Introduction to Lean Construction
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Mechanisation/Robots, Visualization,
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We take mechanization and robotics. So, here are given a couple of examples again you go to the web and you look at what is construction robotics today, you will find a lot of companies are working on this. Because construction used to be unstructured it used to be a tough environment to bring robots into, but today the technology is advancing so rapidly and the requirements of construction are also advancing rapidly that robotics in construction is becoming economically feasible globally.

So, here is a bit of a difference from all the IT aspects we looked, one is definitely reduction of physical effort. We have superhuman capabilities, which can then things which are manually you just could not do. And this can improve your productivity, it can improve your safety performance, occupational health, workers not having to lift all of this gets improved significantly your all of these other aspects of which we are interested in Lean get have a positive impact.

Let us discuss variability, what is variability with respect to mechanization of robotics.

Student: It will reduce the Variability.

Professor: It will reduce because my processing time is based on the automated process and not a manual process.

Student: Plus it is more of a standardization.

Professor: More standardized exactly. So, all of these come into, So, basically enable more lean processes through the, in the in construction.

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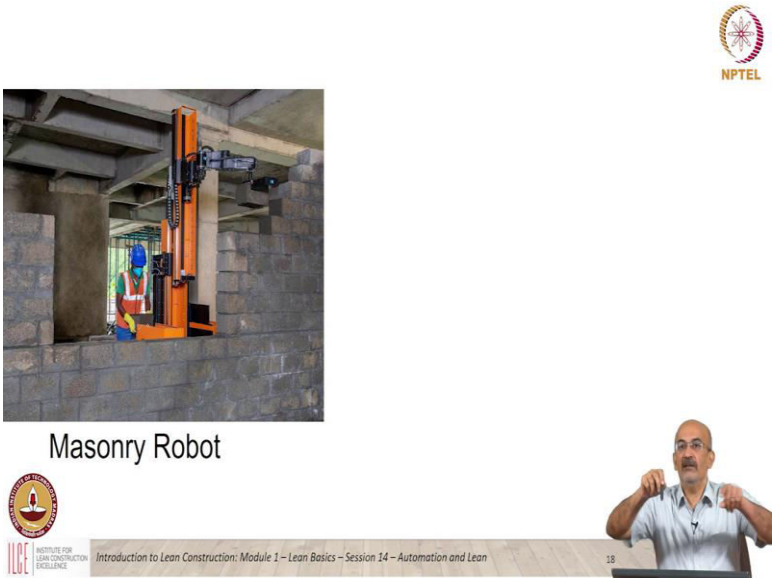

So, here is an example of a couple of automated pieces of equipment which we have we are aware of, one is a masonry robot you can see what this robot does this you need one person to place a break, you can actually go to this website and see how this robot works. It is in a build the references will be having supplementary material, but how do you think a robot like this can impact construction.

What it does is it places the blocks or worker just has to load the block onto its base, it will pick it, and place it at the right position with total accuracy and do the mortar layer in. So, one no need for scaffolding, no need for so, much of temporary works which are taken out is construction of temporary work value adding or non-value adding but necessary, non-value added but necessary.

So, all that is eliminated now, and the from a workers point of view, even if I use a larger block, the robot can lift it. So, strain on my body all of that is reduced. And if it can perform it with the same skill as a good mason and it is something that is productivity is there, the robot keeps track of how many bricks did I lay per shift? What it is, and if you have multiple robots like this across a site, it becomes a distributed kind of a team that is doing big laying across. So, a lot of things to discuss.

Here is another technology which is kind of in a stage where I know it is just taking off, 3D printing and if 3D print with concrete for example. So, here is a 3D printer developed with

IIT Madras and the first structure which we built. How does 3D printing effectively what happens,

Student: More quality, less variability.

Professor: More quality, less variability flow. So, we are looking at your whole for your building information model based design is translated into a product, there is no manual intervention. So, it is like what they say computer integrated manufacturing where you, you make a model of something and you a CNC machine actually produces it. Here, you make a big model of something, and your 3D printer actually builds it. That is where we would like to hit.

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Going into visualization, simulation gave me again a big area. So, you can see again, whether you are using hololens or you are using any other technology, the visualization you can be immersed in a construction site or immersed in a building before you actually even build it. The whole virtual prototyping part of it or you can have augmented reality where you are, you can see the person is holding up a tablet and visualize what is going to be there, on site?

So, virtual reality, I am immersed in something, and it is all virtual, augmented reality, I am augmenting what is there with, with the thing or going into mixed reality, which is both? So, again, you can visualize. And visualization brings in a lot of what do you say awareness of what I am actually going to get.

