Safety in Construction
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Lecture-27
BIM for Safety
A Case Study on Construction Safety

Hello everyone, my name is Priyanka Prashar; I am a research scholar working in the area of building information modelling for safety. In today's class, I will be sharing some of my knowledge in this area. This class will focus on what is BIM and what are its application on construction safety?

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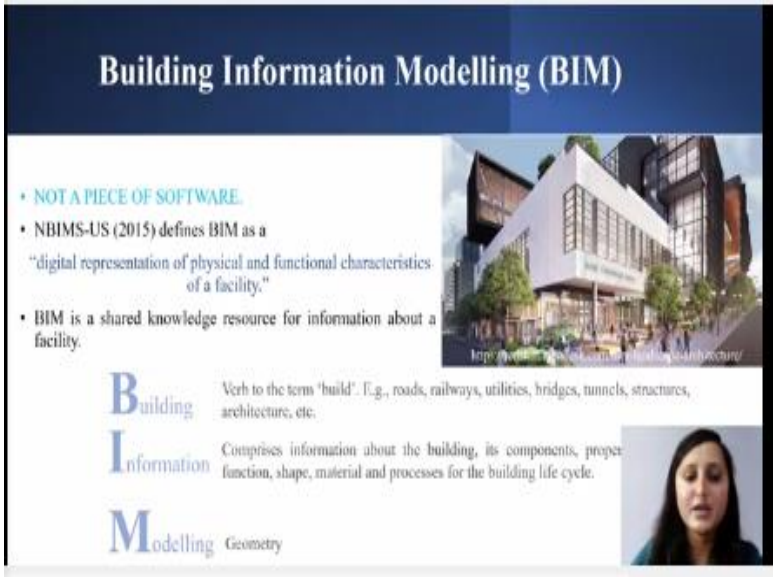

Let us start with what is building information modelling; it is commonly referred to as BIM. The first and important thing to understand is that BIM is not a software, many people get confused and think that there is a software. There are numerous definitions available for BIM; the national BIM standard defines it as a digital representation of physical and functional characteristics of a facility as it shown in the picture.

BIM is a shared knowledge resource for information about a facility which can be utilized for making decisions. Join the project lifecycle that is from the construction of a project to

demolition. Now let us try to break down the term and understand it is meaning. BIM constitutes of three words, building, information and modelling. The first word is building; it does not refer only to buildings, but all the sectors which are associated with construction.

For example, with roads, bridges, tunnels, etcetera, it is a verb to the term build. The second word is information, we can say it is the heart of BIM as the real value of BIM lies in information. It comprises information about the building, it is component, properties such as function, shape, material, and processes for the building life cycle. The third word is modelling; it refers to as the geometry of the building.

BIM uses various softwares for the modelling part, for example Revit, ArchiCAD, SketchUp, Navisworks, Civil 3D Tecla and many more.

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In the construction industry, numerous problems and errors occur because there are certain flaws in the design. There are difficulties in communication of information and coordination among the participants of a project. We can say there is a separation in the design phase and the construction phase. Apart from these problems, there are several other problems that exist in the construction industry. A lot of such kind of problems can be solved if design information is communicated effectively.

This is where BIM comes in. As we see in the current scenario, the architecture, engineering and construction projects are becoming more and more complex, because of the global trends and advancement and the technology. Since technology is also advancing, it is helping the industry professionals to work efficiently and effectively. Example of such advancing technology is this; it can play a vital role here.

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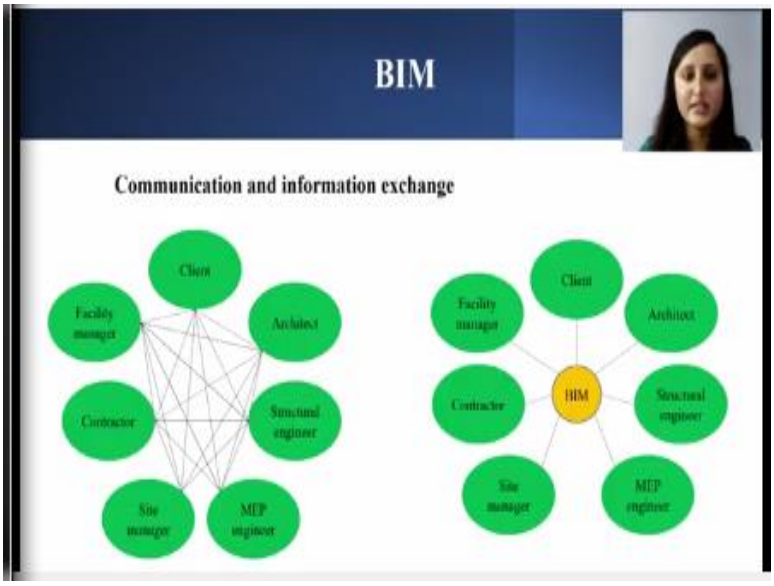

