Introduction to Lean Construction
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BIM uses; Metrics

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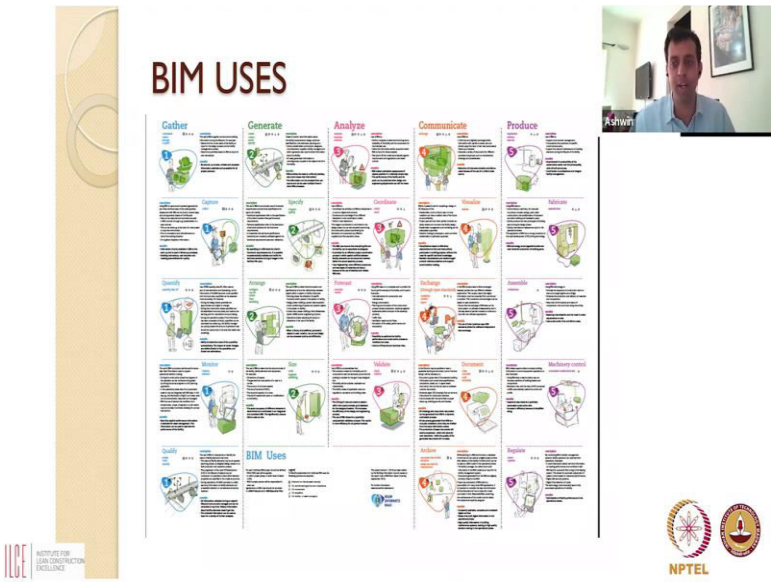

There are a wide variety of benefits that building information models provide. So, if you look at this slide here, there are something like, 20 or 25 different benefits that are out there. Of course, it is too small for you to read. But the point is, there are a large number of benefits. Let me walk you through some of these benefits, and then we will connect them very briefly to lean construction.

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First of all, one of the reasons why there are delays on construction projects is that when the structures come up, once clients can actually see those structures visually they then realize that they would like some changes made, it is a difficult for them to understand blueprints. But when they see the structure in real terms, that is when they decide that they would like some changes made and as and when they recommend changes, that causes delays in the process and possibly increase in costs.

So, one way in which we can avoid these changes, is to start building early on very realistic live size digital models of these buildings that clients can explore So, that they can actually minimize the extent to which they make changes later on.

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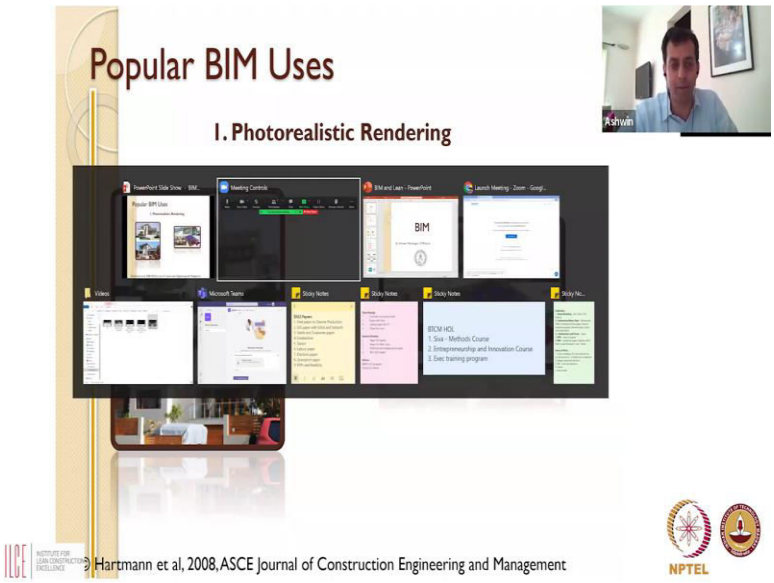