If, as a client, I visualize the building that the architect or the developers building for me, only when I am able to visualize and be immersed in it, I can make certain decisions. And understand what is there and give feedback. When I see it on a drawing, I had say but when it

is actually built, I changed my mind. And this is not only for the client, but also for the construction crew.

They have found that a crew which goes onto a daily huddle, and then visual, kind of not based on drawings, but based on an immersive environment plan, the work is much more productive than if I just go without that kind of data. So, the technology supports this. So, when you look at assessment of value alternative this is from the clients perspective, even from the contracting from the craftsmans perspective, because they might find a better way to construct it.

Student: Constructability will be improved

Professor: Constructability will be improved exactly. So, a lot of lot of benefits of just plain visualization, whether it is virtual, or augmented, is, the next level and taking it to higher levels.

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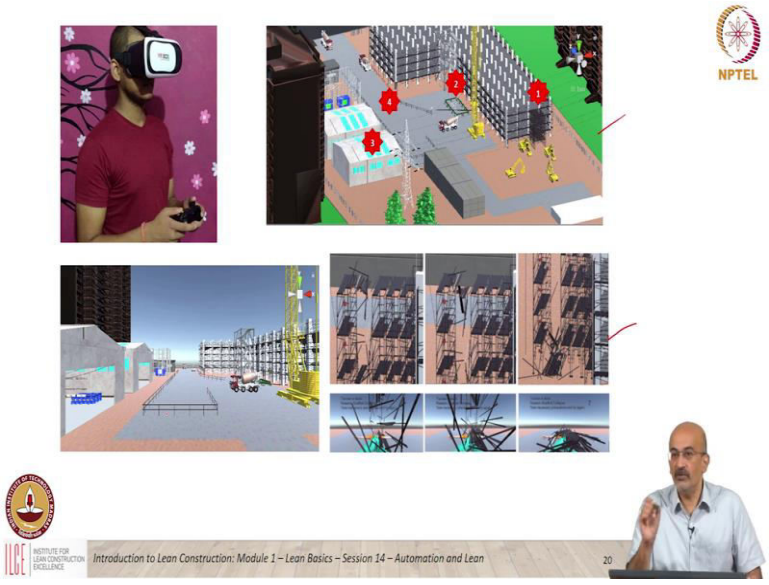

Now, here are some examples, So, this was some of the visualization and augmented reality, kind of applications we developed. And this was a gaming application for construction safety, where if the person did something wrong so, you here you can see, the worker who was gaming in our system did something wrong or the scaffold collapsed or you walk a site and you do not walk on the path, something happens at you. So, you can have gaming based training for using such platforms.

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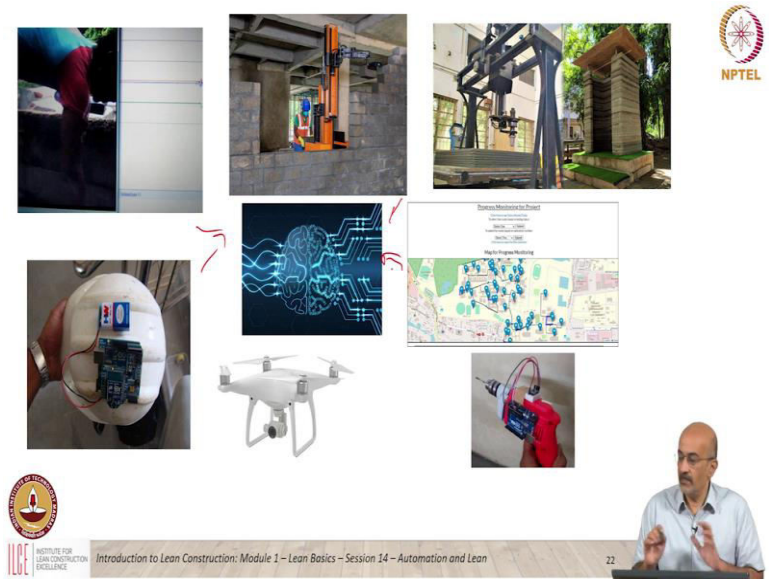

Now we come into AI and analytics, again, big area, lots of discussion going on. As we go into these areas, I am kind of seeing several impacts. And I put these question marks some of these impacts, we are not even, we do not even know yet this is such an evolving area, there is so, much that is going on in this whether it is all of these learning technologies or what are the analytics that is required.

But one thing is for sure, when with all of these technologies we discussed so, far. The AI brain is required to process the data, to be able to bring out the decisions, to be able to bring out appropriate decision support for the project management, I can get a lot of sensing data from these kinds of sensors, I can get my robot to do things I can get my GIS platform to do what is required, but ultimately, the processing and analytics are required. So, this is where the AI and associated technologies play a big role.

