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Building Information Modeling (BIM)

NEW ERA IN INDIAN SENARIO

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Abstract *— Building Information Modeling (BIM) is an emerging technology in Architecture, Engineering, and Construction (AEC) industry. BIM is a computable representation of building and its related information, which provides a virtual view of the objects in the building with physical geometry (2D or 3D) and other functional parameters. Compared to parametric models in CAD, the object-based parametric models in BIM represent the objects by both physical and functional parameters. Diverse BIM tools such as Autodesk Revit Architecture, ArchiCAD, and Bentley Architecture have been widely adopted within AEC industry in design/modeling, construction energy analysis, and clash detection, construction scheduling and cost estimating.*

Keywords*- BIM, 3D Modelling, 2D Drawing, cost estimation, resources allocation, construction scheduling*

I. INTRODUCTION

BIM stands for-
B = building.
I = information shared to generate feedback and for decision making.
M = geometry (modeling).
Building Information Modeling (BIM) is a set of interacting policies, processes and technologies generating a "methodology to manage the essential building design and project data in digital format throughout the building's life-cycle". As a key part in the project lifecycle, contractors play an important role in making sure the project will be delivered on time and within the budget. This project will show how BIM technology will benefit for Architect, Engineer and contractors for Estimating & schedule and cost controls. It begins with a general introduction of BIM technology and the different ways it works compared with traditional CAD (Computer Aided Design) method, and continues with evaluation of BIM tools. It then explains the uses of Scheduling and Cost Estimating in BIM respectively and provides a case study to show how BIM can work for Architect. Engineer and contractor.
Building Information Modeling (BIM) is an emerging technology throughout the world in the Architecture, Engineering, and Construction (AEC) industries. BIM technology provides users with accurate and consistent building/project data and information, accommodating the functions needed to model the building and provides a virtual view of it. Building information models are increasingly used, for several purposes by the diverse stakeholders during the different phases of the project and building lifecycle Fig. 1.