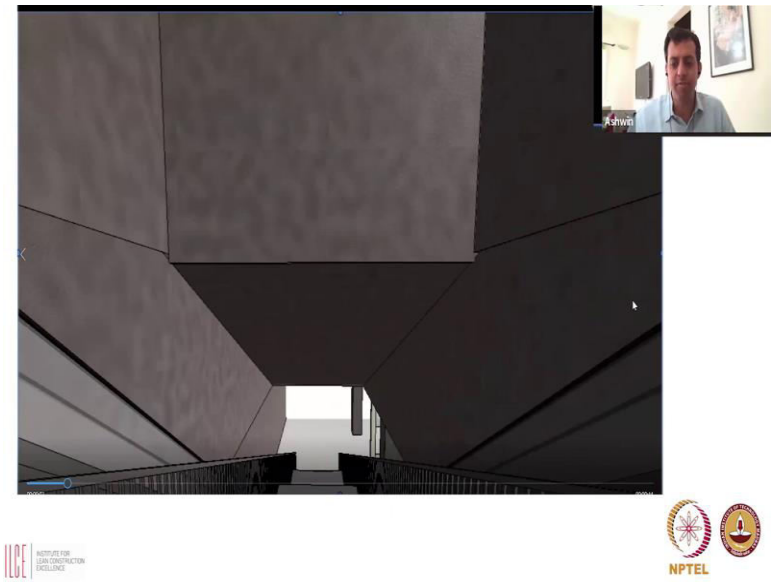

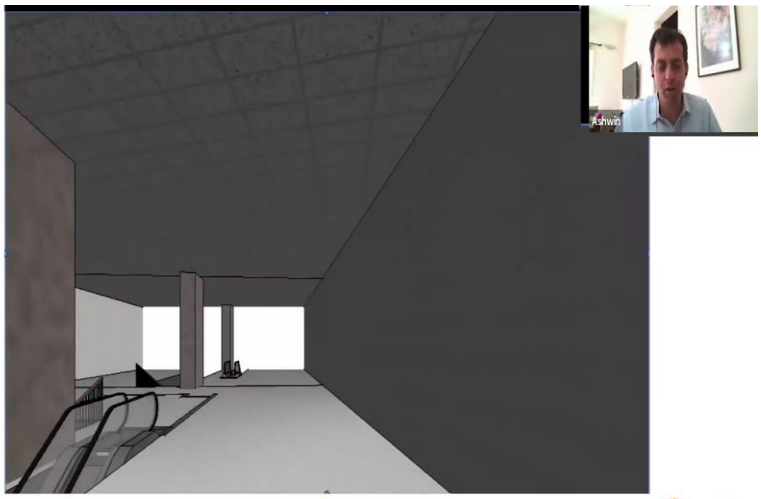
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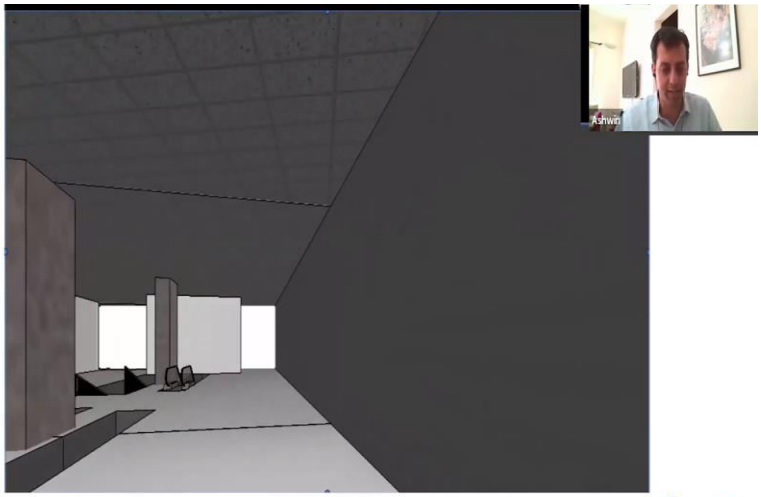
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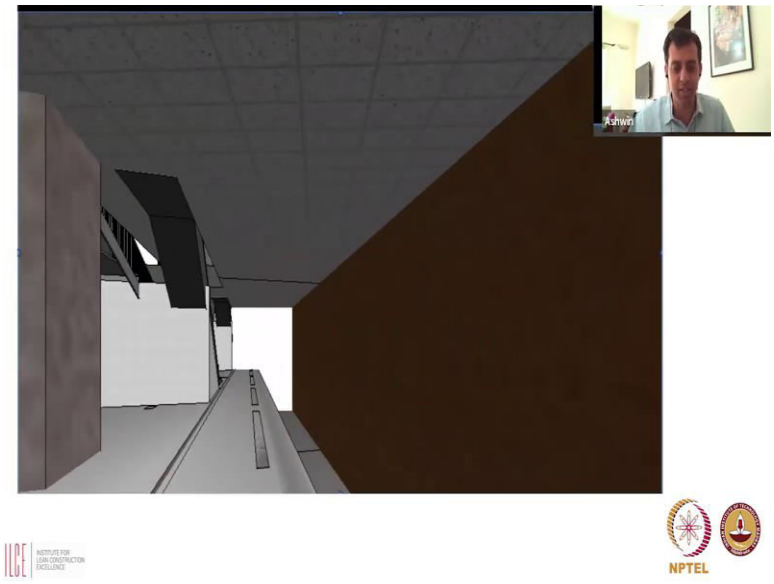