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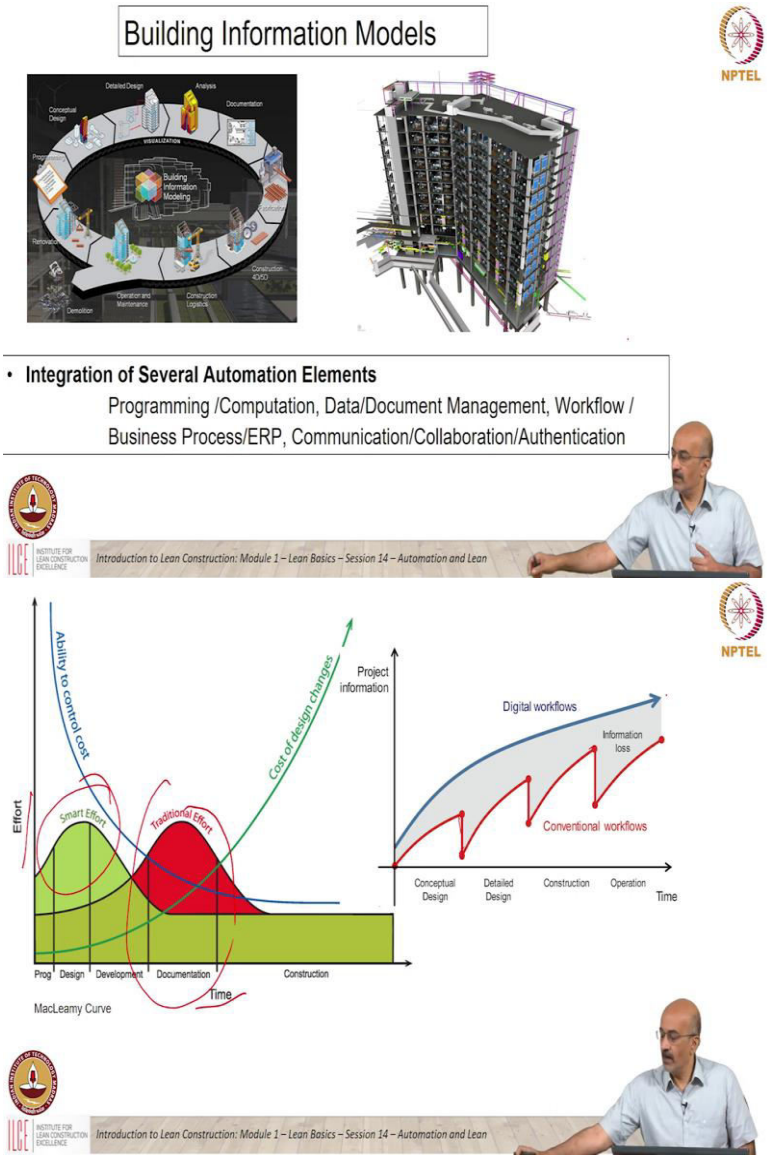

BIM is an area which many people are familiar with and like I said, I think I know my colleague, Ashwin Mahalingam has covered aspects of this. But again, this is a integration of several automation elements So, we look at, we look at the benefits of all of these, whether it is programming computation, data documentation will be felt by the organization that is implementing this, just a couple of points to make on BIM.

So, when we look at BIM, this is a very standard graph, I just wanted to emphasize it, when we look at the traditional effort, traditional method of construct, of doing a project you can see that this is effort, this is time, a lot of the effort is during the documentation and the construction phase. Whereas when we use a virtual model of BIM, a lot of the effort goes in the design and development phase. What does that mean?

Student: It actually reducing the time for…

Professor: We are reducing the time and any errors we are correcting, we are correcting it in the virtual model and not in the built model. So, the cost also reduced and the when you have to do a correction on the virtual model, it is much easier than in the, I mean within the real model. Similarly, here is another graphic which is very relevant to this. What this shows is the information.

And when we use traditional approaches and conventional workflows, you will find that between each phase there is an information loss. This could be a requirement for a printed document. But when you do a digital, digital workflow, the information can continuously improves that is the ideal place where there is no drop in information as information gets added it keeps continuing to grow so, this kind of summarizes where BIM has an impact.