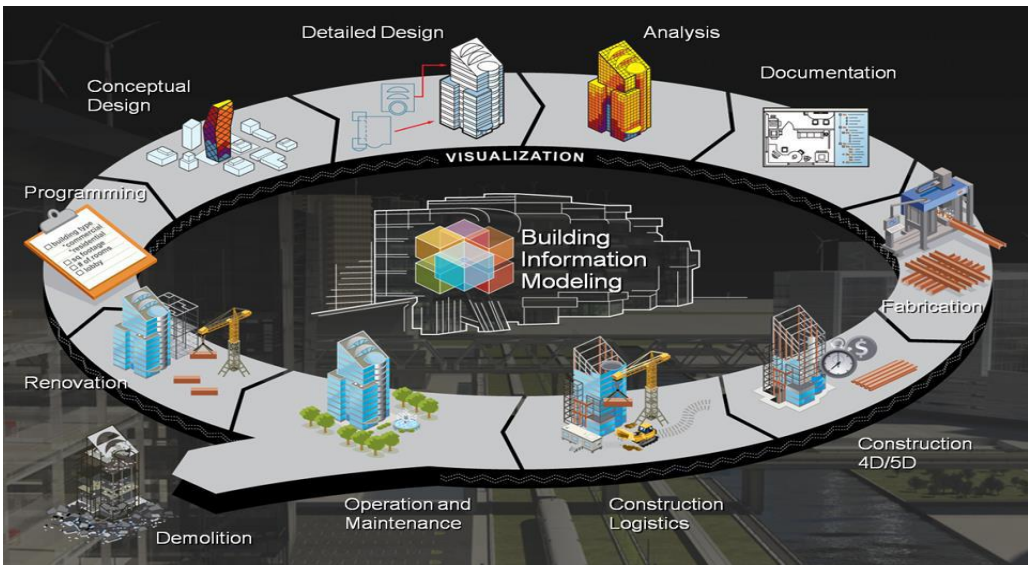

Fig.1 Phases of project and building lifecycle

BIM revolutionize the AEC industry, being not only a change between CAD and parametric modeling with 3D capabilities, but a change of workflows, methodologies, process, and relations. Basically it changes the way business is done throughout the industry. Although all of these changes may seem too much to be easily accepted by the industry, the benefits are much greater, making BIM the future for the industry. According to the 2012 McGraw Hill construction report "The Business Value of BIM in North America", since 2008, industry wide BIM adoption as grown 43%. In 2012 71% of American architects, engineers, contractors and owners had already become engaged with BIM. Although BIM adoption by contractors as shown a significant growth (Fig. 2), it reflects the increasing number of contractors that are engaging BIM in the preparation and monitoring of the construction activities, schedule and budget tracking, 4D and 5D BIM, virtual construction, and office activities.

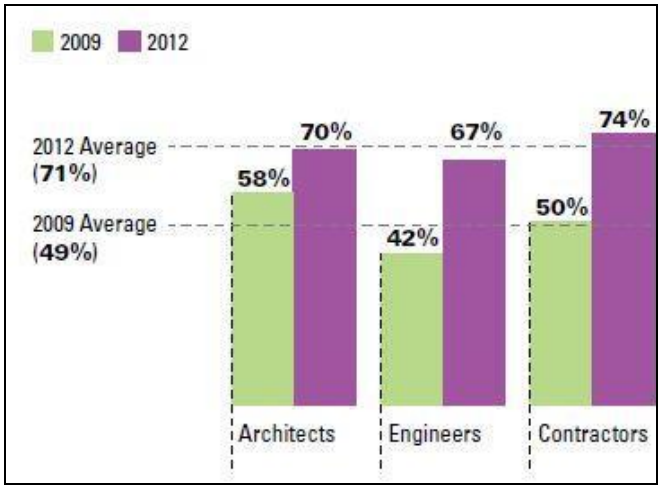

Fig.2 Adoption of BIM

Nowadays, Construction and BIM technologies are built for the trailer and the office. To improve productivity and efficiency in construction, these technologies need to be built it for the field, where the work is done and money is spent. According to the Construction Industry Institute 75% of all construction dollars are spent in the field, however, 90 % of the technology is made for the trailer and the office. This is one of the reasons for the low level of productivity associated to the AEC industry, where 25% of all construction dollars spent in the field are wasted, consequently there is the need to take BIM to the field. With field software like BIM 360 Field contractors now can start to change this reality and improve the productivity of the AEC Industry.

II. CONCEPT

As one of the most promising developments in the AEC industries and yet with no single, widely-accepted definition, the acronym BIM is used to describe the building information model, referred in this work as "BIM" - which is, a project simulation consisting of the 3D models of the project components with links to all the required information connected with the project's planning, construction or operation and decommissioning – and the Building Information Modeling "BIM" methodologies and processes – the management of information and the complex relationships between the social and technical resources that represent the complexity, collaboration, and interrelationships of today's organizations and environment, the focus is on managing projects to get the right information to the right place at the right time. Due to the embedded complexity and different possibilities of use there are a lot of misconceptions about BIM, and so it is critical to firstly understand what BIM is not, in order to erase misconceptions and to be able to understand its concept. In this section the role and use of Building Information Modeling from the Construction Management point of view. First BIM is reviewed and defined. The uses of Building Information Model, and the Building Information Model software and integrators are also discussed mainly from construction manager perspective.

III. AIM OF BIM TECHNOLOGY

- Reduction of Errors.
- Design visualization.
- Feasibility check.
- Clash Check.
- Quantity Take Off.
- Constructability.
- 1 Click Cost Estimating.
- 1 Click drawing generation
- Asset/Equipment Inventory.
- Facility Operations.
- Space assignment.
- Maintenance/Repair.
- Emergency response, etc.

IV. OBJECTIVES

Primarily, through the literature review, is intended to give a better understanding about BIM, its concept, capabilities, uses, benefits, risks, and difficulties, focusing in the construction sector, correcting at the same time some misconceptions associated to BIM.