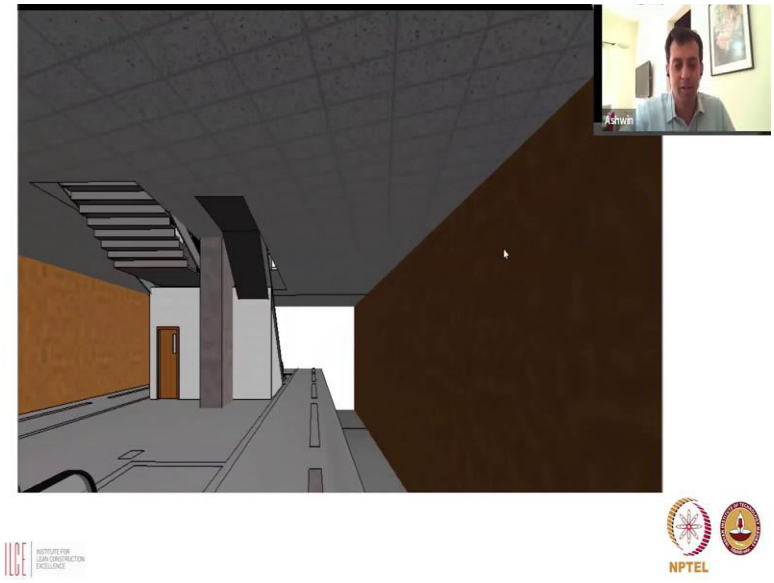

So, let me show you, for instance, one example, this is a very simple walkthrough of a Metro Rail underground station. Once you have a three-dimensional BIM model, it is just a question of plotting a route through the model and asking somebody to, or asking the computer to show you that route. And literally, this can be done in a few seconds. And you can change these walkthroughs, you can have different kinds of walkthroughs that you play in your, that you create, and you can play to determine whether the asset that you built meets your specifications or not, or whether any changes are required.

So, these kinds of things do not require any computer graphics expertise. They are very simple interventions that can easily be undertaken once you have a building information model.