In the last slide, we discussed that the communication of information plays a very important role to overcome certain issues. In the left figure, we can see that it shows a traditional process of communication and information exchange among the stakeholders of a project. There are various stakeholders in a particular project such as architects, structural engineers, MEP engineer, site manager and many more other stakeholders.

So, it is easily understood by this picture that the information exchange is very confusing and chaotic. Whereas in the right-hand side, the picture shows the communication with the help of BIM and it looks quite easy to understand. In such case BIM model serves as a database, their information from all the stakeholders can be put in and can access the information provided by other stakeholders. So, this is the good way or the effective way to communicate and exchange the information.

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If we talk about the design process, it has evolved with time. Initially, the design process was carried out by hand drafting, it was an extremely time-consuming process. If changes were to be made in the drawing in any of the components, then it required a lot of reworks to meet the changes. It means that the chances for errors and omissions were pretty high, with the advent of CAD a shift was made from hand drafting to CAD.

With CAD, the industry professionals started drawing on computers and do their drawings on the monitor. Although CAD replaced the hand drafting, but it did not change the way in which information was displayed in a significant manner. Or just like in case of hand drafting, there used to be numerous drawn documents for a single structure. For the CAD drawing also, the same situation was there.

But CAD had an advantage over this, that it was less time consuming and also errors and omissions for lesser. Till this date, many professionals are still using CAD drawings with the digital transformation BIM has not come up in the industry. And owing to it is numerous advantages; it has becoming the future of AEC industry. Unlike hand drafting and CAD drawing, there is a single model for a single structure.

And all the related information is linked into a single model. In BIM, a model of a building is completely built in a virtual environment before the construction starts. This process is very

much time saving and far less expensive to make changes prior than in the site during the construction.

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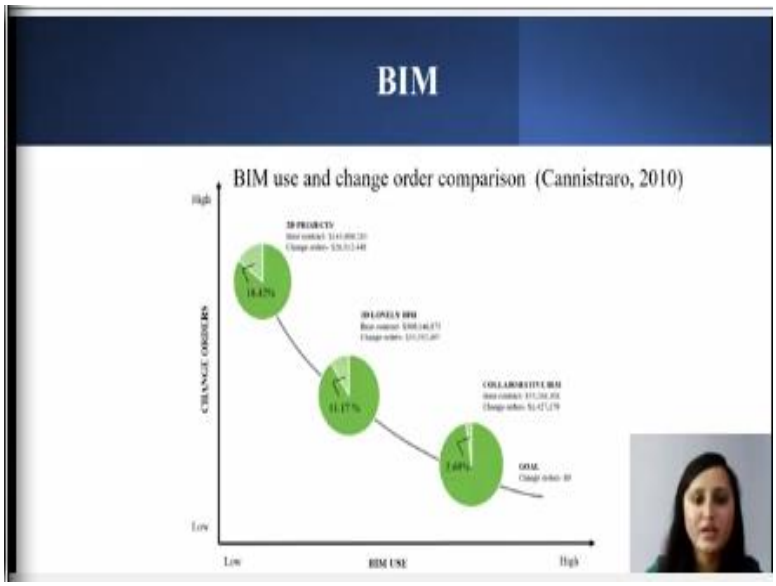

As BIM using in cost savings to quantify this or researcher examine around 400 projects, which were completed between the time duration of 2003 to 2009, with a project value of about 550 million dollars. And he separated those projects into 3 categories, namely towards projects where BIM is not used and the traditional 2D drawings are used. Second one (06:49) was lonely projects where BIM was used, but in a silo approach.

