techniques, as I mentioned in the beginning of the class, we saw there is the optical phenomenon where light gets rain force and get a silver line you have this as phenomenon of caustics, which is used in high stress variant problems; like when I when you want find out, what are the stresses develop vicinity of the crack this is very useful technique.

And because of passion effect the specimen behaves divergence line. And caustics is can be classified as a point by point technique, because it gives only one information and you have a field information a coherent variant sensor, which is the variation of caustics. And also appreciate newer techniques are constant constantly added. And I said earlier a single experimental method or arrangement rarely provides complete information of the stress, strain or displacement fields.

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

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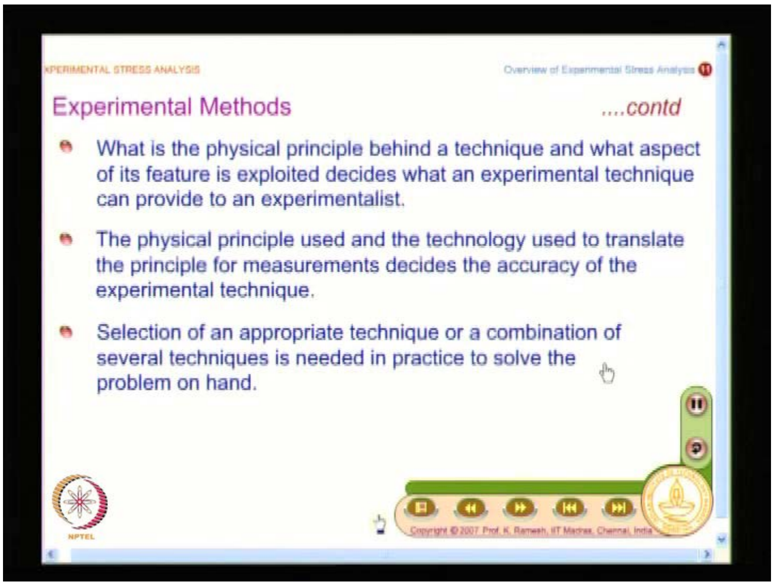

And as I mentioned earlier also, what is the physical principle behind a technique and what aspect of it is feature is exploited decides the, what an experimental can give. So, I need to know the physics behind it. Another aspect is what is the physical principle used and the technology used to translate the principle of measurements decides the accuracy of experimental technique. Because, if we go to photo elasticity earlier we were making measurements manually, now you have image processing techniques available.

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

I can make measurement using, suppose I want to measure the length of this room, I can go and take a tape and measure it. When I take a tape and measure it, I am going to say so many centimeters. On 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 length, same length measurement by depending on whether you use a scale, whether use a tape, whether use a venire or whether use a screw gauge or whether you have optical methods 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 six stress components, all the six strain components, all the three displacement components at every point in the model or only a particular kind of information at a few locations.

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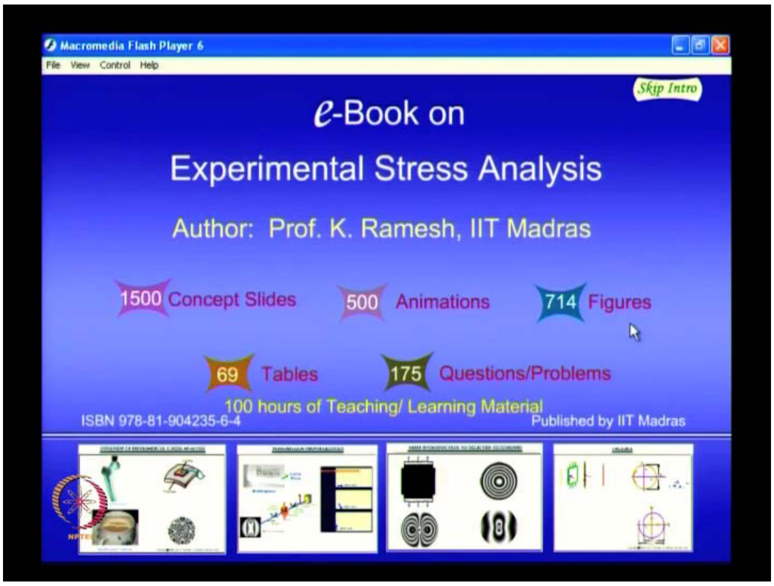

So, this decides the selection of an experimental technique and for this course I would essentially use my book on experimental stress analysis, e book on experimental stress analysis. This has been develop at IIT madras published by IIT madras and this contains more than 100 hours of teaching and learning material.

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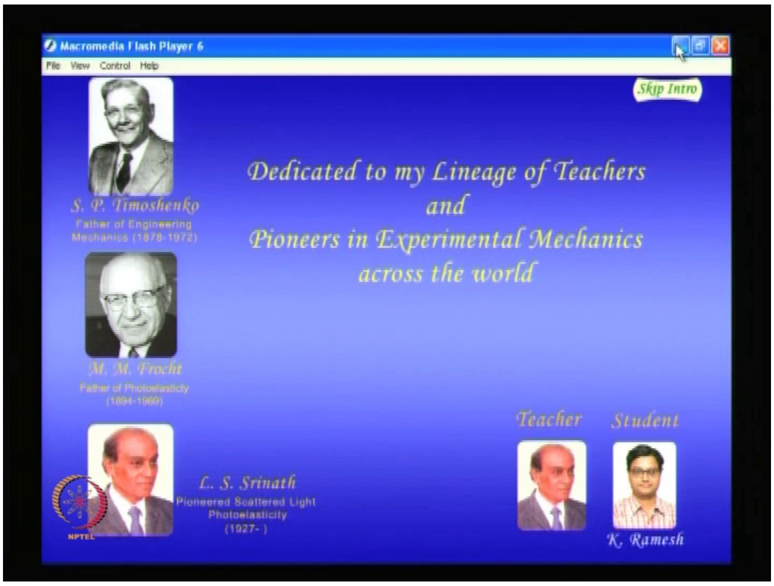

And this book is dedicated to my lineage of teachers and pioneers in experimental mechanics across the world. And this will be the core book that I will be following it and other books that you require for self reading and reference I would you give you as we go by in the course are you clear that, what is the fundamental different between an 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 death, in shear 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 of the first of approximation and you can get some inside what is happening.

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

And when I have complex geometry, I can always go and attack the problem for numerical approach, by numerical approach has to be handle very carefully, because you may go wrong in understanding and implementing the boundary conditions. So, any numerical approach has to be validated by experimental inputs. Once you validated 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 have very close to reality. In model studies you had be very careful in designing to loading jigs is they are not design properly you may not really simulate the actual service loads.

So, that will also be I do not yes, but you need both, you need to have prototype studies you also need to have model studies and you will also have to look at whether a particular experimental technique can be applied for both prototype and model studies. Because, if you look at photo elasticity one version of a can be applied on models a variation of that can be applied on prototypes.

So, the technique can be applied both on models as well as prototypes. So, you have to choose depending upon the problem on hand what is the way you would go and select this experimental technique. On an experimental technique by itself will not give all the information of what the basic stress analysis all about.

It not give all the fifteen components, what component I get is dictated by the physics behind the experimental technique. So, in this course we would pay attention on what is the physics behind each of this experimental technique. How this have been exploited, what is the technology use and what is the do's and don'ts in a employment experimental technique, that is what we are going to in the classes to come.