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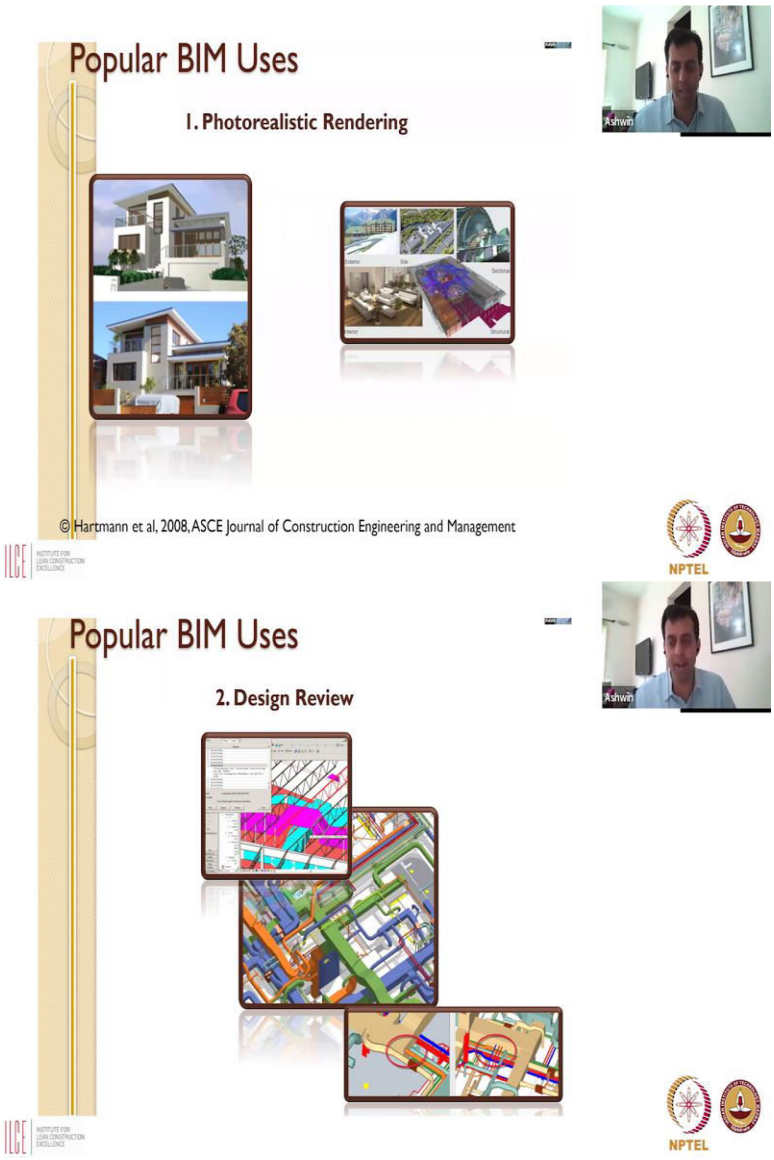

So, photorealistic rendering is one application of it. Second, you have an issue that plays construction sites called clash detection. So, very often what happens is you have several components, structural components, and mechanical and electrical components? When the mechanical subcontractor is trying to erect a duct on site. Suddenly, they might find that there is actually a beam that is blocking where the duct is supposed to be.

Now, this means you have to go back, and you have to resolve how do I rewrote the duct all of that it takes time, it costs a little bit of money. What building information models can do is because you are having architectural information, structural information and mechanical

information coming together on the same platform. You can actually run a very simple query where you can tell the model or you can ask the model, you have all of these pieces of information that are on your platform are there any two elements, mechanical, electrical, civil, whatever, that share the same xyz coordinates and if so, that is a clash please list them out from me.

So, the computer very quickly looks at all the information you put into the model. And since here is all the clashes that we have detected here are 27 different elements which are sharing the same xyz coordinates. And you can do this before even a cubic millimeter of concrete has been poured, before you have started construction. So, prior to construction, you can very quickly sit down and say here are some clashes.

Let us resolve them, let me reroute this beam there, let me reroute and duck there, let me reroute that pipe there and come up with what we call good for construction or clash free drawings. So, that when you actually start constructing there are no issues with regards to clashes and construction proceeds at a very even and fast pace. So, this ability to do clash detection and review designs to see if your designs actually meet the standards that you expect is something that building information modelling can provide again a very big benefit of building information modelling.

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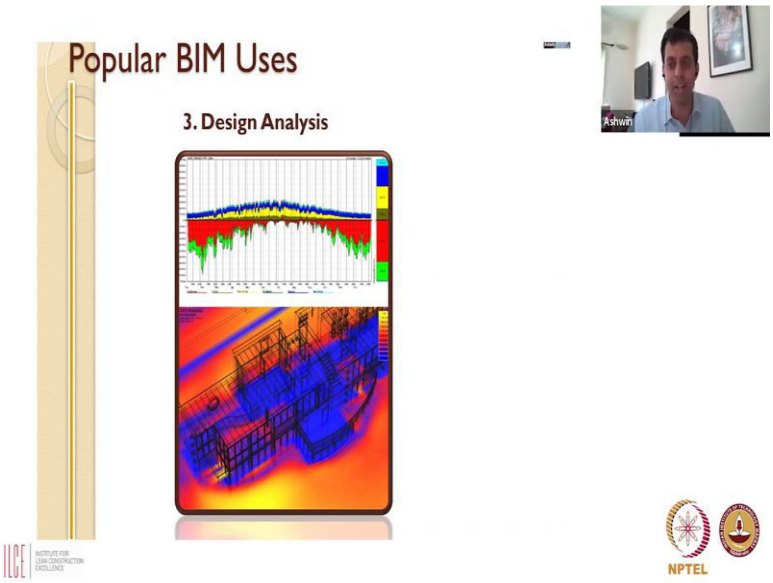