Every stakeholder work on their own using them. The third one was collaborative projects, where BIM was used and it involved multiple parties of the stakeholders in collaboration with each other. He found that as the project team collaborated, the cost saving became increasingly more significant as is shown in the picture. Hence, we can say that collaboration among the project participants play a vital role for using BIM.

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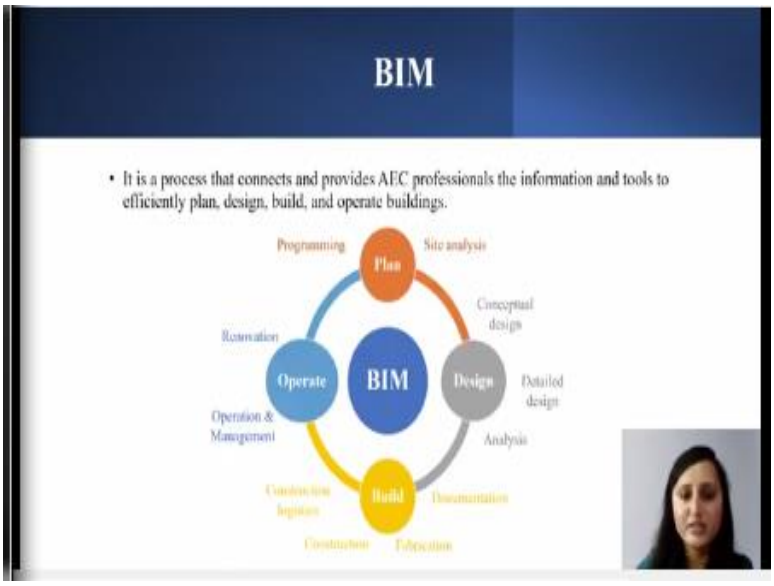

BIM is the process that connects and provides the AEC professionals with the information and tools to efficiently plan, design, build and operate buildings. So, we can say that BIM is more than just designing, it is not limited to just use in the design phase. But can be used in the entire lifecycle of the project as shown in the figure. That is, we can use it in the planning phase, designing phase, building phase, operating phase, and even the control this renovation and demolition phase.

BIM can do the budget analysis, manage the material inventory, perform scheduling update, clash detection and much more.

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Till now we are understood what is BIM. But there is a question why to use BIM? Construction professionals are using 2D drawings to deliver the project and they are comfortable doing so. So, why to shift from 2D to 3D? Here in the slide, there are three pictures out of which one shows a 2D drawing and other two shows 3D models. On visualizing all these pictures, we can see that the 3D model provides better rather effective visualization of the final product before the construction has even started.

In 2D drawings, there are different drawings for a single model. For example, architectural drawings are in a different document. Similarly, the structural drawings are different; MEP drawings are different and etcetera. Whereas, in case of BIM within a single model we can integrate all these aspects together in a single model. Other than this, we can integrate time, cost, we can do the energy analysis of the building and also do the safety management.

There is a better communication among stakeholders in case of BIM. Everybody can see the BIM model, so everybody knows what is happening in the project. Whereas, in case of 2D drawings, everybody works on their own, so the communication is not that effective and the chances of rework are more than in the 3D model.

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Now comes the difference between the traditional versus the BIM safety management. As they have already started in the previous lecture that safety planning is an integral part of construction

planning process. It involves the identification of all potential hazards and accordingly decide the safety measures. If safety planning is an effectively and efficiently it leads to the prevention of accidents.

Traditionally, safety planning is relying on manual observation and experience of the safety planner to detect the potential hazards. Such planning requires manual effort is time consuming and also considered error prone. Traditional safety planning is based on 2D drawings and should use to understand the need for safety equipment on a construction site. It is very difficult to identify potential hazards because 2D drawings are static.

Then on the other side helps the constructors to visualize site condition, recognize hazards and eliminate or reduce them before the construction start.

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Now comes for BIM for safety, it is desirable to have a technology which may have been analyzing and communicating safety related issues. In the recent years, due to the growing application of BIM in construction industry. Researchers as well as industry professionals have started using BIM to enhance construction safety. As BIM shows a visual representation of a facility, a BIM model allows the constructors to visually assess jobsite condition and recognize hazards.

