Engineering Drawing and Computer Graphics
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Module - 07
Lecture - 51
Overview of Computer Graphics–I

Hello everyone. Welcome to our online certification courses on Engineering Drawing and Computer Graphics. We are covering module number 7 which is about Computer Graphics.

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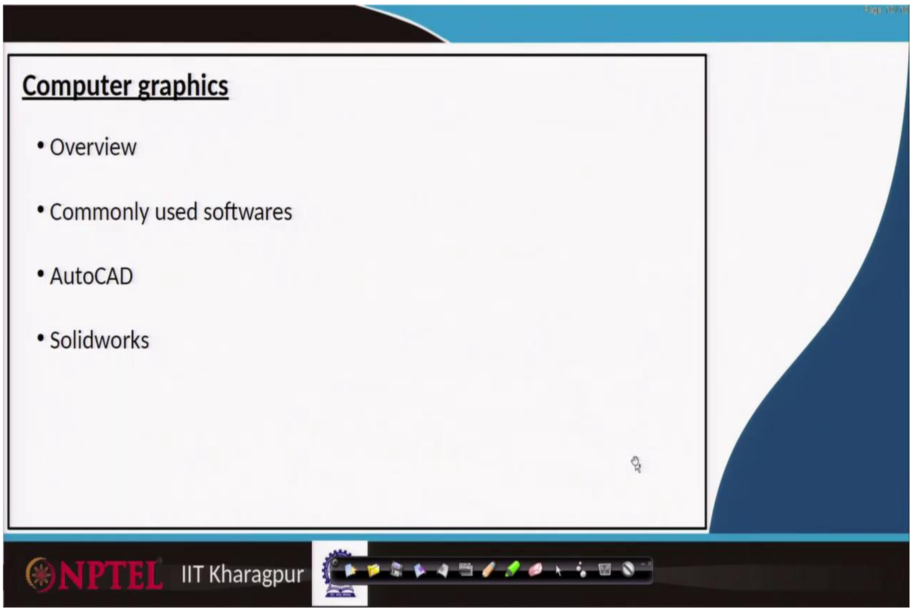

In computer graphics, we mainly cover an overview of computer graphics, how they have originated and what are the commonly used software; a little bit about AutoCAD and in detail about SolidWorks. These are the modules what we will cover in computer graphics.

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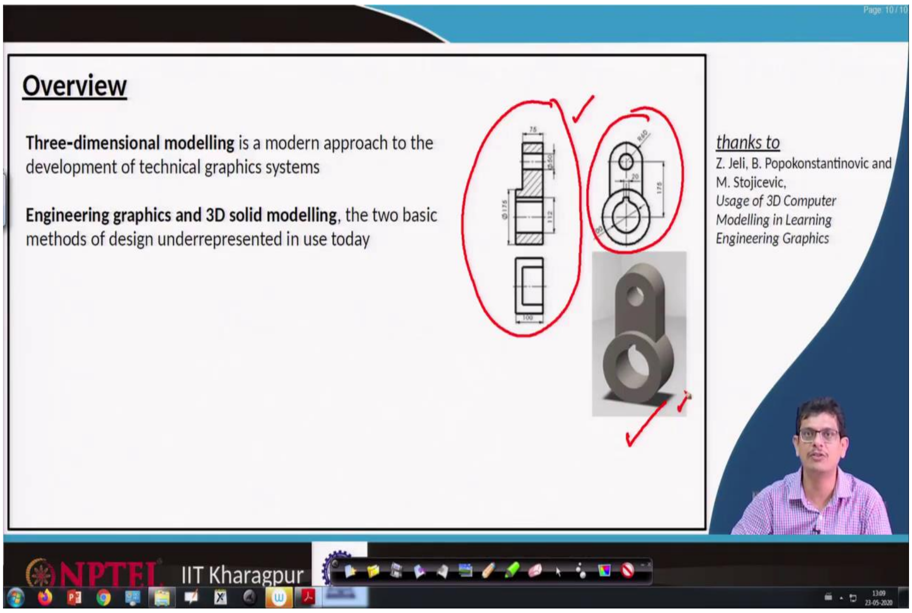

In terms of overview; so, till now we have learnt how to draw the technical drawing on sheets using dimensions, compass, dividers, scales, protractor and other objects we have used; try to construct two-dimensional and perhaps three-dimensional objects in isometric views. Now, onwards we will try to use computers, how to construct such kind of three-dimensional objects or perhaps the cut sectional views of three-dimensional objects.

To begin with that first we will look at some overview of these computer graphics. So, modern days engineering designs always involves three-dimensional objects and 3D solid modelling.

For example here these are the views, but usually we construct it on the sheet, our drawing sheets; perhaps right side views, left side views, top view, the front view we construct. Try to imagine how an object looks like in 3D and try to represent that in isometric views.

The advantage of these computational graphics is they look nice and over that precise dimensions we can always use. Whenever you are drawing sketches there always be the least count whereas, at computer graphics, you will have precise information.

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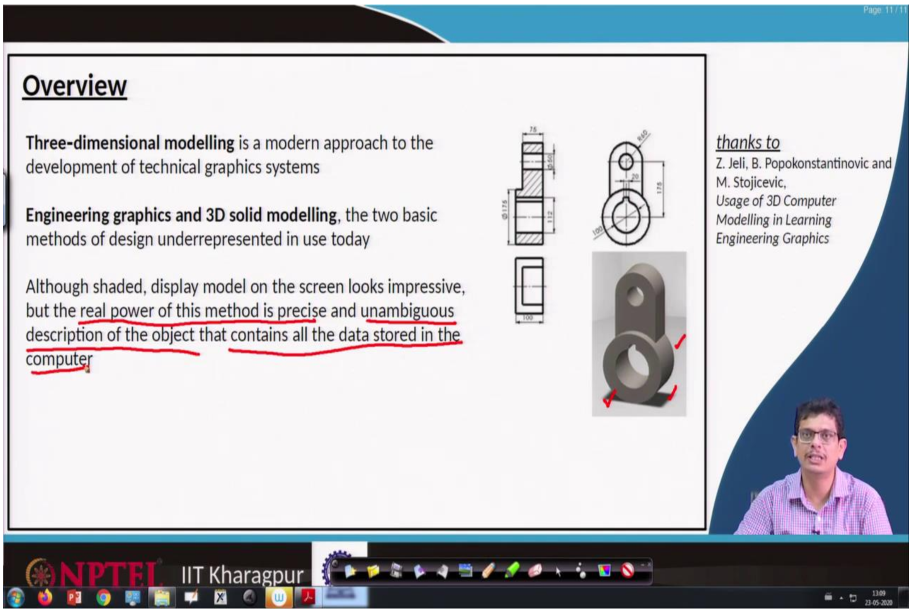

Although, the shaded portion like bright, light colours, dark colours this kind of things gives nice appeal to eyes. The real power is about precise and unambiguous description of the object. And, all that information we can store it on the computer; even after 10 years if one would like to recover that information, we will be in a position to use that. Whereas, drawing sheets and other things what manually we do they have a lifetime.

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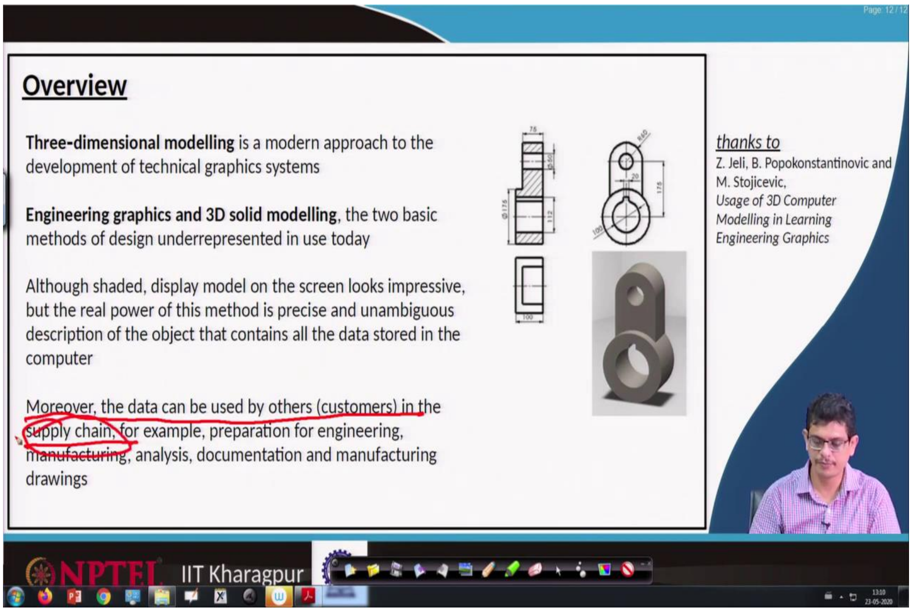

And, further, if we want to share that information with others that can be also possible for the supply chain. So, technical drawings will be prepared at one place and that will be supplied to different teams. And, this is the easiest way of transferring information from one location to another location in the supply chain.