You can do all kinds of analysis on your building because now you have an intelligent three-dimensional model of the building, you can say here is the latitude and longitude of where it is going to be located. And based on that you can simulate the sun path and determine what are parameters like indoor air quality, indoor air temperature, thermal comfort the computer can very simple, very easily simulate all of these parameters.

So, you can then analyze the sustainability of your building, analyze your design and make changes if you want to again virtual. And again, this is possible because all information geometric information that kind of glazing that you have, the thickness of the walls, the insulating material, all that information is available on that single BIM platform.

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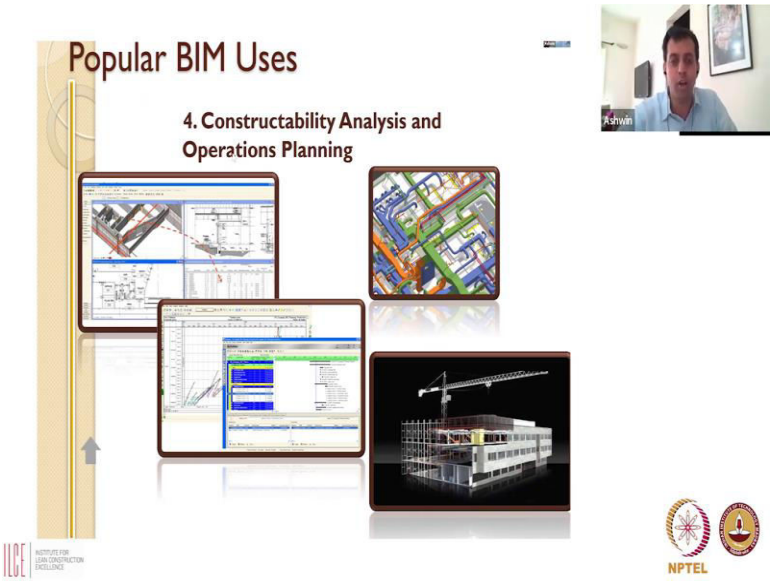

Moving on, once you start construction, constructability is very easy, important issue it pertains to how easily can you actually construct what you want to construct. This is not as easy as it sounds, because in some cases, you have a lot of very big machinery that you have to manoeuvre through a constraint side, you have a number of crews that are working simultaneously, and you will have to ensure that they are working in a manner in which, they are all able to work productively together. So, constructability and the planning of your construction operations becomes critical.

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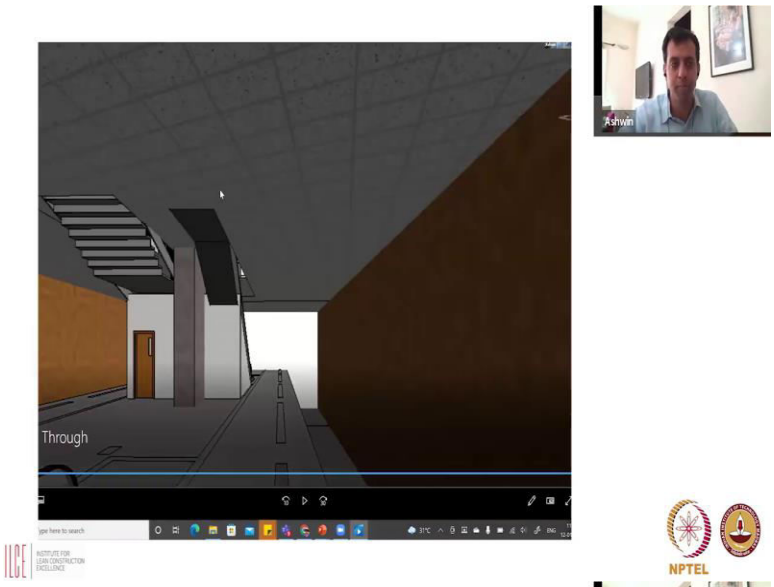