Likewise, is the objective of this work, to present the potential gains and advantages of taking BIM to the field, through an empirical study of Autodesk's BIM platform, BIM 360 Field and their latent benefits? Intending a better understanding and comprehension of what engaging BIM implies and represents, by construction management

companies, is objective of this Master Thesis to provide a better knowledge, recommendations and guidelines into the path of adoption and implementing BIM.

The construction industry has experienced a gradual decrease in its labour productivity since the early 1960s. In the meantime, the non-farm industries such as the manufacturing industry have increased their labour productivity. The reduction of labour productivity in the construction industry requires more labour hours per contract dollar amount. This indicates that construction industry is lacking the development for labour saving ideas.

V. LITERATURE REVIEW

Ralph Grabowski studied that some 40 years after the introduction of 2D computer-aided drafting, programs like AutoCAD and IntelliCAD that mimic the hand drafting process are still popular. This is surprising, given that 3D modeling software programs, like Revit and ArchiCAD, are nearly as old, and yet have the added advantage that they simulate the real world. True, it is easier to start drawing right away with a 2D design program, but it is puzzling that many architectural and engineering firms still prefer to represent walls and floors with four lines, rather than model them as a 3D walls and floors, complete with structural information.

Christoph mershbrock at el studied that research on building information modeling in construction, with the aim of identifying areas in which domain where IS research can contribute. The concept of BIM comprises an infrastructure of IT tools supporting collaborative and integrated design, assembly and operation of buildings. This integrated construction approach, with all stakeholders editing or retrieving information from commonly shared models, requires major changes to well established processes, organizational roles, contractual practices and collaborative arrangements in the construction industry. Considering that a well-established knowledge based in IS research can be drawn upon for studying these issues, combine with the existing potential of BIM for transforming a major industry such as building construction, we conclude that BIM is an area ripe for IS research.

Kam-din Wong at el studied that because of global environmental concerns, sustainable design has become a main stream building design goal in recent years. Sustainable development is even more urgent in light of global climate change. This ends to examine the contributions which BIM can make to the production of sustainable building designs.

VI. WHAT IS BIM

As so what is BIM? As previously said there is no single widely-accepted definition of BIM, as can be seen in the definitions given by five different parts involved with BIM. the American National Institute of Building Sciences defines it as "A computable representation of the physical and functional characteristics of a facility and its related project/life-cycle information using open industry standards to inform business decision making for realizing better value", the American Institute of Architects says it is "Information use, reuse, and exchange with integrated 3D-2D model-based technology, of which electronic documents are just a single component (AEC Info systems)". While the software developers like ArchiCAD, Bentley and Autodesk describe it as "A single repository including both graphical documents - drawings - and non-graphical documents - specification, schedules, and other data" (ArchiCAD); "A modeling of both graphical and non-graphical aspect of the entire Building Life cycle in a federated database management system"(Bentley); or even "A building design and documentation methodology characterized by the creation and use of coordinated, internally consistent computable information about a building project in design and construction" (Autodesk). "Building Information Modeling (BIM) is not a piece of software. It is a belief in collaboration for the greater good of the project through the open sharing of information supported by software"