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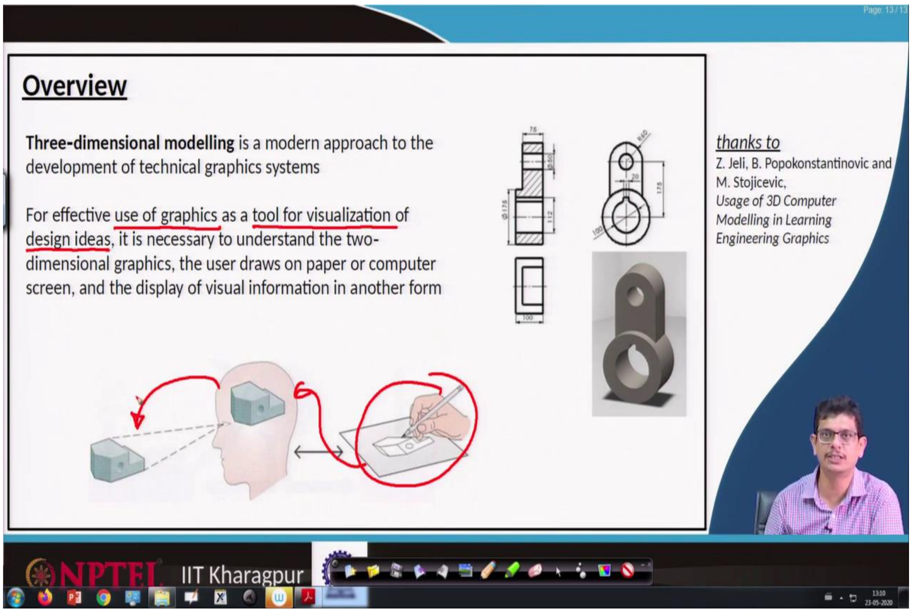

Usually, this computer graphics involves the effective use of graphics as a tool for visualization of design ideas. We first try to construct on the two-dimensional sheet, interpret that and from there finally, construct that 3D objects.

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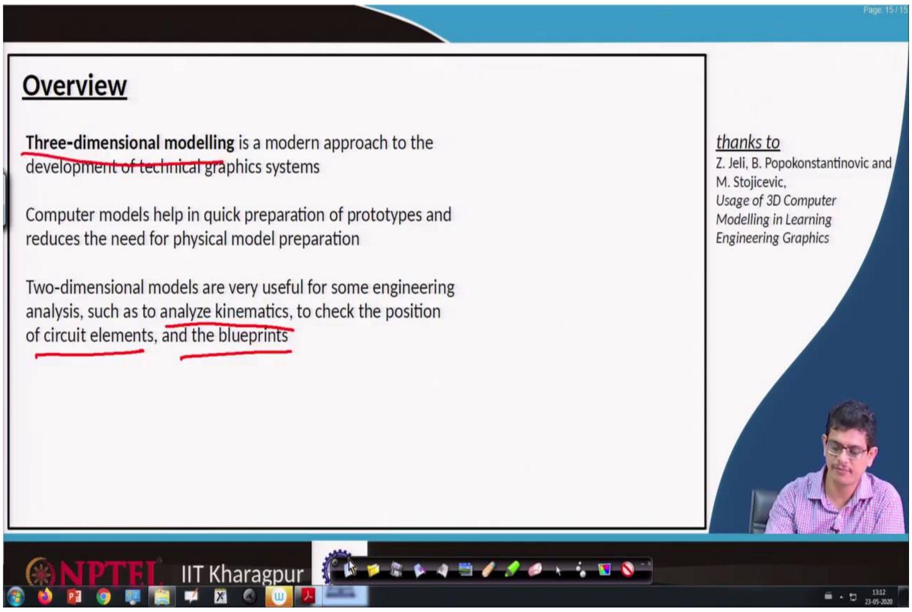

The other advantage of these computer graphics is if one would like to quickly prepare a prototype it is quite easy to use these drawings; these days people are going with 3D and the advance is like

4D printing. In 3D printing, if you can supply this computer graphics, the complete design of that object; the machine will be in a position to print that object in a very effective way.

So, if one is interested in preparing a very quick prototype, the typical software like AutoCAD and SolidWorks; there are other software also like CATIA. These are the ones which one can come as handy. Till now we have learned about 2D drawings, mainly those 2D drawings are helpful in terms of understanding kinematics and to check the position of circuit elements or perhaps for the point of blueprints.

These are just documentation to give us easy information, the detailed information we will get only through three-dimensional modelling.

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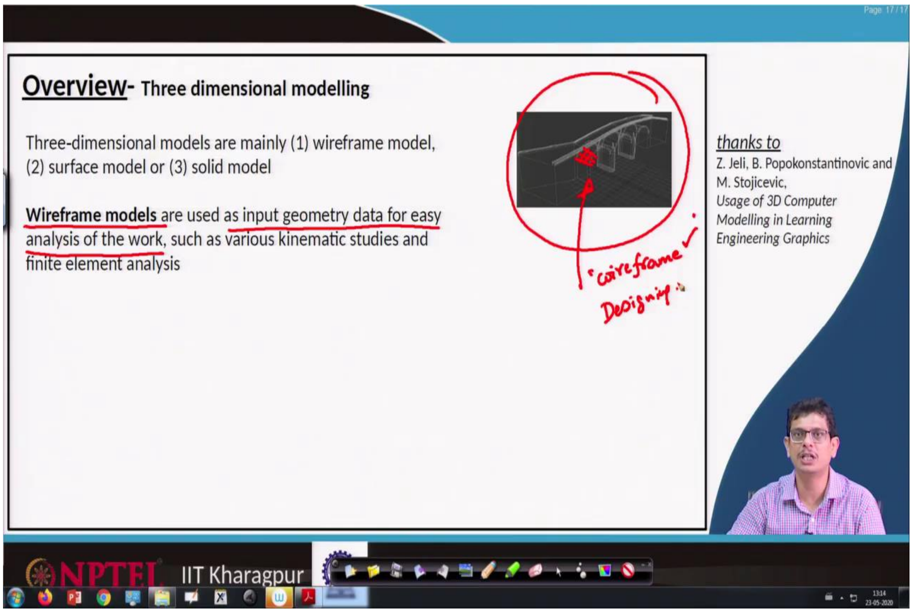

Especially, the three-dimensional modelling consists of three different varieties: one is the wireframe model, the other one is a surface model, the third one is the solid model.

Before, looking at this software, an overview always helps us to remember certain keywords of this technical drawing; for that purpose, we are covering this brief overview of computer graphics.

The first wireframe model is used as input geometry data for easy analysis of the work. Here a picture of the bridge is shown, if you look at carefully it contains many line elements, it looks like a wireframe. So, the skeleton of the object we always get it from this wireframe and this wireframe has to be supplied, if one is interested in designing an object.

For example all these civil engineering problems, aerospace engineering problem, chemical engineering, mechanical, electrical engineering; they mainly work on continuum mechanics principles. There will be fields, information about stresses, strains, temperature perhaps the information about current and many other things, we usually represent like fields.

That means, at each point of the system, we will be in a position to identify that particular information. For that purpose, usually when we are writing programs or perhaps solving partial differential equations, to understand those essential physics issues we have to supply the object in a wireframe model. For example, like you have a cell phone; there might be a chip processor. It is continuously exchanging energy with the surroundings.