This visual model allows the construction team to assess site condition and identify unsafe areas that might otherwise remain unnoticed until the construction team is on site. BIM can improve safety by identifying potential hazards in a virtual environment before the construction start. It not only identifies the hazards, but also helps to analyze why it happened? The potential hazards can be exposed floor penetrations, unprotected edges exposure to equipment etcetera.

In this way BIM connects the safety related issues more closely to the construction planning process. BIM provides the methods to manage and visualize up to date plans and provide site information. BIM supports communication in various situations, such as informing site personnel to make arrangements in response to a particular risk or to provide warning against that risk. Despite all the technological advancements in construction, we cannot say that any digital tool can guarantee an accident-free workplace and BIM is no exception to this nonetheless but health.

According to a study 37% of owners and contractors reported more than 5% decrease in reportable incidents due to BIM. With the help of BIM as the rate of workplace fatalities are decreasing, BIM remains one of the most powerful tools to improve safety on construction sites.

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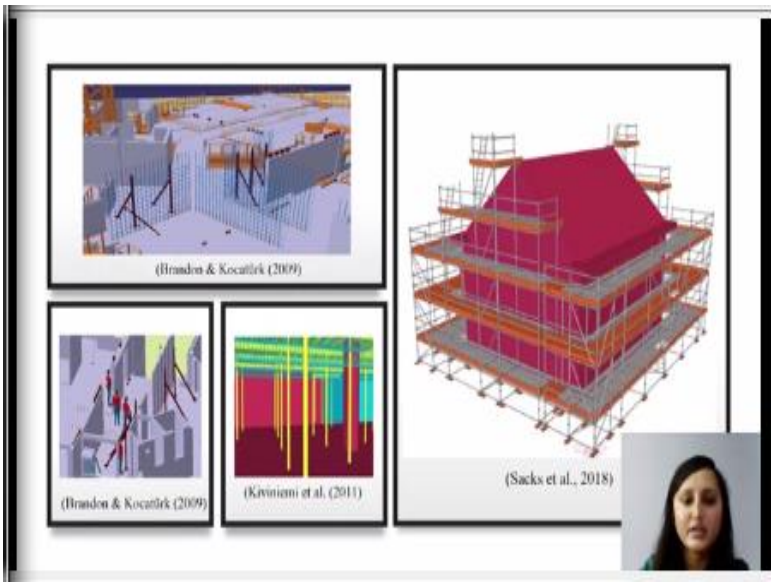

Here are few pictures to show how we can visualize the site conditions using BIM. The fourth picture shows the reinforcement fixing process. The other picture shows the movement of workers on site. The other one shows safety nets for concrete casting formwork. And the last

picture shows a model which is presenting scaffolds on a building. Like this, we can create different scenarios and visualize them in a virtual environment and plan for safety accordingly.

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Now come, how can we improve safety in construction? For this, I have divided it into five categories, namely safety planning, safety training and education, prefabrication, design for safety and automatic safety checking. In the further slides we will be discussing them one by one.

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Now let us start with safety planning. How can BIM help in safety planning? So far, we have discussed that BIM based safety planning is useful in identifying hazards and communicate the

safety plans to workers. 3D BIM modelling helps in identifying and correcting errors that may lead to hazards at the end of pre-construction phase. But the site conditions at the construction site keep on changing therefore 3D modelling may not be that helpful.

In such a case 4D BIM help, 4D BIM means we integrate the schedule data into 3D models, so that the safety is planned and monitored as the construction work progresses. 4D BIM is important for safety planning, as it enables the visualization of safety arrangements at different times and provides more illustrated safety plans. 4D BIM model can be utilized in the design phase as well as the construction phase to detect workplace conflict.

4D model is used is generated in the design phase, and it can be used in safety planning for the site. A construction project has numerous tasks, and each task has it is own risks associated, BIM can focus on each individual task. So, that it becomes easier to identify the risks, arrange for safety measures and complete the tasks efficiently and safely. During the construction stage, safety managers can access the BIM module and help in inspections and validate that safety provisions are being met a lot.