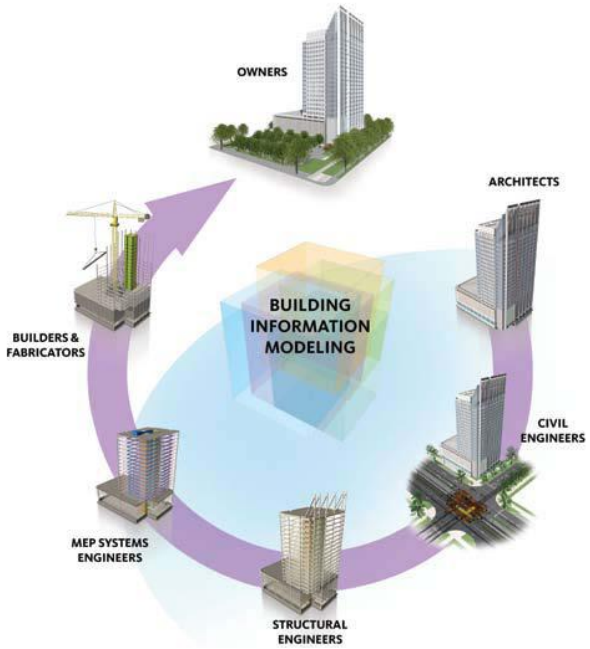

Fig.3 Lifecycle of a building

In other words BIM is a set of software, 3D models, processes, and data bases. Meaning BIM starts with a 3D building model that is more than a simple visualization of geometry and textures added to the model, a true BIM model is the virtual equivalents of the actual building sections used to create a building, consisting these virtual elements in a prototype of the physical building elements that enables the simulation and understanding of the building behaviour previously to the actual construction begins. With these model is created a data base that is more than just architectural and engineering data, it creates data that is not visually represented in 3D, it contains scheduling information, which clarifies man power, coordination and anything that can impact the schedule, cost information that allows the perception of what the budget or estimated cost of a project might be at any given time of the project, as the impact in of modification in cost of the overall project. This information is not only useful during the design and construction phase of a building project, it can be used throughout the entire building life-cycle representing a reduction of the operation and management cost of the building which is significantly more than the entire cost of construction.

The nature of the components that make up a BIM (3D models and project information) will evolve throughout the development phase of a project. Duly resulting in a major change in the nature of both the 3D models and the linked information. This observation particularly serves to reinforce the importance of the process, rather than the model itself; building information modeling is a dynamic process.

Early BIM demonstration projects have already achieved savings of around 20% during the construction phase, with some on course to make 33% savings over the life of the building; future projects are targeting even greater savings.

However, BIM goes beyond simply switching to new software. It requires changes to the definition of traditional architectural phases, more data sharing than architects and engineers are used to, and a willingness to embrace partnering in an approach that collects all project related information digitally. BIM is able to achieve this by modeling representations, specifications, and the critical paths of actual parts and components used in the construction process, representing a major shift from traditional computer aided design.

The interoperability of the model requires that drawings, master building specifications, standards, regulations, manufacturer product specifications, cost and procurement details, environmental conditions (emissions data), critical paths, clash detection and submittal processes all work together. The whole process is about disparate information resources feeding into a central store of digital documentation, which then becomes the heart of the building information model.

BIM is far more than 3D CAD modeling; it is a rich information source containing geometric, visual, dimensional, and process information. If the software is the interface to a building information model; rich information content is its body and soul. Managed BIM will reduce the information loss associated with handing a project from design team, to construction team and to building owner/operator, by allowing each group to add to, and reference back to, all information they use/create during their period of contribution to the BIM model. To put it simply, without the embedded information, BIM is little more than 3D pictures.

Technology advances due to transition of design medium from 2D paper-based drawings to 3D digital models on computer screen - led to the introduction of Building Information Modeling (BIM). It's continuous progression from 2D to 3D, 4D, and BIM. 3D models make valuable contributions to communications, but not all 3D models qualify as BIM models. BIM is more than 3D geometry.

VII. THE BIM PROCESS

The process of BIM is revolutionary because it provides the opportunity to migrate from practices that are cantered on human craftsmanship to a more augmented and modern machine craftsmanship - and all that this might imply. It provides the basis for construction companies to save time and money by rapidly creating simulations (time/cost/constructability) allowing to plan and virtually test a design anticipating problems before they become highly expensive. In more detail, the BIM process facilitates all aspects of the project, and can be divided into four main processes:

- ✓ The processes enabling the owner to develop an accurate understanding of the project;
- ✓ The processes enabling the design, development, and analysis of the project;
- ✓ The processes enabling the management of the construction of the project (which will be deeply addressed further in this work);
- ✓ The processes related to the management of the operations of the project during its actual use.