It might be overheated. Now, what might be the temperature distribution of that? Perhaps, on that, there may be a slight bridge is happening. So, certain kind of boundary conditions are there; now, if I would like to understand such kind of problem what I have to do is, first of all, construct an engineering drawing based on where exactly chip is located, where the resistor is present.

And what are the other components involved on that, what kind of boundary conditions in terms of temperature field I have to apply? This kind of things, I have to make it on the certain object; and, that information we have to teach it to the computer at every point and for that purpose, usually this wireframe designs or drawings will be helpful.

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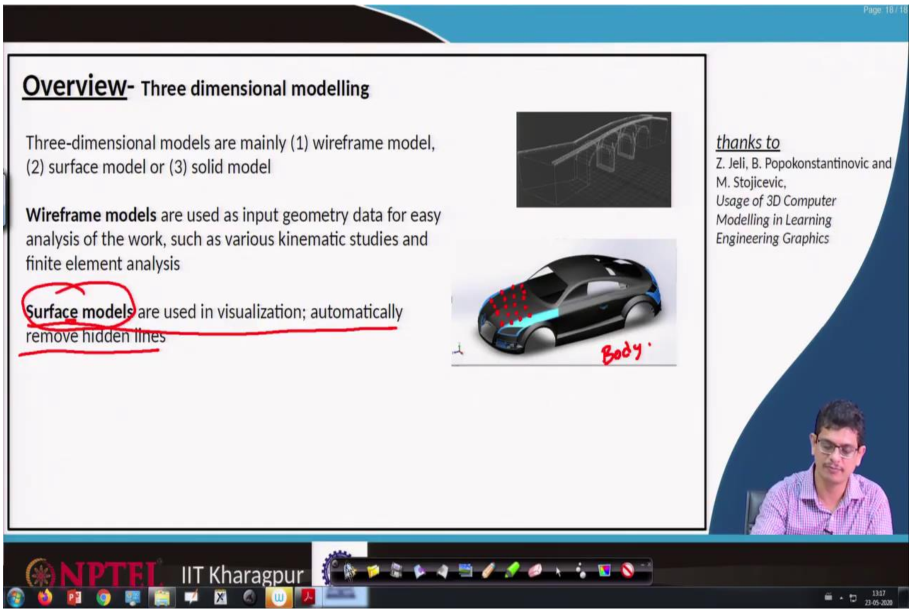

The other one is surface models. These surface models are mainly used for visualization of the fields and they remove any hidden lines of that object. You would like to visualize an object or perhaps the temperature distribution on the surface; instead, though we supply a wireframe model which solves the equations at those points. But, your surface information like a colourful contour of temperature distribution or electromagnetic field what you are going to see, that gives a nice appeal by these surface models.

Though information is available at discrete levels at one point, two points may be hundreds of points, but there should be a reconstruction supposed to happen from point to point. So, any surface modelling concept involves such kind of interpolation from the discrete information.

For example, this car body whatever these we are looking at, it looks nice to eyes, but the essential information about colour contrast or perhaps the curvature of that object; these kind of things are available at discrete information. Using that discrete information, we go with rendering techniques, try to construct a nice appealed object; that kind of process what we call surface modelling.

For and these surface models they do not have any thickness, they are infinitesimally small in thickness, their length, breadth, this height, this kind of things matters, but not the thickness. If we have such kind of objects, we call surface we construct it using surface modelling; there are certain objects where thickness are the other dimensions are also important.

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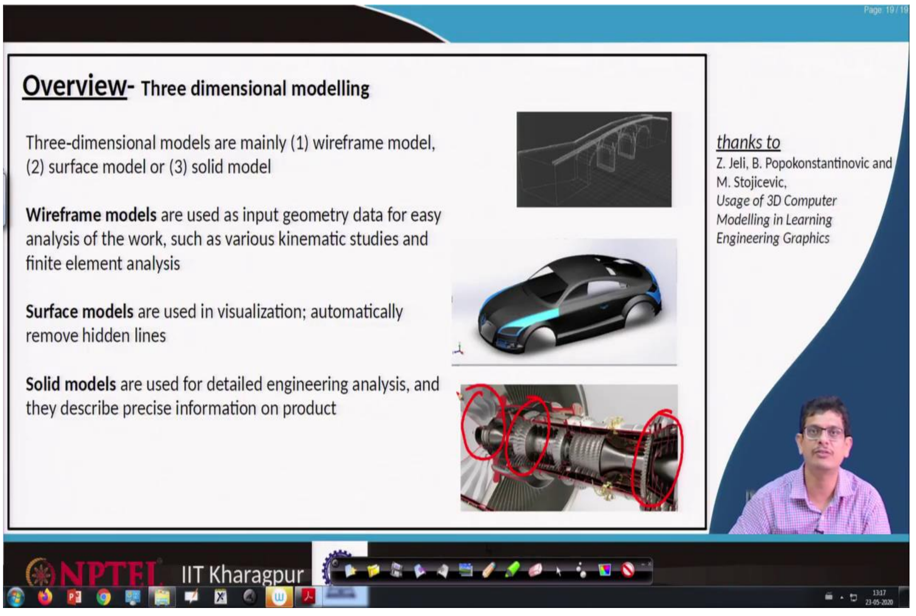

For example, there is a gas turbine may be for a jet engine, you might be having something like turbine blades, compressors and nozzles, fans and other kind of things are there. Some of the parts are surface like fan blades these are having 0 thickness. But, some of them like nozzles and perhaps the shaft of that object these are three-dimensional things.

So, a detailed view if we are going to provide such kind of things what we call solid models; though all are three-dimensional. In terms of computer graphics the representation, they will be categorized as wireframe models, surface models and solid models.

If you are going with solid models, it requires enormous or gigantic computer memory. You have to store information at all these points, the surface is in between wireframe and solid models.

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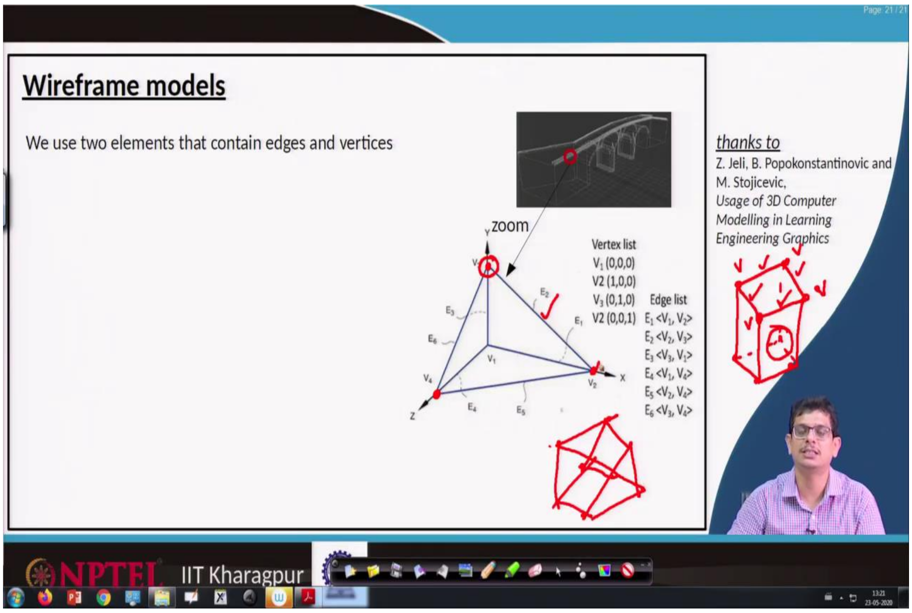

So, let us look in detail about this wireframe models. Usually, any three-dimensional object, if we are going to connect it by wireframes; that means, we are going to identify something like vertices and something like edges. For example, if I want to represent a cube, cuboid; in the wireframe model what I require is something like vertices. These are the vertices.

And, we require certain more information like data structures which are these vertices connected, linked. If we know that information only we will be in a position to represent these two supposed to be connected by these edges. These supposed to be connected by those edges, these connected by that edges and further. So, there is a proper data management one has to do with that.

