Journal of Civil Engineering (IEB), 43 (1) (2015) 9-28

Journal of
Civil Engineering
IEB

Scopes of Building Information Modelling (BIM) - Bangladesh perspective

Khandakar Mamunur Rashid and Md. Shamsul Haque

Department of Civil Engineering
Bangladesh University of Engineering and Technology, Dhaka 1000, Bangladesh

Received 4 June 2014

Abstract

Massiveness of Civil Engineering projects is not new, neither the struggle of overcoming vast problems regarding this massiveness is. With this thrust, architect, engineering and construction (AEC) industry related research wings are constantly trying to develop new ideas and modify resources just to bring easement in construction work to make it more goal oriented and well collaborated. This research paper introduces name of a new step of this development process to Bangladesh, building information modelling (BIM). BIM is now recognized as an emerging technological and procedural shift within the AEC industry. Worldwide, BIM is not only considered as a way to make a profound impact on the professionals of ACE, but is also regarded as an approach to assist the researchers towards new paths of thinking and practice.Primary intention of the authors of this paper is to introduce BIM to the AEC industry of Bangladesh. In this research paper, starting from the main concept of BIM to its scopes, applications and diversities are described. Another motto of this paper is to explain how BIM differs from conventional paper based CAD design. It also focuses the opportunities BIM opens for professionals of all level throughout the whole project life-cycle. Finally, the present condition of Bangladesh's AEC industry and the necessity of BIM adoption with detailed research are discussed with several suggestions.

Keywords: Fertilizer, nutrient load, rice cultivation, agricultural return flow, nonpoint-source pollution

1. What is BIM?

BIM (Building Information Model) is defined as "a digital representation of physical and functional characteristics of a facility. It represents the process of development and use of a computer generated model to simulate the planning, design, construction and operation of a facility.

The resulting model, a Building Information Model, is a data-rich, object-oriented, intelligent and parametric digital representation of the facility, from which views and data appropriate to various users needs can be extracted and analyzed to generate information that can be used to make decisions and to improve the process of delivering the facility.

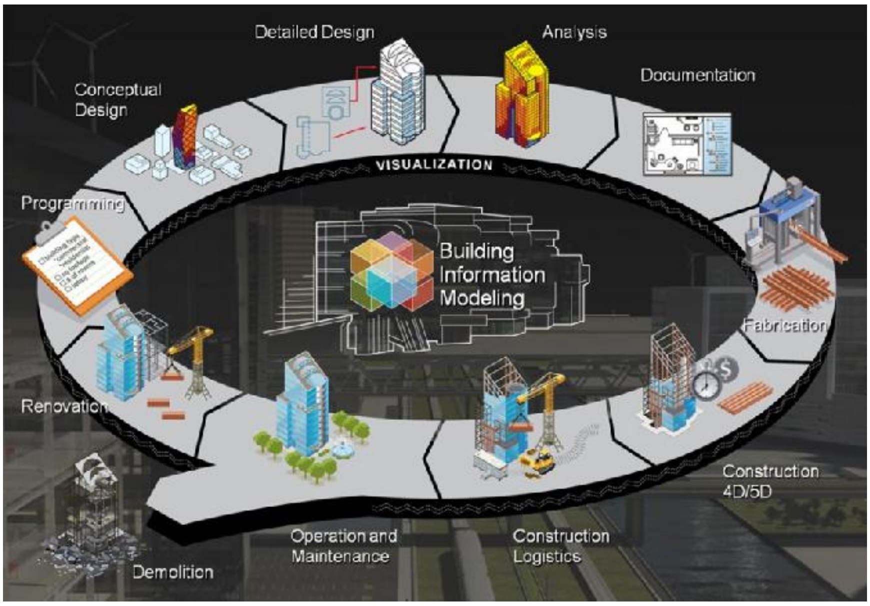

Fig. 1. Workflow of Building Information Modelling

a) How it differs from the conventional CAD Design?