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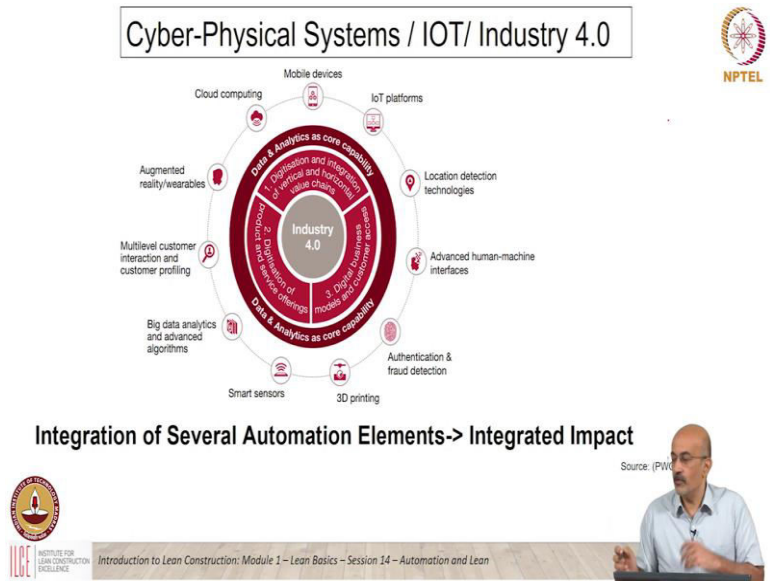

Now, when you go into cyber physical systems or industry 4.0 again, it is a portfolio of several technologies, a lot of these technologies have been shown here and many of these technologies we have discussed. And again, there is an integrated impact I am not getting into details, it is as an exercise you can look at these technologies and see if we actually start integrating these together, what is going to be the impact on construction.

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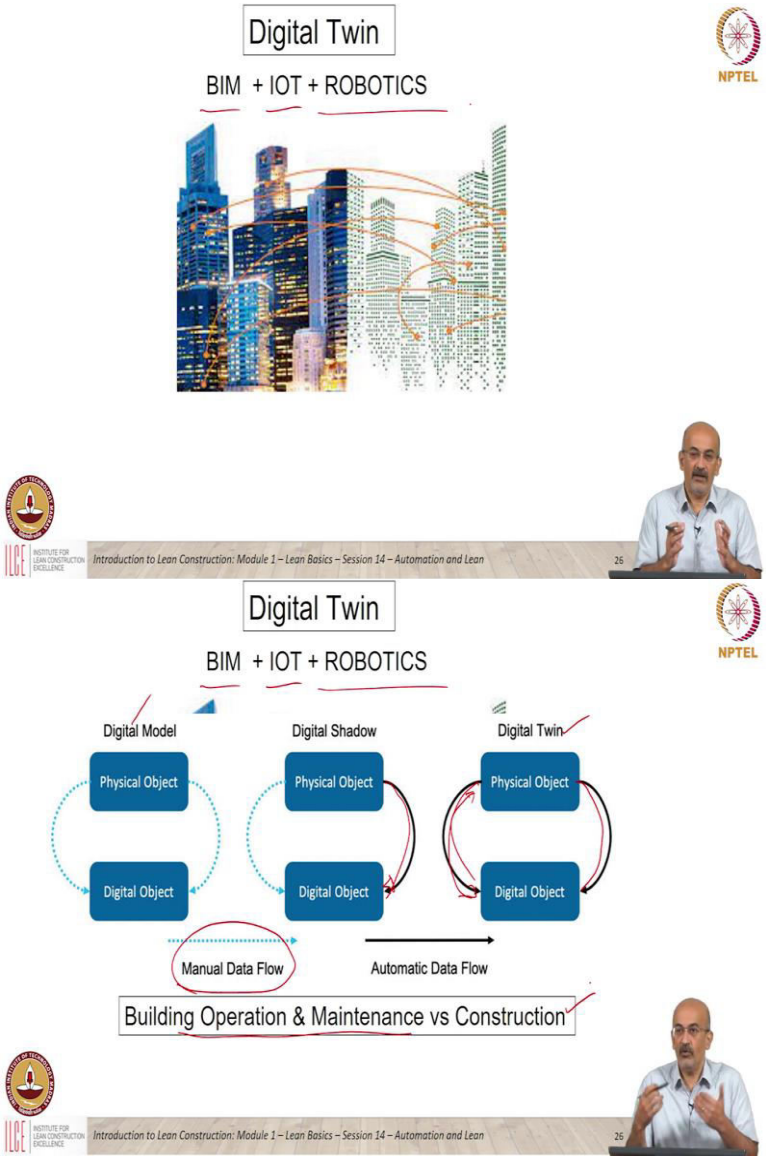

Now, we come finally to digital twin which is an emerging technology. So, here have kind of saying that digital twin is a BIM plus an IOT plus robotics. All what we talked about so, far integrating everything because that is the trend, and if we look at from a digital twin perspective, we always wonder what is a digital twin, how is it different from say a BIM model.