So, in wireframe model, we do not show this kind of hidden lines, but it contains vertices V and these edges. Any three-dimensional object, we would like to represent; these are the minimum information we require it to connect it. Now, if we are not careful in terms of tracking these nodes, vertices, edges and other kind of configuration, the same points may give us misleading information also.

If we are not in a position to carefully connect this information maybe this one goes there, this one comes there, this one comes and it will be a complicated picture we will be having which might be observed also. So, when we are using wireframe models, these vertices adjust their links. The hierarchy has to be carefully followed.

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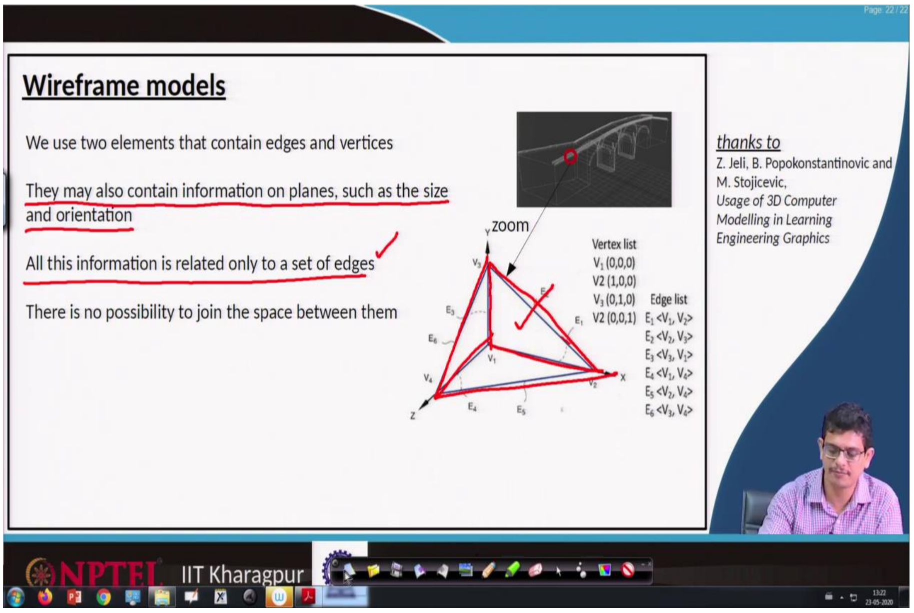

Usually, this wireframe models contain information on planes such as the size and orientation; something like whether the surface is oriented by 40 degrees, 50 degrees and so on. And, all this information is related to a set of edges. So, we always are having edges; something like this is one edge, other edge and this one is another edge and so on. So, set of edges always be there and these edges usually intersect with each other to make it a three-dimensional object.

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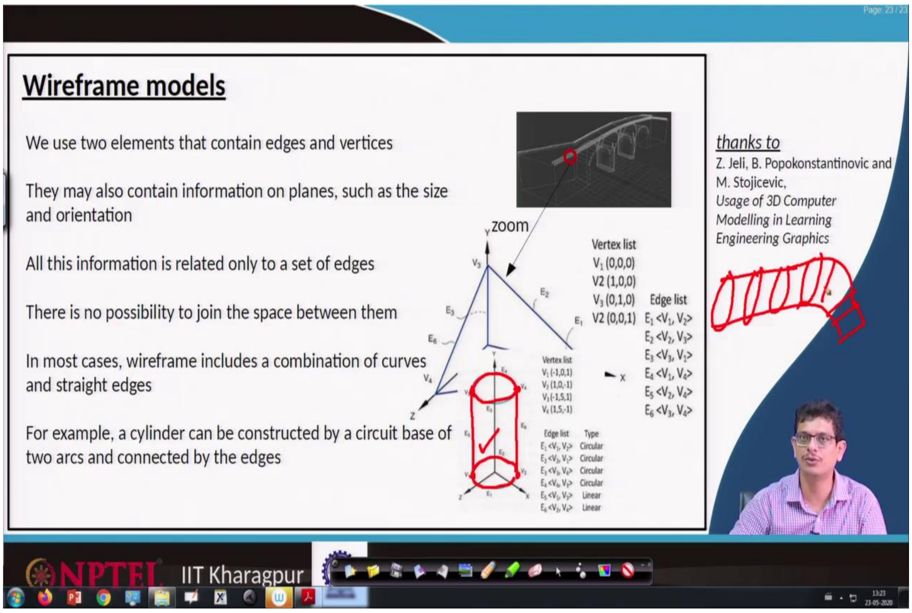

And, usually, it is not necessary that we have to connect these vertices only by lines, they can be connected by curves also. Here we have such an example cylinder if these are the points what we are defining as edges; then we can construct by arcs also. If I repeat similar kind of objects, perhaps I will be in a position to construct three-dimensional shapes.

For example, if I would like to have something like a very long pipe, then we will have that kind of cylindrical elements many connected line by line. If we have a pipe bend, then again some part of that cylinder portions, some other things by other kinds of curves and arcs; we will be in a position to connect it.

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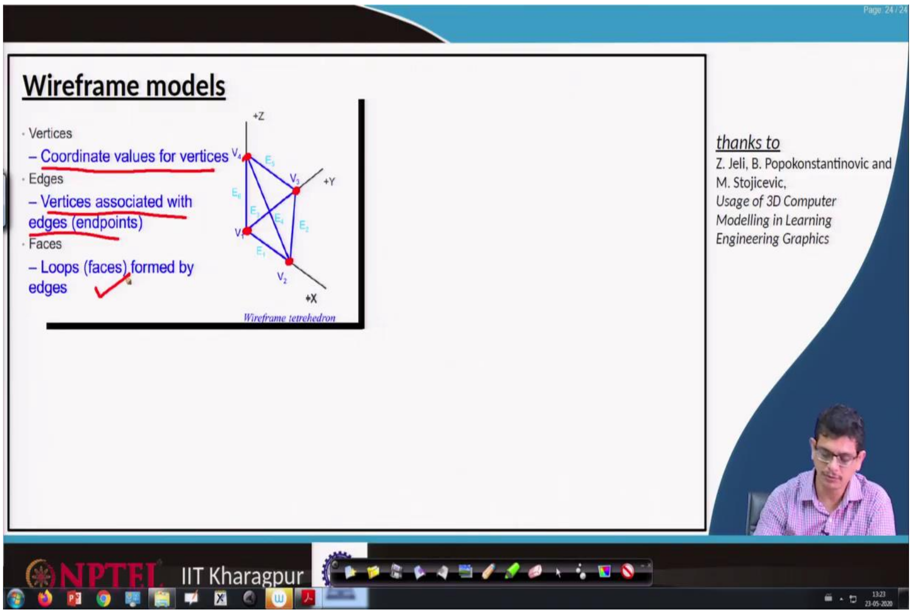

On the overall, the wireframe model always consists of coordinate values of vertices. And what are the vertices associated with particular edges and are there any faces forming from these edges? These are the most important information.

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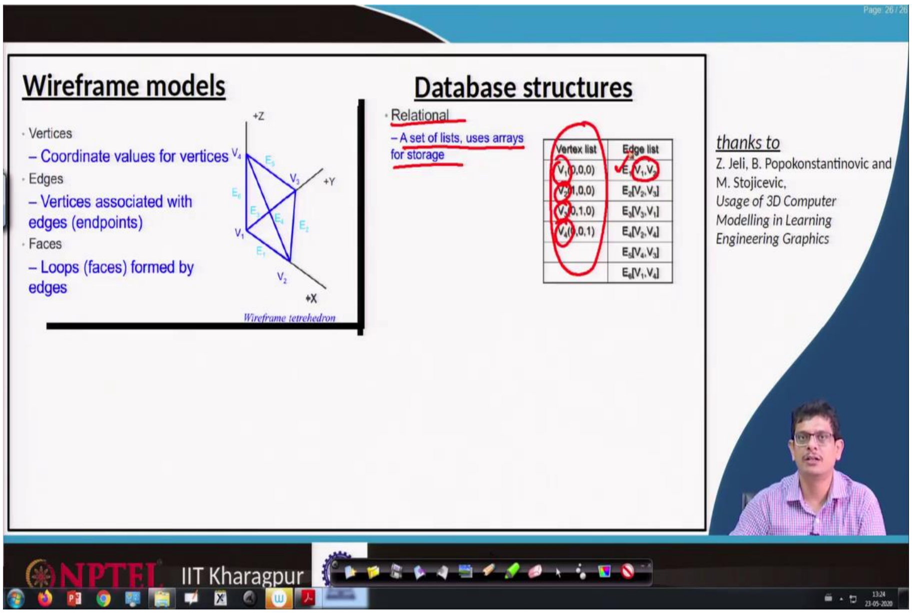

Now, when we are looking at these edges, vertices careful database structures one has to construct; there are different kind of operations or perhaps combinations one can use. One of them is relational operators, where a set of lists and errors we will use it to store; something like what is the vertex list, something like V 1, V 2, V 3, V 4.