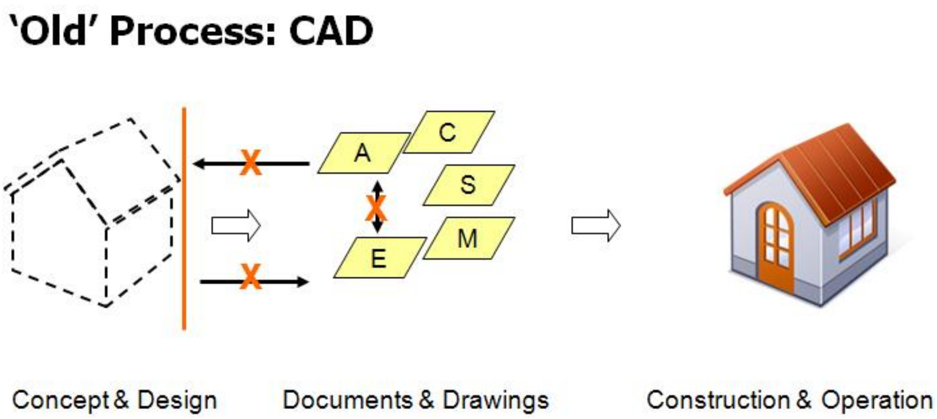

Fig. 2. CAD design workflow

BIM is not just the latest release of CAD software; it is an entirely new way of looking at the design and construction of a building. The principal difference between BIM and 2D CAD is that the latter describes a building by independent 2D views such as plans, sections and elevations. In a traditional environment (2-D plans and drawings), the movement of a wall—or a window or duct—may necessitate multiple updates: first in the main drawing, then of all detailed drawings affected by this change, which can sometimes run into dozens. This, of course, leads to the issues of making the change correctly in all drawings, and then ensuring that all who need these updates receive them.

On the other hand a building information model characterizes the geometry, spatial relationships, geographic information, quantities and properties of building elements, cost estimates, material inventories and project schedule. This model can be used to demonstrate the entire building life cycle. As a result, quantities and shared properties of materials can be readily extracted. Scopes of work can be easily isolated and defined. The construction documents such as the drawings, procurement details, submittal processes and other specifications can be easily interrelated.

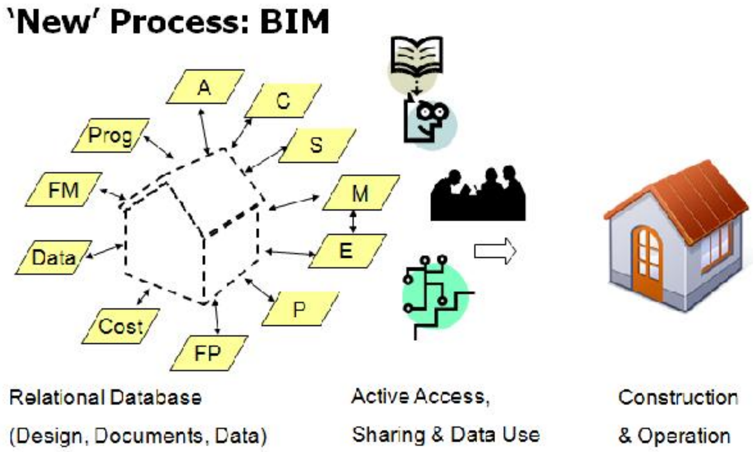

Fig. 3. BIM Design Workflow

The 3-D images of BIM are no longer surface-only shapes. They are objects. They are objects with content. The wall contains studs at indicated intervals; it contains wallboard of a certain thickness. The concrete slab contains rebar to increase tensile strength. The windows are double glazed (or not). If all database fields (parameters) pertaining to a given object are correctly populated, one can find out everything is needed to know about any given item. One can look at a true (meaning all pertinent information is accurately entered) BIM rendering and know as much about what he is looking at as if he were looking at the real thing, in real time. Understanding the BIM 3-D model so much better than a 2-D drawing as well, because it is seen as it is supposed to look. BIM has much other strength but this one is the key. BIM truly facilitates communication and understanding. BIM facilitates communication between the owner and the designer and between the designer and the contractor, who now sees how it all goes together, and who can be assured through clash detection that there will be no conflicts; and between the contractor and the subcontractor, who also gains a much better understanding of what, exactly, is to be done from the clear visual that BIM offers.