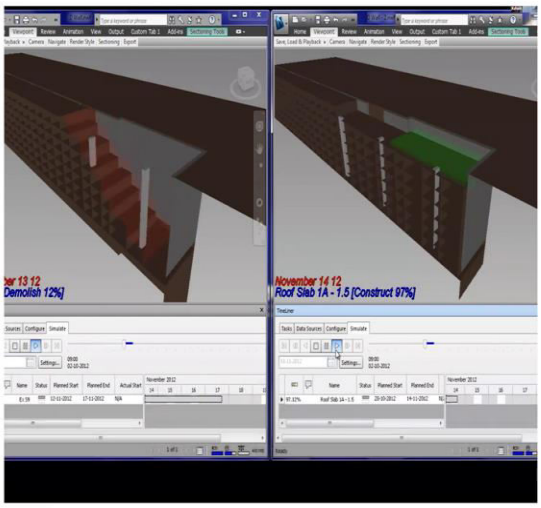
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Roof Slab 1A - 1.5 [Construct 97%]


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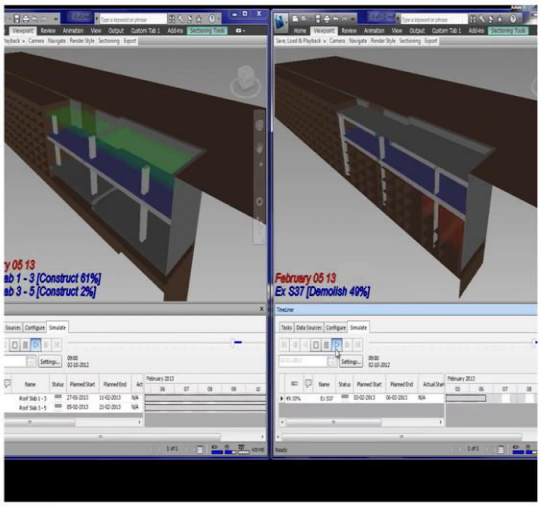
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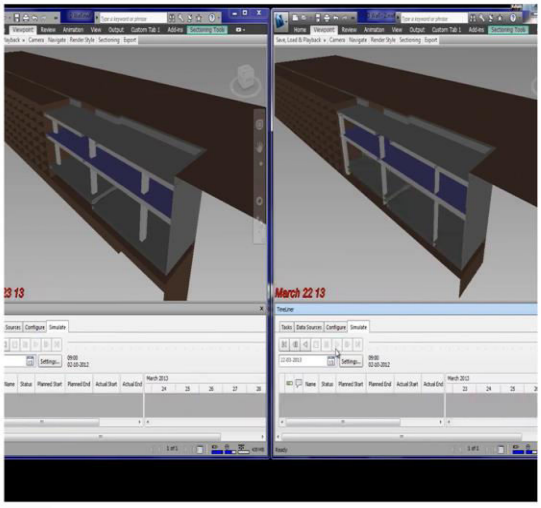
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Now, again, this can be simulated ahead of time, you can simulate various construction sequences, and based on that, you can pick out what you feel is an optimal construction sequence. And this is what we call 4D model. So, let me show you a very simple 4D model on the left, I have tried to simulate what is called bottoms up construction, a lot of excavation, and then thing come up bottom to top. And on the right, I have something called a top-down construction of a station, I build the top floor slab and then I start going two layers below.

Now, both of these are different construction sequences that I can simulate, how am I simulating this I am building something called a 4D model, where I take the 3D structure, but instead of showing it to you in one shot, I attach the structure with a scheduled. And I run a timeline and based on the schedule items show up when they are actually installed. So, it gives you the feel of actually seeing an animated construction sequence, Again, this takes barely a few minutes to do once you have a schedule and the model. And what you are able to do is understand and compare between various construction sequences. So, that is another use of building information.