And then something about edge list, what are those vertices connected; so, that it forms an edge? Though here this 0 0 1 0 0 0 1 0 0 0 1, it may be forming a cuboid.

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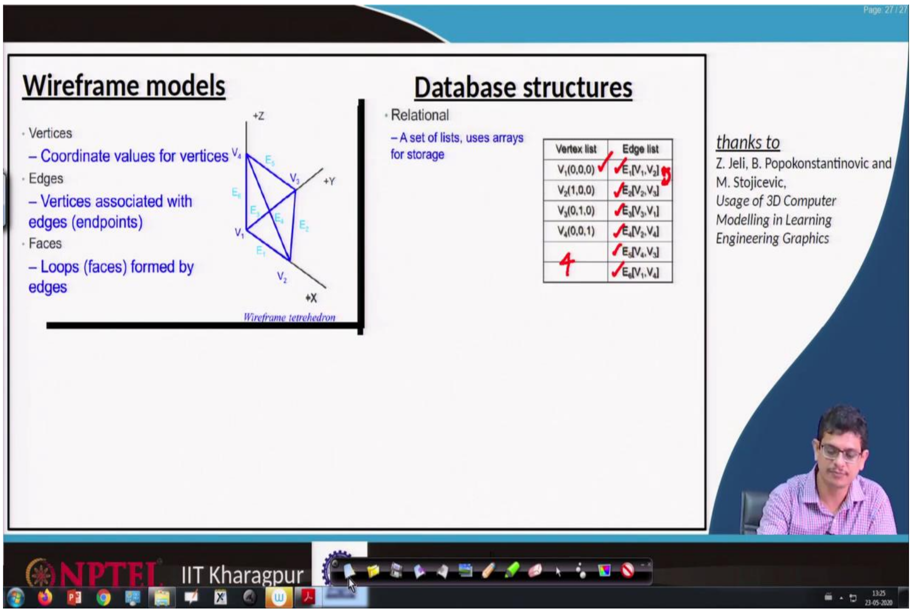

To teach it to the computer, we have to store not only that vertices information but information which are the two vertices connected.

So, here for four vertices, we have a combination like 1 2 3 4 5 6 combinations we have; is a combination in between two pairs from out of 4 we have to construct. That is the way we teach it to the computer or store it to say that it is of that particular cuboid.

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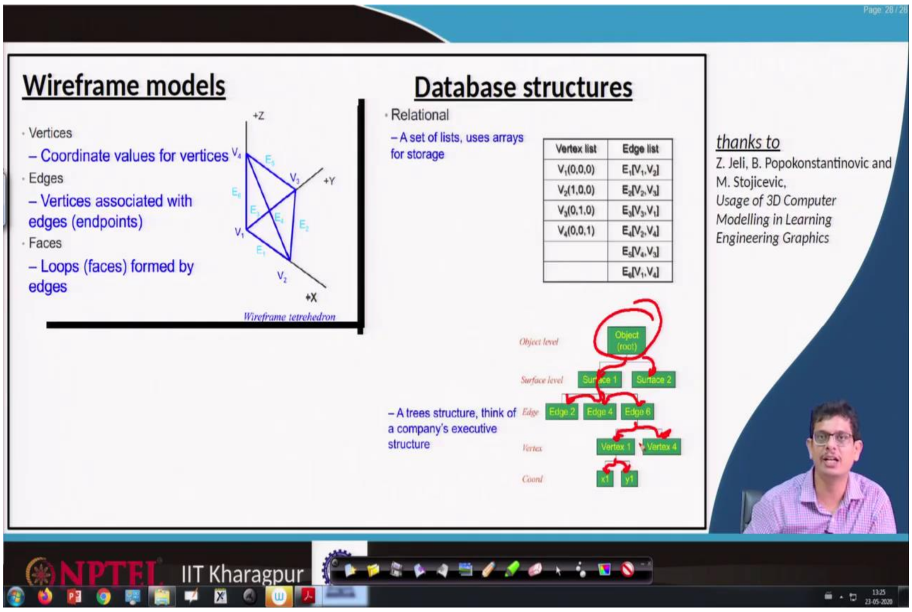

Similarly, there will be tree structures one has to be careful, something like what is the object, which surfaces are connected and each surface how many edges are there. And, in that edges which are the vertices and in those vertices what are the x y information. So, a detailed hierarchical structure one has to go with that. So, there your basic programming a concept comes into the picture; sometimes defining class is also a useful concept for this connecting these points.

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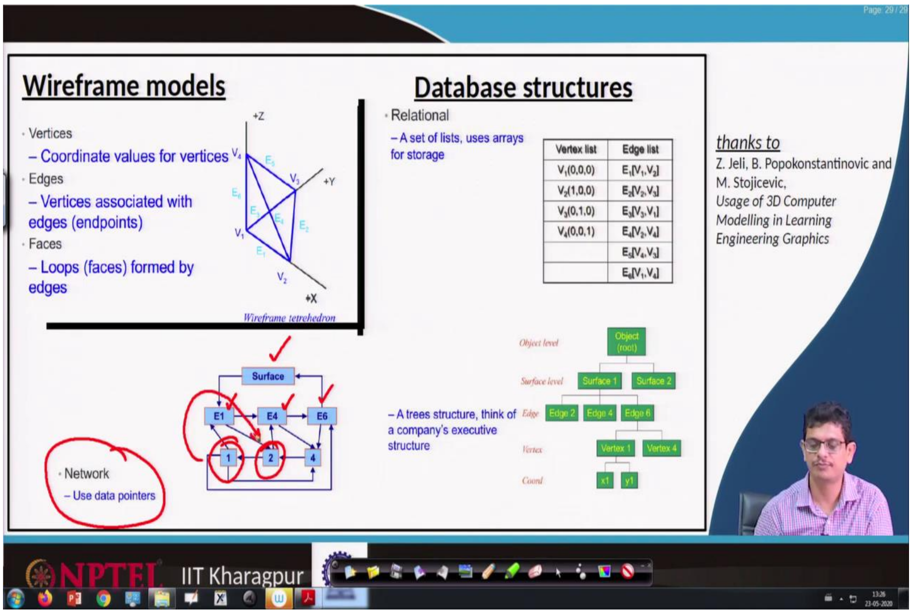

And, also a network will be involved when you are connecting these points. For example, data pointers naturally come into the picture, something like a surface that is having edges E 1, E 4, E 6. So, to construct E 1 perhaps you might be using 1 and 2 points; so, these are naturally connected as a pointed variable.