The AEC industry is not accustomed to think about and analyses the business processes in a methodical way, there is a fearsome number of business processes and workflows that are undocumented and fragmented which do not allow information to flow freely. This happen because to manage information using the traditional paper based information methods, the AEC industry has been obligated to compartmentalize the information. With BIM there is no longer the need to be restricted to those methods.

It is crucial to understand that processes are intrinsically connected to each organization's structure, workflow and market; consequently there is no "correct" approach to it. However, there are some good practices and aspects of business process reform and changes that should be considered as part of any BIM implementation and process:

- ✓ Reduction of manual data entry with a greater electronic information exchange;
- ✓ Reduction and elimination of low-value and no-value tasks;
- ✓ Reduction of time spent on "defensive documentation";
- ✓ Integration of construction cost estimating with building information modeling;

- ✓ Reorganization of business processes to enable more tasks to occur concurrently;
- ✓ Increased prefabrication of construction assemblies;
- ✓ Implementation of direct design-to-fabrication processes
- ✓ Implementation of efforts to achieve and maintain optimal performance of operating systems and equipment;
- ✓ Implementation of continuous learning processes to improve the quality and profitability of the operations.

Once again BIM and related technology may be of incredible use in this change, but the fundamental issue is how information is used in order to improve the way business is done. Through time there has been a large amount of approaches to business process, which result in failure. In order to implement the BIM process, is needed another major change. Lest end up as another failure and produce results, business leaders cannot approach it with an extreme top-down leadership, instead they need to find equilibrium between the rigid leadership and an employee's support leadership, understanding at the same time how to transform their organizations.