2. The Power oF BIM

2.1 Virtual Building

Fig. 4. Virtual Building, created by BIM

The key to grasping the inherent power of Building Information modelling is that during the design phase, the architect (and the owner), along with both engineers and contractors, actually construct the building virtually first. This bears repeating: they actually construct the building. With input and expertise from all concerned, the project is built from the ground up in whatever detail is needed for the purpose of the model. By collaborating at this phase, one can detect and resolve conflicts before ground is broken.

2.2 Parametric Objects

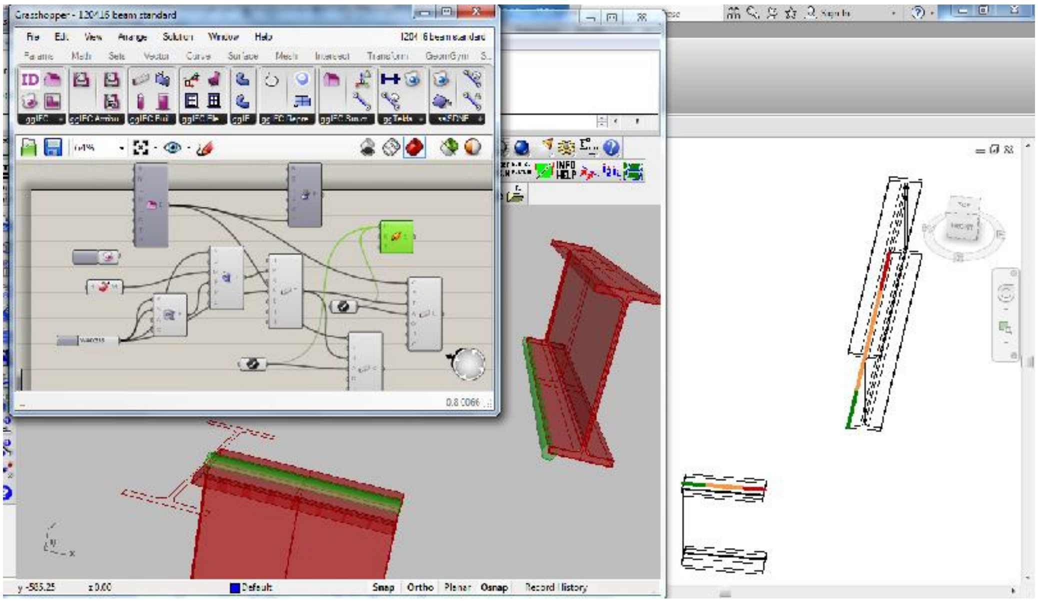

Fig. 5. Parametric Objects in a BIM software

A Building Information Model is constructed with Parametric Objects, which are software counterparts of the actual things used to construct the physical building, such as steel beams, concrete slabs and rebar, framing, drywall, ceiling grid and tile, ducts, windows and so on. The parametric object is not only represented in three dimensions, but inherent in the object is all the information concerning it to make it "intelligent." As an example: A wall "knows" that it ends in an adjoining wall. If the adjoining wall move 3 feet farther out, the initial wall will then automatically adjust its length by adding 3 feet. Technically, parametric objects, by definition:

- contain geometric information and associated data and rules;
- have non-redundant geometry, which allows for no inconsistencies;
- have parametric rules that automatically modify associated geometries when inserted into a building model or when changes are made to associated objects;
- can be defined at different levels of aggregation;
- Have the ability to link to or receive, broadcast, or export sets of attributes such as structural materials, acoustic data, energy data, cost, etc., to other applications and models.

2.3 Coordinated Design Model

A strong point of BIM is that if any change is needed, it is only required to make it once, in one place. In a traditional environment (2-D plans and drawings), the movement of a wall or a window or duct may necessitate multiple updates: first in the main drawing, then of all detailed drawings affected by this change, which can sometimes run into dozens. This, of course, leads to the issues of making the change correctly in all drawings, and then ensuring that all who need these updates receive them. The one change made in BIM will alter the location of the wall, and will also, and automatically, adjust all affected objects accordingly. The model is now current and all is needed to export or print 2-D plans (as needed) from the updated model and distribute to those concerned. This is further facilitated by the fact that, as a rule, all members of the BIM team can access the BIM remotely, and so can print the detailed plans as needed just before beginning the work, knowing now that they are dealing with current (and fully coordinated) plans.