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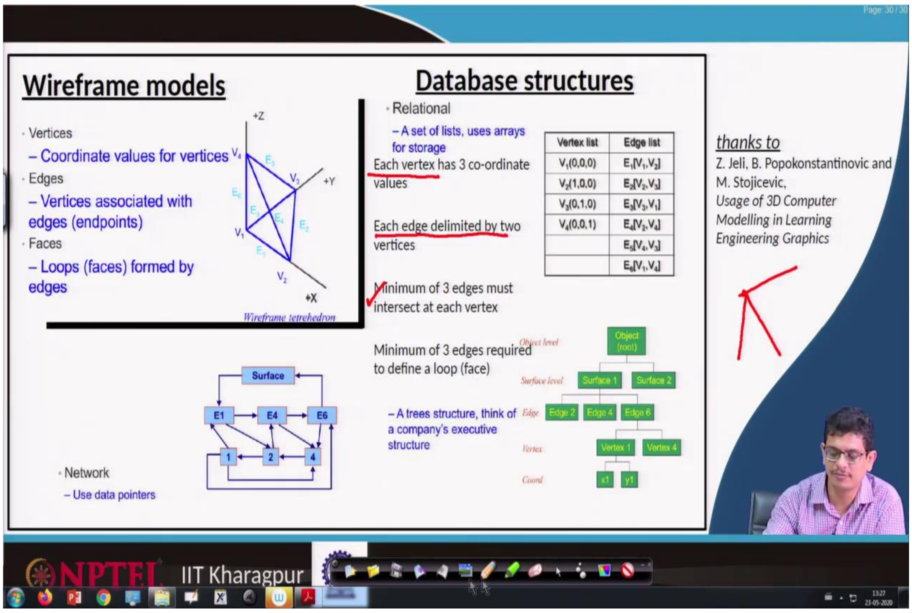

Usually, each vertex has 3 coordinates x, y, z and each edge is delimited by two vertices; if I am saying something like edge; both the ends supposed to have these vertices. And, usually minimum of 3 edges must intersect at each vertex. Something, like if I am saying this is the vertex perhaps there might be one edge, another edge is coming, another edge is going; that way a network will be constructed.

Even to define something like a face you require 3 edges.

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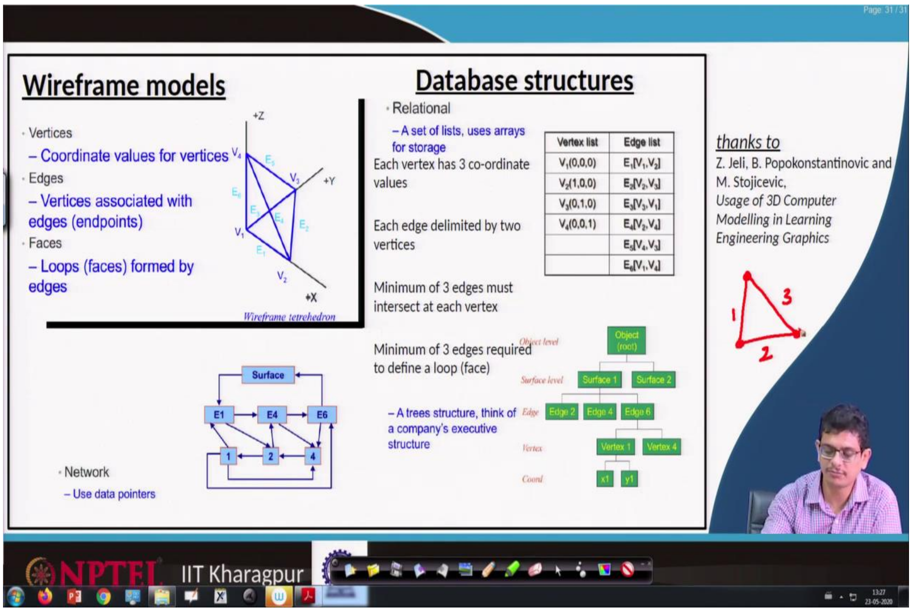

For example, here we have a triangular face. This is the 1st edge, 2nd edge, 3rd edge maybe the vertices are V 1, V 2 and V 3.

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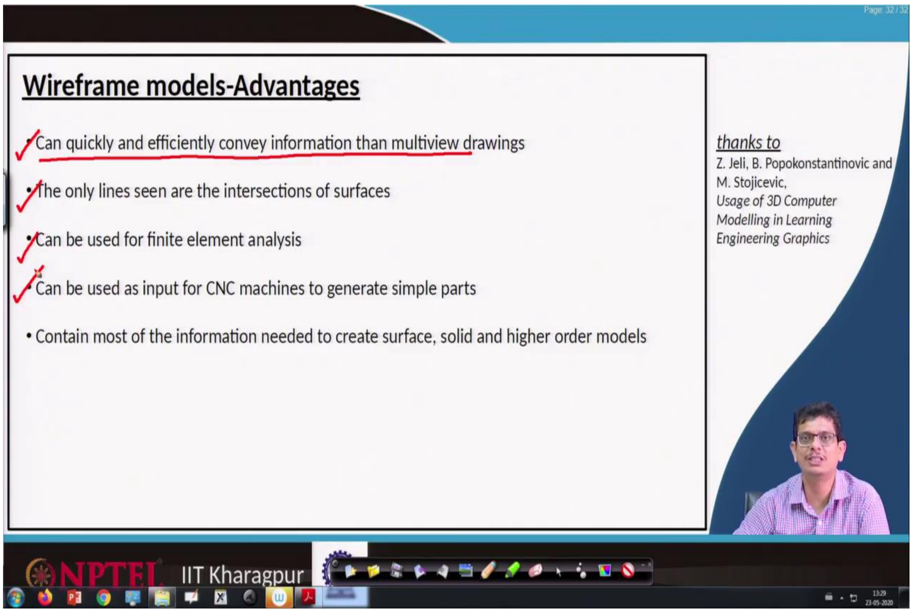

As I said these wireframe models are a low dimensional representation of a three-dimensional object; this is the minimalistic way one can represent a 3D object. It has its advantages like when you are loading the geometry or perhaps analyzing the geometry or perhaps post-processing the geometry not only in terms of you, even for engineering design perspective. These wireframe models are easy to load it on the computer and clear the memory also.

They can be quickly and efficiently convey information and we will have multiple views also we can easily construct. Any lines what we are seeing this supposed to be the intersection of surfaces; that means, we have an idea about what are the surfaces connected; for any continuum analysis like designing the objects, one of the popular numerical methods what we call in engineering finite element analysis.

These wireframe models are the beginning step to analyze the data. Even these days people use computer-controlled machines, CNC machines; this kind of machines for which one can straight away supply this wire models information. So, required operations like turning and other things can be easily formed. Any higher-order models we would like to construct, a wireframe is the basic step.

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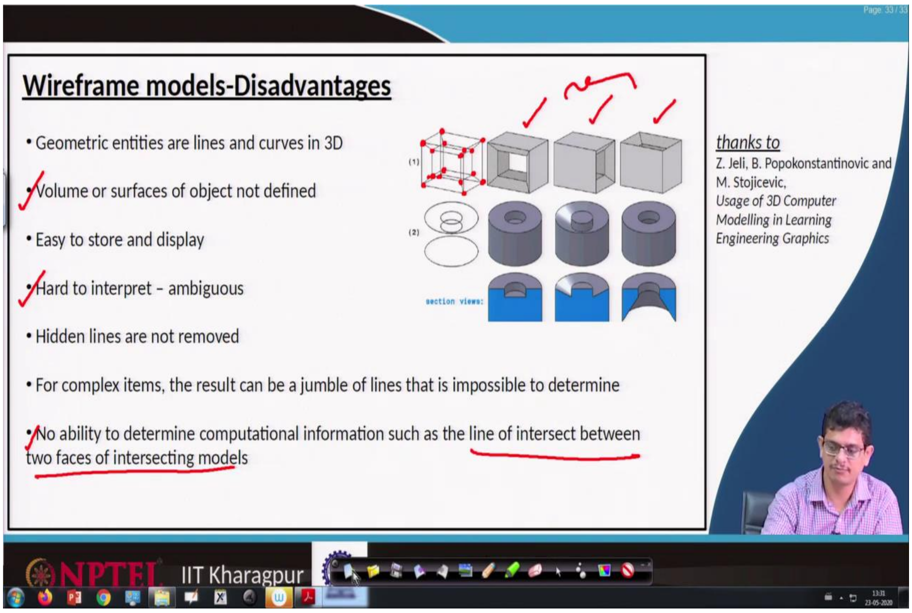

They have certain disadvantages also if we are not careful with this list which edges are connected, it is not so, easy to identify what kind of 3D object we are looking at. For example, let us look at this. We have these are the vertices, in case only these data points vertices are available and there is a mismatch in terms of vertices which are connected like edges.