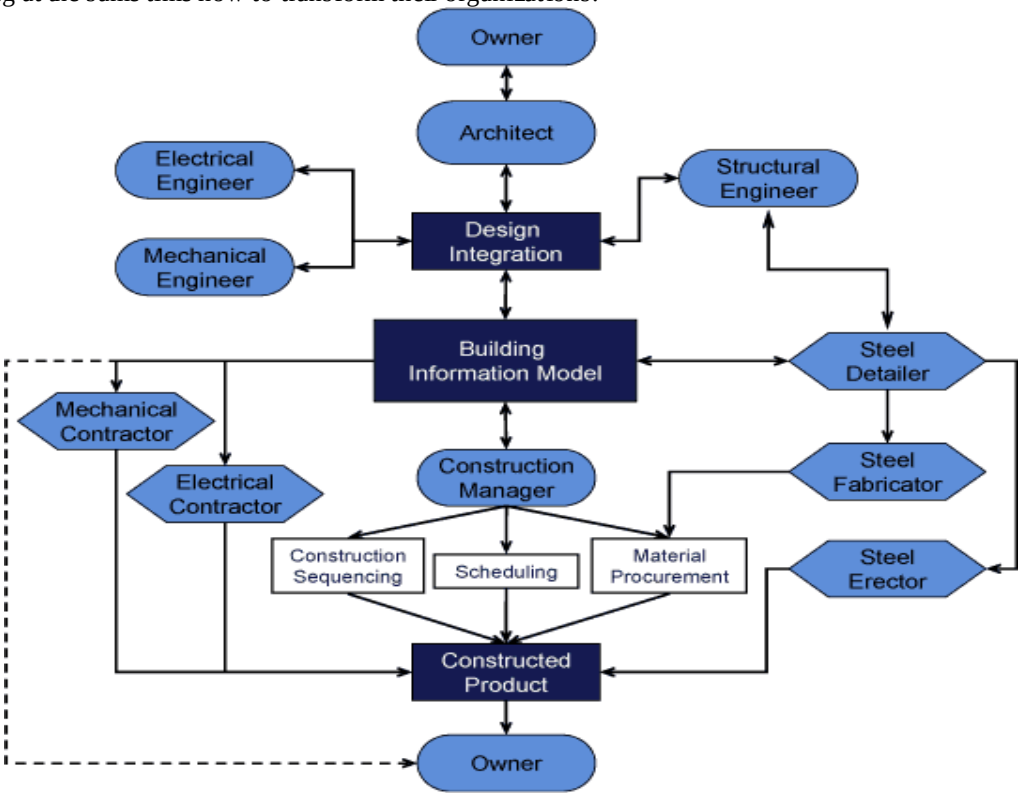

Fig.4 Process in BIM

VIII. FUTURE OF BUILDING INFORMATION MODELING

The future of architecture and the construction industry is digital; of this there can be no doubt, and BIM is the future of design and long term facility management; it is government led and technology driven; and it is implementing change across all industries, but there is still much confusion about what exactly it is and how it should be utilized and implemented. BIM is a digital model which helps everyone understands the building; however, it is a new technology in an industry typically slow to adopt change. Rest assured though, BIM will grow to play a crucial future role in building design and documentation. BIM provides the potential for a virtual information model to be handed from Design Team (architects, surveyors, consulting engineers, and others) to Contractor and Subcontractors and then to the Owner, each adding their own additional discipline-specific knowledge and tracking of changes to the single model. The result greatly reduces information losses in transfer; makes buildings work and help build better value constructions. By signalling conflict detection BIM prevents errors creeping in at the various stages of development/construction, because the model actually informs the team about parts of the design which are in conflict or clashing. Finally BIM offers detailed computer visualization of each part and assembly in relation to the total building.

As hardware, software and cloud applications herald greater capability to handle increasing amounts of raw data and information, use of BIM will become even more pronounced than it is in current projects.

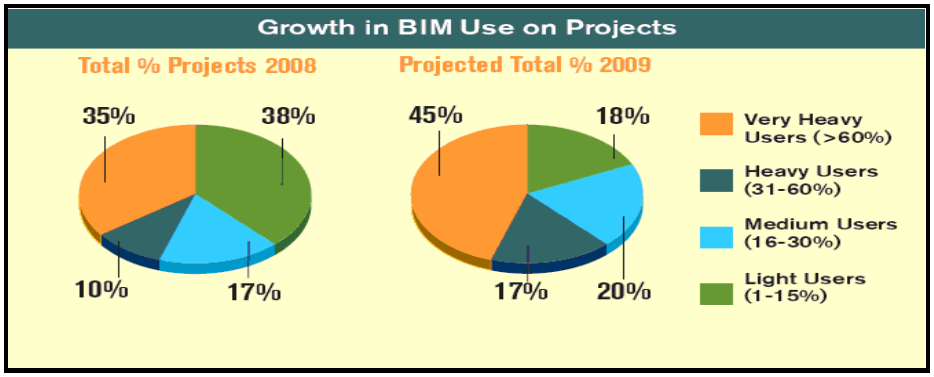

Fig. 5 Impact of BIM on construction industry

IX. Benefits of BIM

Managing a construction project and building lifecycle using a building information model can result in substantial savings, in both time and money, from design and construction through to on-going maintenance. The model saves time and waste on site, and renders extra coordination checks largely unnecessary; the information generated from the model leads to fewer errors on site, caused by inaccurate and uncoordinated information. When all members of the construction team work on the same model, from early design through to completion, introduced changes are automatically coordinated through the BIM, across the whole project, and information generated is therefore of high quality.

BIM has already given the industry measurable positives:

- ✓ Increased understanding and predictability – offering greater certainty and reduced risk
- ✓ Improved efficiency
- ✓ Improved integration and coordination – meaning less problems onsite
- ✓ Less waste
- ✓ Better value and quality
- ✓ Better buildings throughout their life-cycle.

Information technology is an integral part of today's commerce, and transferring design/construction information from designers to producers/constructors is an example where, with the availability of modeling software, the tools are already in place. However, when choosing which simulation tool to use for a project, the teams involved must consider the application's accuracy, reliability, user base and possible needs for training, considered against the project information they will have at their disposal.