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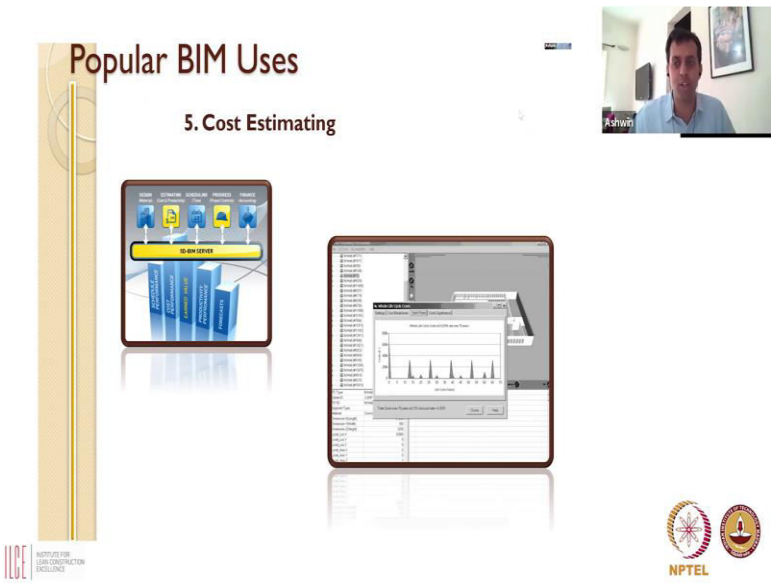

You can also, use building information modelling for cost estimating, you can, for instance, directly take out quantities from the building information model, you have a 3D model with all the information, how difficult it is going to be to figure out, how many columns you have, and what the dimensions are. And computers can generally do this without making the kinds of errors

that humans do. So, for quantity estimation, for cost estimation, you can directly get these out of the building integration module that you build.

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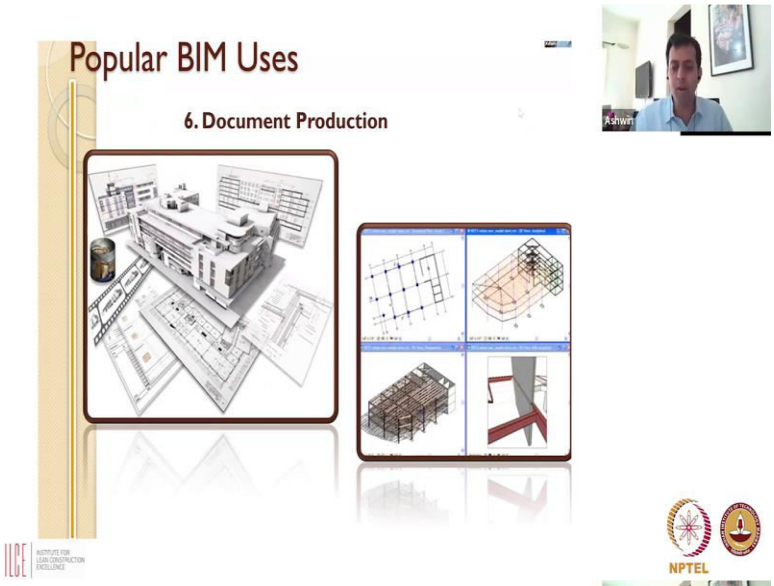

And if you need two dimensional drawings, because that is what works on site, you can always print out sections, take your 3D model cut a section, print out a 2D diagrams and give it to people on site or isometric views or whatever it is, you want. So, there are a number of these kinds of uses of Building Information Modelling on site, there are a few others, I am not going to go into these in very much detail.

But for instance, just too quickly mention earlier, when you wanted to fabricate something, you would actually send information to a fabricator, that person will put that information into their fabrication machine, it will fabricate something, then that component will be transported to your site. And sometimes there are errors in terms of what has been fabricated and what you are required.

Here, information goes directly from the building information model into the fabricators machine. So, what comes out has to be precisely what you had in your drawing. So, again, BIM can be used for fabrication. Safety, again being able to visualize your construction site, visualize operations, understanding where safety nets and harnesses might be required, understanding where and when edge protection might be required.