So, this is a definition that is kind of used, so digital twin, you have the physical object and the digital model and all the data flows manual between the physical and the digital. Now, when you have a digital shadow you have some amount of automatic data flow through sensing. When you have a digital twin you have a full all the data flow is digital through sensing.

And I would like to say also the reverse, if the digital twin finds that, makes a forecast and finds that some information needs to be changed, or some action needs to be taken, it should be able to communicate back to the robots on the physical object to be able to change something. So, when you look at digital twin today, it is a lot of it is used for building operation and maintenance.

We talk about structural health monitoring, we talk about many aspects of digital twin from a building operation and maintenance point of view. But we should also look at digital twin from construction. Because in Lean construction, what is happening is the geometry of the structure is changing, it is evolving. So, many groups are now starting to look at digital twins from a construction perspective, which is not as simple as it is when we look at for finishing.

So, this is an open area, I think there is a lot and obviously as it is an integration of all of these technologies, all the benefits potentially are there to gain when we look at it from a digital.

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Just to summarize, we looked at a lot of how automation can enhance lean practices. But does lean enhance automation? Is there a reverse? In what context is there a reverse?. Any discussion on this.

Student: Lean practices it also.

Professor: Lean reduces reworks. Yes.

Student: Lean the variability. So, whenever we have to give some input to the automation that part will be very simple or automated from the right.

Professor: So, that is one way to look at it. The other way is lean is still yeah, go ahead.

Student: Where this supposed to move forward different technologies or tools.

Professor: That is also a relevant point, I am also adding one point where Lean we remember is also about people and processes. So, if lean addresses the people side appropriately and the general process of automation is I can automate the process I have, but if my process is bad, I am automating a bad process. So, if Lean has made my reengineered my process to be appropriate and then I automate that then it facilitates.

I have used this as an example what do you see we discussed this. So, if you try to implement this on a small project, what people have found is a contracting strategies on projects like this and this or that we culverts are contracted to a different agency, the rail is a different agency. So, a lot of times when the rail is being laid, it comes to a culvert and stops.

The planning the culvert is not so, if I am relying on technologies like this, I can afford to have this equipment idle or I have to go past that culvert and then lay the remaining part. Whereas the technology like this, I need continuous work phase of kilometres a day to be able for this to be effective. Now where do I have to change the process to make sure that my culverts are constructed when the rail is before the rail is being laid

Student: So, integrate collaboration.

Professor: Correct. So, that is not necessarily, I mean that is not necessarily something that can be automated any you had to go back to your process, you have to go back to the macro level policies and be able to change that look at the people side of it change it and then your automation work. So, while we have discussed this, there is also a very strong link from how lean practices also enable automation and this cycle is required for the overall efficiency of the project as well as industry to improve.

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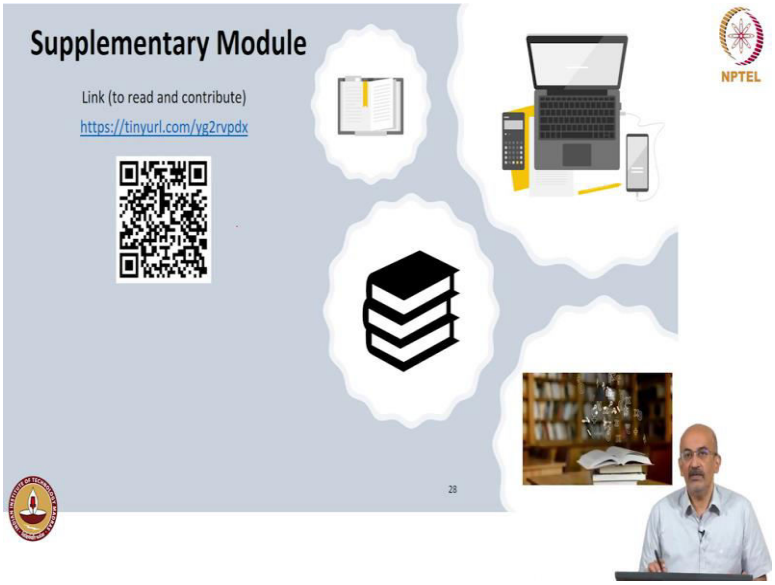

So, again, let me refer you to the supplementary module where you will find a lot more information on some other cases we developed and each of these topics which we had covered. Thank you.