Construction is the world's most wasteful industry; it is the largest consumer of global resources, raw materials and global energy supplies; it creates the largest amount of global solid waste; and it is responsible for around 50% of greenhouse gas emissions. However, it is worth trillions of dollars per annum globally.

BIM technology presents a great opportunity for manufacturers, but they must ensure that they keep up and are part of the industry changes, not a future 'Kodak'. Ability to identify collisions.

- ✓ Ability to visualize what is being built in a simulated environment resulting in fewer errors and corrections in the field.
- ✓ Higher reliability of expected field conditions, allowing for opportunity to do more prefabrication or materials offsite, which is usually of a higher quality at a lower cost.
- ✓ The ability to do more "what if" scenarios, such as looking at various sequencing options, site logistics, hosting alternatives, cost, etc. Reduction in field changes, tightened subcontractor bids, and improved information flow throughout the design and construction process.
- ✓ Clarity in design communications based on BIM visualization platforms. Three dimensional presentations of information allow everyone to see the project components and how they work together. This quickly and clearly conveys ideas and intent.
- ✓ Higher quality design that is not delayed during construction because of rework.
- ✓ Can be easily exported to other design software's like STADD-Pro, etc. or architectural software like 3D max and to cad software's like AutoCAD.
- ✓ Can also be exported to CNC machines directly.

X. SOME TRUTHS ABOUT BIM

- ➢ **BIM takes design to next level**

Technological developments open up new avenues for design, and BIM is no exception. The 3D function enables complex shapes and the software's ability to handle sophisticated calculations will allow structural engineers to push the boundaries with ever more daring designs, It is as an information management tool that BIM software really shines. One reason for the slow take up of BIM in the civil engineering sector is that the BIM community has so far focused on "building" to the detriment of 'information'.

- **The colour of BIM is green**

Using it properly will cut project time and thereby energy use, as well as cost. BIM will reduce the waste of materials during construction and building management and eventually assist in sustainable demolition. Energy modeling can also minimize energy use over a building's life.

- **BIM will destabilize the construction industry**

Unlike CAD, which computerized a single activity while leaving macro processes largely intact, BIM will change everything. There's no point attempting to implement BIM software throughout the industry with the expectation that things won't change. They will.

- **Governments must take the lead**

The benefits of working the BIM way only come with close collaboration. If one member of a project team is using BIM while the others continue doing things the old way, there will be limited benefit. To make the investment worthwhile, someone has to break the stalemate. That someone is often the government.

- **Companies must work together as one.**

Firms and disciplines working separately, interacting only through the exchange of construction documents just won't do any more. BIM both enables and requires tighter integration.

- **Both the software and the professionals must work together**

But simply working together isn't enough – habits and routines have to be aligned in order to make cooperation natural. The software will need to be developed to allow seamless integration, and so will the attitudes of professionals.

- **New contracts will emerge**

Both digitalization and close collaboration challenge the prevailing system of intellectual ownership. There are two possible development routes. One is increased specialization where ownership resides with modeling specialists. The other is consolidation into giant firms, as companies work increasingly closely, solving ownership issues.

- **The software platform is at a crossroads.**

The fight for supremacy in the software world rages on. Depending on the outcome of current power struggles, the digital environment in the new construction industry will conform to one of three types: open standard, closed and proprietary standard, or no/several standards.

- **BIM will become the DNA of future construction**

When the system is sufficiently streamlined we can start to focus on using it. Once the basic information infrastructure is in place and we've learned to work with it, numerous technologies, in use or in the pipeline, can be brought in.

XI. BIM APPLICATION AREAS

BIM model is parametric-object based and all the information stored in the model can be shared and reused by different stakeholders involved in the building lifecycle. By storing and exchanging the information of the building automatically, BIM model can provide more accurate data and information of the building. BIM technology can be utilized in different application areas such as design/modeling, energy analysis, clash detection, cost estimation and construction scheduling. These multiple application areas in BIM can help users to improve the communication, reduce errors, and potentially save time and money. This section will explore important BIM application areas in various phases of the building lifecycle.