Then the object may be represented in that way, it might be represented even in that way and it can be represented in that way also or any other object which might be observed. So, one has to be careful in terms of using wireframe models. So, there always be ambiguity in terms of surface construction and it does not define anything about volumes and surfaces of the object.

Usually, ambiguity is hard to guess or interpret is difficult. And, they do not have any ability to determine computational information such as the line of intersection between two faces or intersecting models. When you have two, three models which are intersecting with each other; they represent these curves contacts becomes slightly difficult.

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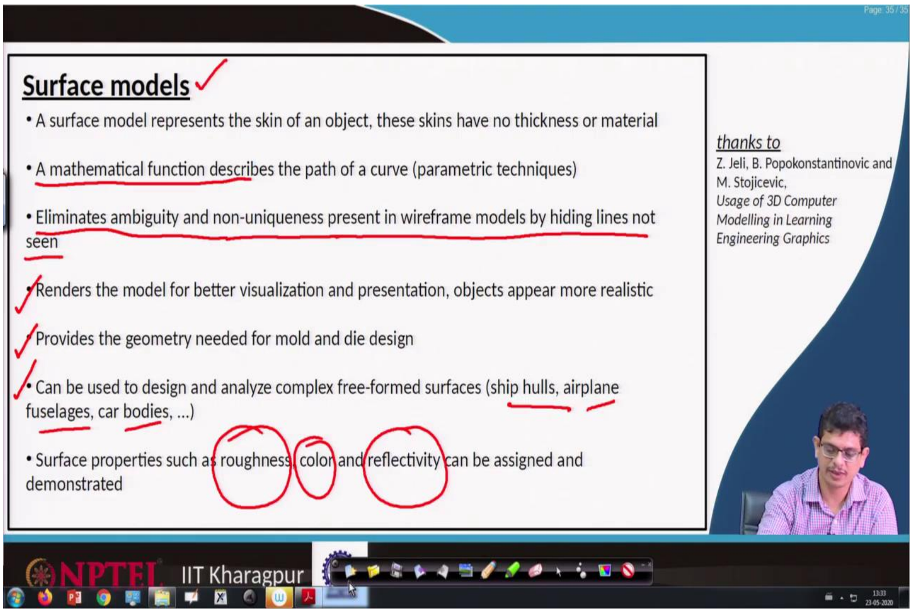

Now, we will look at other object name surface model. So, we learned about there are three varieties: one wireframe model, surface models and solid models; so, now, we are going for these surface models. A surface model represents the skin of an object, these skins have no thickness or the material. And, usually these surfaces we define it by mathematical functions. We use parametric variation to define something as a surface.

And, these surface models eliminates any ambiguity or non-uniqueness present in wireframe models by hiding lines are not seen. And, better visualization and visualization and rendering are possible only on surface models and the objects look more realistic in this network. For example: like mould designs, die design this kind of things can be easily constructed by these surface models.

Even complex free-formed surfaces like ship hulls, aeroplane fuselages and car bodies; we can use these surface models. And anything about roughness, colour, reflectivity; we can easily assign it on surface models.

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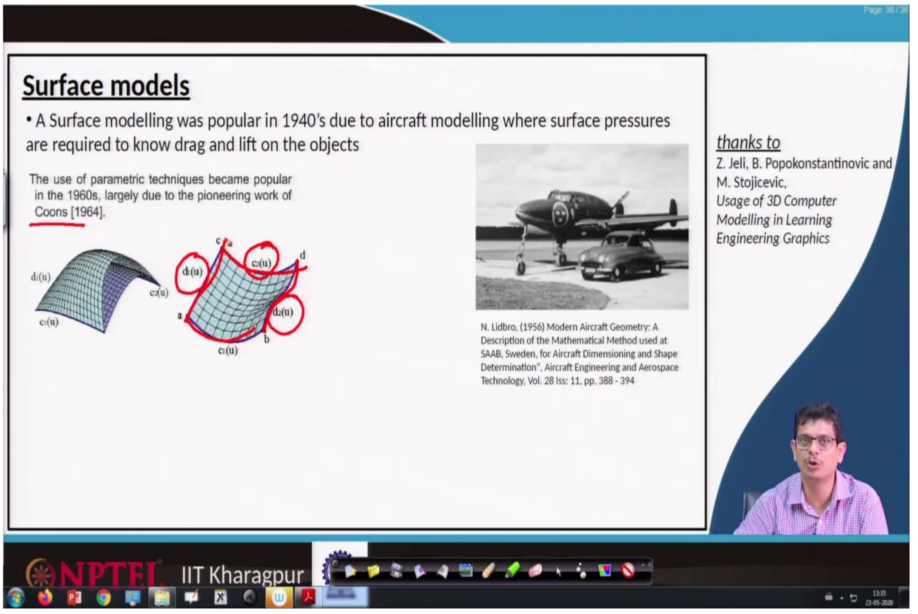

This concept of wire models came around 1900 when people try to look at finite discretization and try to understand that represent the surfaces, connect the surfaces; to recapture people used to go with these dots like wireframes. Then around the 1930s-40's people started looking at something named surface models because they are more interested in knowing drag, lift on the objects.For example, here we are showing an aircraft, what should be the surface? Because there always be internal, the olden days' aircraft always be having an internal structure; on that, you will be covering it with surfaces. Now, how that surface supposed to be turned on that aeroplane such that one will be having less drag and more lift on that object; because earlier day construction was not on using typical composite materials.

So, they have to deform the object nicely and that supposed to be supported by the internal skeleton structure. So, deforming, riveting this kind of process requires surface information and entire surface modelling concept came in those days 1940's. And, the way they developed further using parametric variations, especially by Coons way of surfaces which we will learn about later classes.

There is a different kind of surfaces like Bezier surfaces, spline surfaces and in some sense, the ambiguity in terms of the intersection of surfaces will be removed by this Coon surfaces.

So, where parametric information about curves we will use; that means, there might be a curve, there is another curve, there is another curve, there is another curve. How to join these curves to represent something like a surface? There is a way this entire surface modelling works in the parametric variation.

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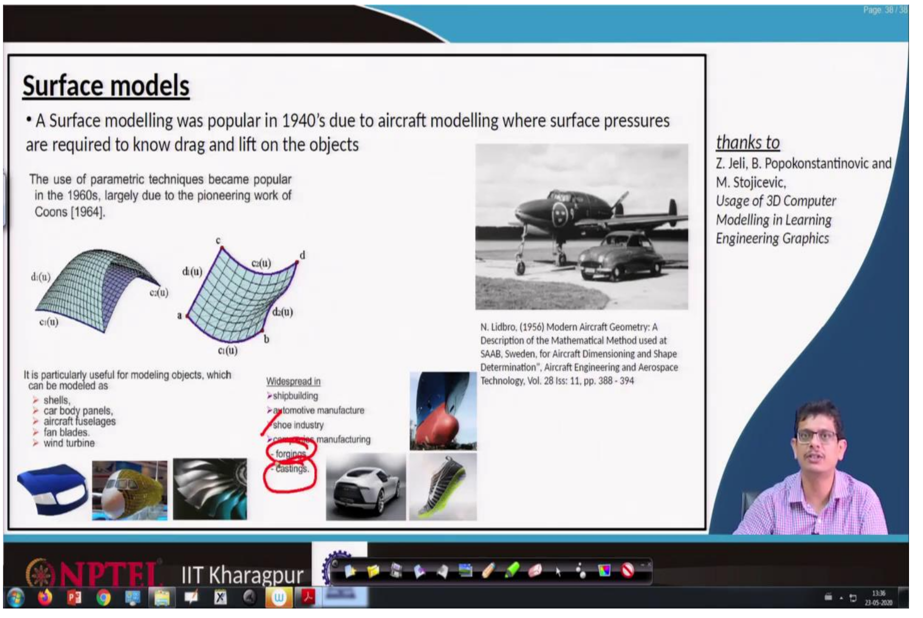

Especially, this kind of surface modelling is used for shells like bullets you would like to see it on that shell, outer shells or domes that kind of objects. Car body panels, aircraft fuselages, maybe the fan blades, the twisted fan blades and perhaps wind turbine blades.