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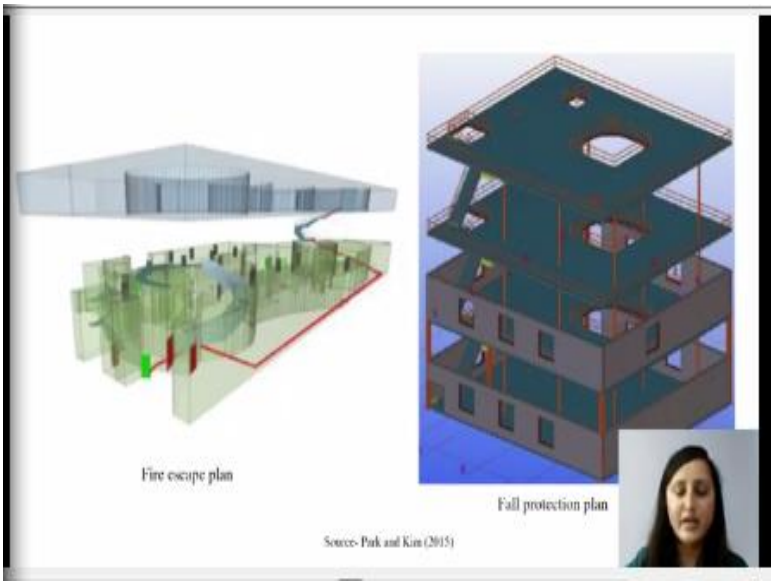

Here are the pictures to show the safety plans in a BIM model. The first picture shows the simulation of fire escape, these red markings show the fire escape plan. The second picture shows a model of fall protection system, it shows the protection plan of edges and the floor

penetration. Using 4D modelling, this fall protection can be installed whenever it is required and removed when they are not required. Such modelling can help in planning for safety prior to the construction. And similar to these scenarios, we can model for different scenarios to plan for safety.

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Now, let us discuss how BIM can help in safety training and education. Any tool that supports safety training and education and reveals the unsafe condition is of a great value to the construction team. BIM has shown its capabilities to provide training for workers off site by increasing their awareness about the hazards by visualization of various facilities such as scaffolding, gadgets, etc.

The ability to understand the abstract concept can be enhanced with the help of visualization. Visualization or the animation is an effective method for understanding the safety related issue. This is important especially for the new workers at site who are unaware of the site safety measures. With the help of BIM such new workers can understand the construction processes in a better way.

Another thing is the language barrier, at construction sites there are many migrant workers present who come from different places with different languages. They may or may not understand the language of the place that they are working. In such case providing safety training

is difficult, but BIM helps in overcoming this language barrier. As visualization can help them understand all the related issues and processes.

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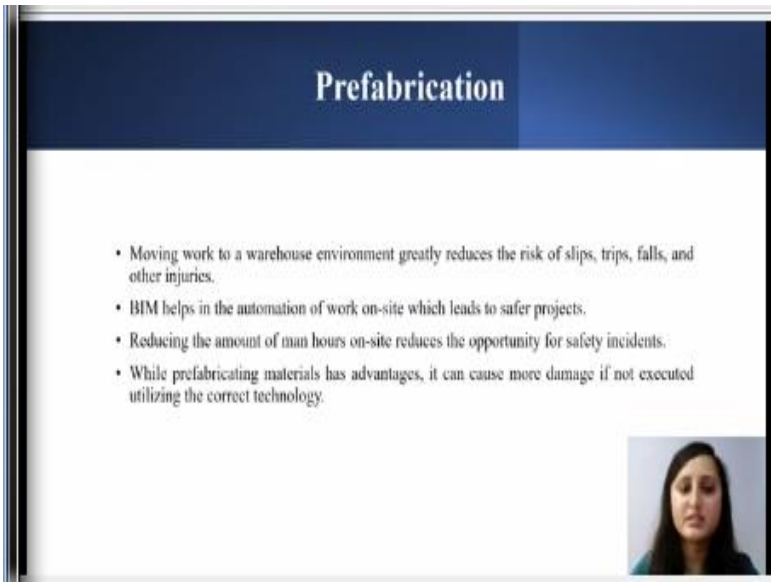

Now, let us discuss prefabrication, when we move our work to a warehouse environment, it greatly reduces the risk of hazards such as slips, trips, falls and other injuries. BIM and prefabrication have led to many favourable scenarios that help in reducing the risk. BIM helps in automating the work on site, which leads to safer projects. We can simply say that reducing the number of manhours on site reduces the chances of incidents happening on site.