Again, a lot of safety based analysis can be done using building information model. So, the point here is that having an integrated 3D model that allows people to coordinate and put all their information together in one repository is likely to have considerable benefits in allowing you to coordinate better minimize errors and do things faster on site. So, building information modelling is very useful in that manner.

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S.No	Particulars	Metrics
1	Safety	Frequency rate and severity rate
2	Function / Performance	% satisfaction in post – occupancy – Evaluation
3	Cost variance	Variance w.r.t approved budget across portfolio
4	Schedule variance	Variance w.r.t approved schedules for design and construction across portfolio
5	Sustainability	Life time use of energy and water and materials and suitability of the facility to support changing client needs with minimum retrofit.
6	Globalization	% of components and services obtained globally at a cost cheaper than local cost.

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S.No	Metric	Definition	Target
1.	Detailed schedule conformance	% activities that started and completed within one day of look ahead schedule	≥ 80%
2.	Decision latency (Decision making promptness)	Time for decision making on key issues from the time all information are available.	≤ 2 days
3.	Response latency (promptness in responding)	Time for responding to RFI	≤ 2 days
4.	Detailed cost conformance	% of budgeted items cost within 2% of their budget cost.	≥ 95%
5.	Field generated RFI	RFIs for questions that could have been identified before construction.	≤ 1%
6.	Rework volume	Volume of work redone (labour hours %) because of unanticipated conditions	0%
7.	Field Materials Delivery	% of materials delivered within or less than 2 weeks ahead of scheduled use.	≥ 90%

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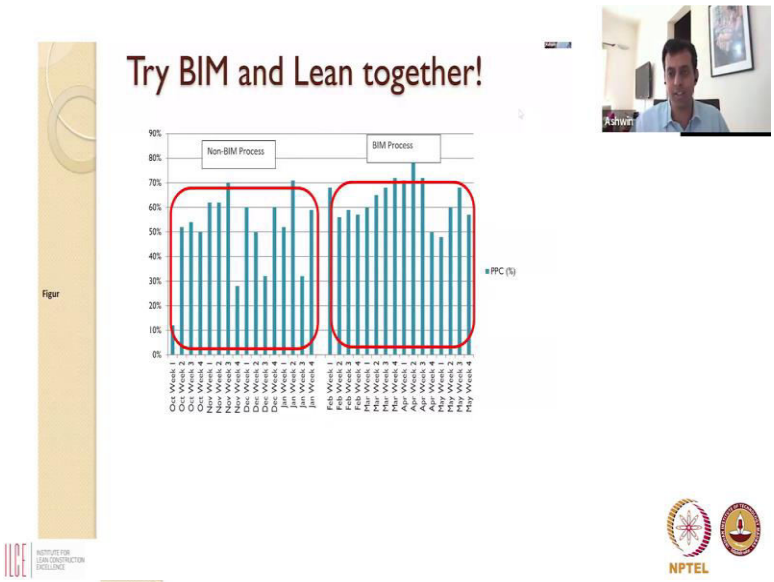

Now, a question that you might have is yes, this is all qualitative. Theoretically, it is useful practically is Building Information Modelling useful, can be measured. So, people at CIFE, Centre for Integrated Facilities Engineering at Stanford University some time ago, said yes, let us measure, let us measure, are there any quantitative improvements on safety, on cost, on schedule, on sustainability? Let us actually go ahead and measure.

And they looked at certain BIM implementations and through careful measurements actually found data like this. Let me not go through all of these but look at some at the bottom, look at the rework volume 0, there is no rework, because you have essentially done what is called Virtual Design and Construction. Ahead of time you have detected all your clashes, you have asked your

design doubts, people understand the optimal construction sequence absolutely no rework, when BIM was implemented on a project.

Field generated request for information come down by 99 percent because there are fewer questions that are answered in the field. Cost, conformance is very, very high and so, on and so, forth. So, quantitatively BIM does have benefits and if you are wondering are these benefits only in America their benefits in India, we have done studies in India as well and we also, get similar results.

So, there are lots of improvements that accrue due to BIM that also, lead to time savings and costs. So, BIM can certainly help improve the performance on your construction sets.