These kinds of things have surfaced, complicated surfaces; how to make that kind of things requires surface modelling concept. And, they are widespread in terms of shipbuilding and the other one is shoe industries also is quite popular. If you are looking at mechanical industries, the forging and casting operations usually involve these surface modelling principles.

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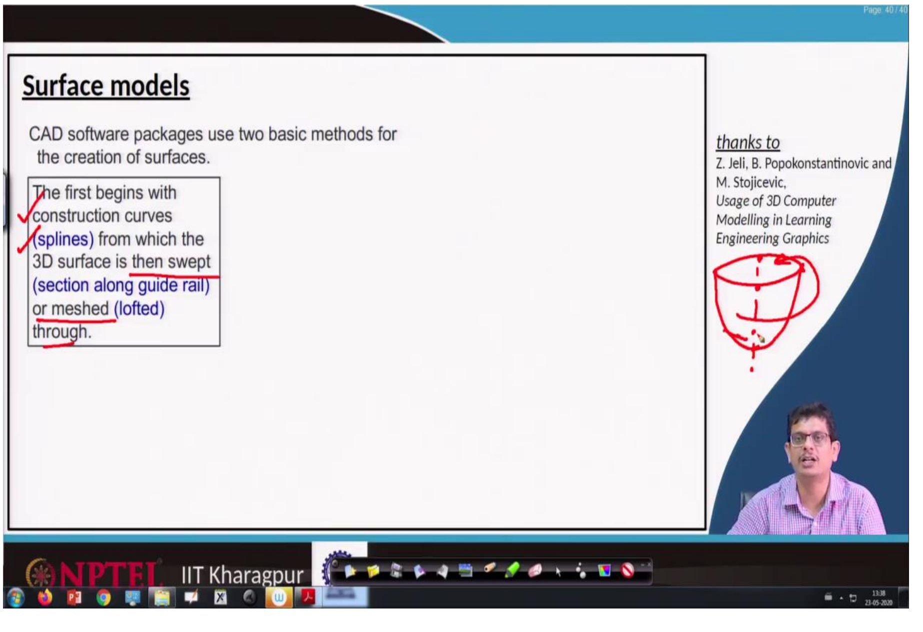

We popularly use a word name CAD: Computer-Aided Drafting and also Computer Aided Designing. This kind of concepts requires surface construction. There are computer packages which are available to construct that and what we will learn is how this software, the background of those software works. So, first begins with the construction of curves which we call splines, from which 3D surfaces then swept or meshed through.Something like, if I want to make a pot, the essential information what I require is something like a curve and I might be requiring something like an axis. If I revolve this entire spline around this one, I will be in a position to construct a cup. It is a surface what we would like to construct it, 0 thickness.

So, using these kinds of splines one will be in a position to construct it. So, there will be a computer program where we will define based on the points. So, the software what we are going to learn is when you are going to touch the screen or perhaps click the point, your front end takes that information and send it to your back end of that programming.

Takes that edges, vertices, connect it, fit something like a spline; then it asks you information about which axis you would like to rotate, ask you for those points, you pick that; then it revolves and constructs these objects. So, there will be a lot of information goes at the background and the front end what we are going to learn in the next classes.

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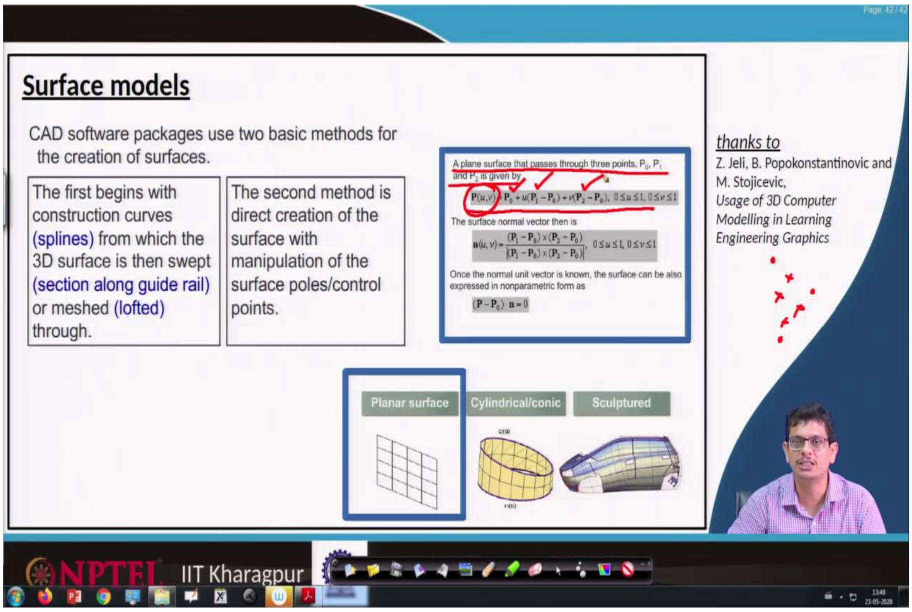

The other method is directly construction of surface by manipulation of the surface poles and control points. Especially, surfaces are categorized into planar surfaces, another one is cylindrical or conical surfaces and sculptured surfaces we call. If it is a planar surface, the back end how it works is; a plane surface that passes through three points P 0, P 1, P 2 is given.

When you are constructing surface on the computer, perhaps we may have to give points P 1, P 2, P 3; x, y, z coordinates either we type it using stylus touches the screen or perhaps with a mouse click on that surface, where we will give x, y, z information. Once we have that x, y, z information; it will construct at the background a parametric variation P of u, v; any point on that surface can be interpolated using the information of first point P 0, second point P 1 and third point P 2.

Because, we want to construct surface from these vertices; so, once vertices are not, a surface which passes through these three points can be constructed using such kind of parametric variation. And, we would like to because it is a surface it might be having a curved shape. So, normal vectors are also important. It might be a planar kind of surfaces, it might be slightly curved kind of surfaces or perhaps the orientation of that surface also we require.So, normal of the surface also we require, but we have only information about three points. We do not know complete information about surface which we are intended or interested to construct. So, in that case, we again use normal vector in terms of P 1, P 0; taking a cross product with P 2, P 0 points.

Similarly, P 1, P 0; P 2, P 0 cross products we will construct. By using that, we will be in a position to construct what might be the normal to the surface, based on that colour mapping we will do right.

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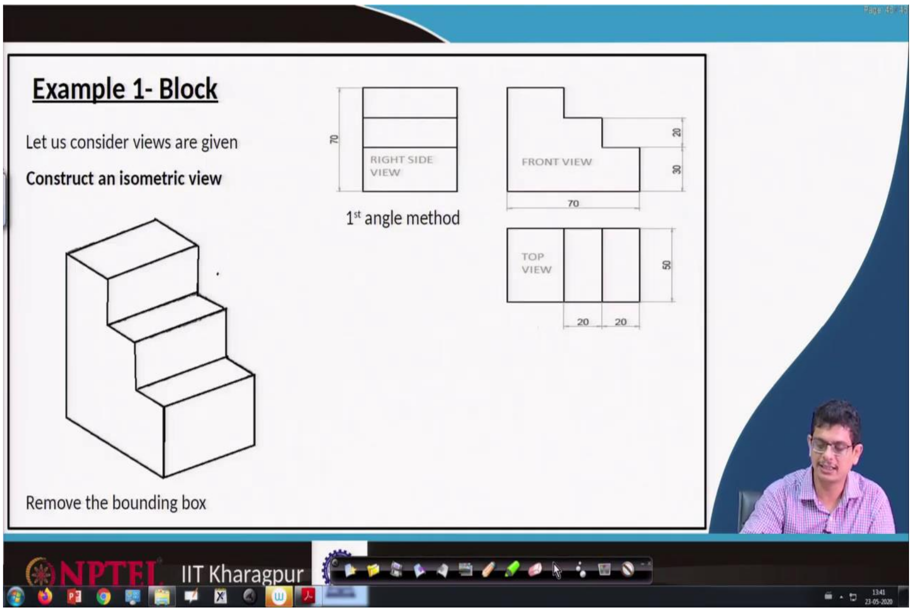

And, in the next classes, we will learn more about surface models and different kind of spline surfaces.

Thank you very much.