A construction company claim at BIM enable prefabrication has allowed them to eliminate thousands of trips, climbing up the ladders and lifts and also to eliminate thousands of hours of hard work and general construction activities in various situations. By prefabrication seems a perfect solution, but it can cause more damage than good if not utilized in a correct manner.

This is where BIM helps, BIM helps in designing the prefabricated material effectively. The problem of the risk that whether the parts of prefabricated material will fit together on site or not, this risk is resolved by BIM. As the BIM model is highly detailed and consists of each and every bit of information.

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Next is design for safety or the prevention to design. You have already discussed about DfS earlier in the previous lecture. So, we know by this time that design for safety is the process that engineers and architects consider safety during the design phase. The potential hazards and risks are designed out in the design phase itself. Researchers have established that there exists a relationship between design and accidents.

Usually, the accident occurs during the construction phase and improper safety planning is the major contributing factor behind the occurrence of accidents. Many researchers have focused on design and planning stage of the project, which shows the efficacy of BIM in preventing the accident through design. BIM helps in providing safety suggestions to the designers, engineers and constructors.

Then the information is acquired order in the project lifecycle with allows the team to get aware about the issues and address them at all your stages. As seen in the picture, safety suggestions are made available using this. So, there is a staircase component which has been highlighted. And there is an issue regarding the flaw in the design which is made available that there is no parapet (21:32) in the staircase. Similarly, we can identify the issues as design flaws using the BIM modelling.

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Last but not the least is automatic safety checking. It is also referred to as automated rule based checking or automated code compliance checking. As term indicates, we can understand that it has something to do with the rules or the codes. In simple terms, we can say that it is the process to automate and check against the set of rules. It is defined as the computational procedure for addressing the manual regulation, verification problem in a finite number of computed steps.

It means that the safety rules and regulations which we have in a human readable format, those are converted into a computer readable format. It is a piece of software which does not modify a building design, but it evaluates that building design whether it is following the set rules or not. It assists the user to define and apply rules into the model and get the report in written. The results generated are in the form of path if the rules are conformed to say for me at unknown if certain set of constraints are missing.

BIM allows an environment where these codes and regulations can be verified automatically through software application, which otherwise is done manually.

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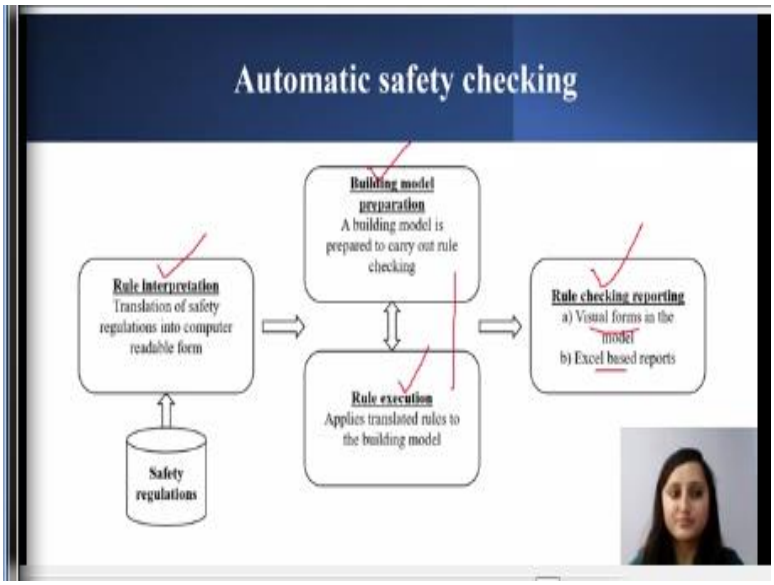

There are four components of automatic safety checking, the first one is a rule interpretation, which involves the translation of human readable set of safety regulations into the computer readable form. The second one is building model preparation, which involves building of a model wherein we have to execute the rules, the converted rules, the third one is rule execution, there we have to apply the translated rules into the building model.