- **Design/Modeling**

The object-based parametric modeling feature in BIM allows architects, MEP engineers, structural engineers and fabricators to leverage multiple functions on the same building model for their own use. With accurate building information and object models, the design/modeling process is dramatically facilitated. The design accuracy and information sharing enhancement span all the phases of the design/modeling process which also benefit the subsequent activities such as accurate quantity take-offs that can be used in cost estimating and the construction phase can be automated for the project control.

- **Energy Analysis**

The capability to link the building model to energy analysis tool allows users to conduct the energy analysis in the early design phase. Traditionally, a separate energy analysis would be conducted at the end of the design process and it is not possible for users to modify the design to improve the building's energy performance. By using BIM technology, the building model can be linked to energy analysis tools for the energy evaluation during the early design phase. The analysis allows users to make energy-conscious decisions and to test the energy-saving ideas without postponing the design process.

- **Clash Detection**

The designs from all organizations can be brought together and compared, and the geometric clashes between architectural, structural and MEP systems will be detected, checked and modified. Coordination among different organizations is enhanced and errors and omissions are significantly reduced, thus speeding up the construction process, reducing costs, minimizing the likelihood of legal disputes, and shortening the construction period. Clash detection is one of BIM's buzz phrases, primarily because it puts a value on the savings made from eliminating problems found during a review. Clash detection can be broken into three categories or types:

a) Hard clash
b) Soft clash/clearance clash

c) 4D/workflow Clash.

A hard clash is simply when two objects occupy the same space. For example, a pipe going through a wall where there is no opening. Soft clashes refer to allowable tolerances or space; for example, buffer zones between components left to provide space for future maintenance. 4D/Workflow clashes refer to clashes in scheduling work crews, equipment/material fabrication delivery clashes and other timeline issues.

❖ **3Workflow/4D**

4D scheduling in BIM allows the designer/manager to see problems scheduled in the works durations and analyses congestion and accessibility more effectively than through standard Gantt charts. A more powerful aspect of 4D schedules are that, unlike a static building model, they are in a dynamic state. By linking time to structural components, it is possible to carry out time related structural analysis using the actual BIM model. If workflow analysis of the model is carried out at design stage, it may determine the preferred material and the construction methodology in order to save time and money.

❖ **Quantity-Surveying/5D**

The level of BIM utilized is often down to the maturity level of the team and that of its respective parts, so utilizing fully integrated 4D and 5D is still uncommon, mainly down to software costs and educational/training limitations. However, the certainty of quantities generated from the BIM model allows several different assessments in finding the most effective solutions prior to construction - BIM modeling means that a schedule of quantities can be produced instantly; whereas previously a QS could spend considerable time measuring and taking quantities from 2D drawings. However, despite BIM's accuracy, there remains the issue of differences in 'standard methods of measurement'. The UK uses several SMMs, Ireland mainly uses a version of ARM (Agreed Rules of Measurement), and the US and Australia use other variants. So, a common international standard method of measurement, compatible with all BIM software, seems to still be a way off.

❖ **Construction Scheduling**

The design and the construction schedule can be synchronized by linking the building model to the project schedule. It allows users to simulate the construction process and show the virtual view of the building and the site. More details about construction scheduling will be provided in the following sections.

❖ **Cost Estimating**

BIM users can generate accurate and reliable cost estimates through automatic quantity take-off from the building model and get a faster cost feedback on changes in design. It is possible to make all the involved organizations aware of the cost associated with the design before it progresses to a more detailed level.

XII. CONCLUSION

It is studied four BIM utilization activities: visualization, 3D coordination, detail Drawing and Estimation. The visualization is generally the simplest use of a Building Information Model such as renderings. Furthermore, the 3D coordination was utilized to detect and eliminate trade clashes and conflicts. In addition to that, detailed drawings can be generated to review and coordinate work between trades. Building Information Modeling is beneficial to construction industry. BIM utilizations such as coordination, construction planning, and prefabrication, make construction projects more efficient.

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