And the fourth one is rule checking reporting where they get our report or the results. And there are two forms in which we can get our result. One is so visual form in the model or in the base, or the Excel based reports.

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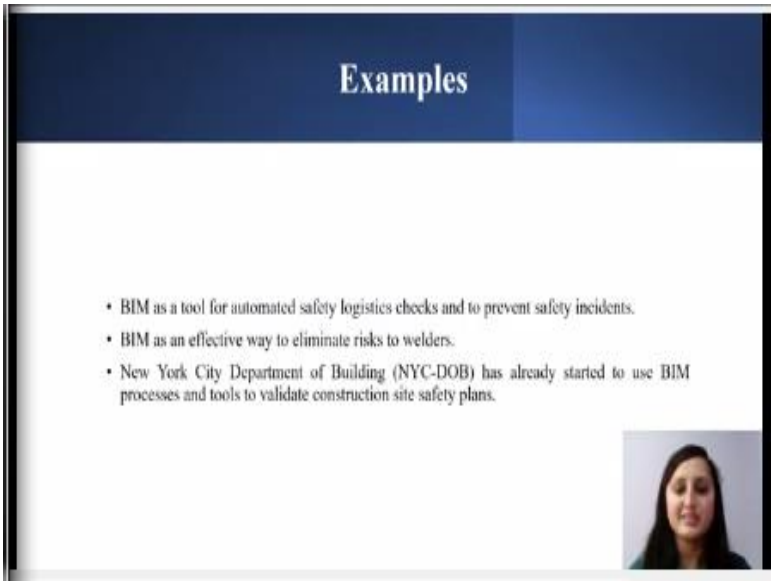

That was all about how BIM helps to enhance safety in construction sites. Now, let us move on to some examples, BIM has been used by different construction companies to enhance safety within their organization, some of them are listed here. One organization use BIM as a tool for automated logistics and prevent safety incidents. They used 3D BIM modelling to run through all construction and installation details before the construction team goes to the site.

Another organization found BIM to be an effective way to eliminate risk to vendor. They used BIM to detail concrete and steel, so that they could cast, embed and attach BIM 4 levels up. In such a way that the workers need not go up an elevator shaft and build it. Though New York city department of building has started to use BIM processes and tools to validate construction sites safety plans.

The submission processes of the safety plans, commendation and review is now fully digitalized on BIM base. Like this, there are several construction companies who have been using BIM to enhance safety.

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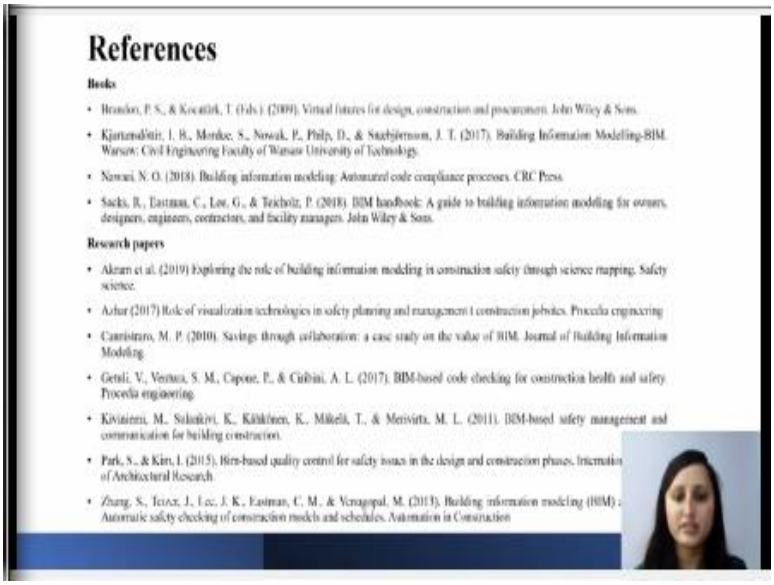

These are the references which I have been used to prepare the content for this presentation. I have used few books, some research papers.

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And some internet resources. Thank you.