2.4 2-D Documentation

Fig. 6. Easy 2-D documentation from 3D model

Although many designers now choose to model their projects in virtual space rather than drafting them in the 2-D plane, the need for 2-D documentation is still with us and will remain for some time, primarily due to regulatory and permitting agencies that will still, and for the foreseeable future, only deal in paper based (or CAD) 2-D plans and detail. Also, many subcontractors are not yet equipped to work directly with 3-D models and will need 2-D plans for their portion of the work. The good BIM-news is that every BIM tool vendor on the market offers the facility to generate 2-D drawings of any area of the model, in whatever detail is required (to the extent supplied in the BIM).

2.5 Prefabrication

When it comes to cutting construction costs, few things, if any, come close to prefabrication. For one, an off-site facility is *built* for manufacturing, whereas the on-site "manufacturing" area, by the nature of the beast, is always improvised to a greater or lesser degree. Also, off-site manufacturing is always more economical and will yield a higher-quality product due to closer factory control. Further, installation of a prefabricated item, made to specs for a given place, will go much faster than building it on site. This will not only cut down the subcontractor's time spent but also will speed up the entire project. Also, items fabricated off-site take up no on-site space during manufacture, and so will not obstruct contractors. Prefabrication, of course, is nothing new; structural steel, precast concrete, exterior panels and curtain walls are often prefabricated and shipped "install ready" to the job site. It seems that BIM was designed with prefabrication in mind. Whereas prior to BIM, the designer—or more commonly the contractor or subcontractor— would develop detailed 2-D documentation for the off-site manufacturer, who in turn would convert these drawings to CNC (Computer Numerical Control) instructions for the automated machine production of the items in question—such as the dimensions of a steel girder. If this same girder were designed in BIM in sufficient detail—which normally is the case—the BIM program, instead of generating the 2-D detailed drawing, can instead automatically generate CNC code and transmit this to the relevant prefabricator. Or better still, if the prefabricator already deploys 3-D manufacturing technology, the BIM can utilize Direct Data Exchange (DDE) and send the manufacturer or prefabricator the relevant portion of the BIM, for production. Prefabrication has already made great inroads with HVAC systems.

2.6 Clash Detection

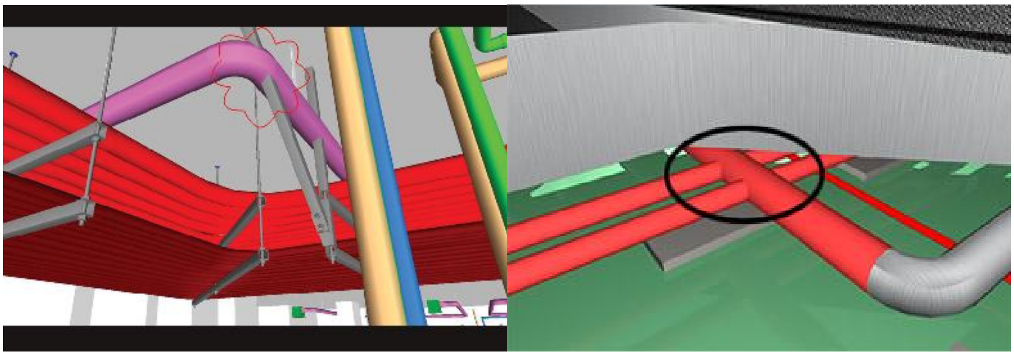

Fig. 7. Clash Detection by BIM software

Another factor that has called HVAC and plumbing to the BIM table is that they are the trades that most commonly "clash" in the field, both fighting for scarce and prime real estate between slab and suspended ceiling—the HVAC intake duct insisting on occupying the same space as the plumber's major waste line—and so easily see the great benefit of the clash detection, and resolution, provided by BIM. It is also important to remember that it is only with the confidence that there will be no clashes on site, once assembly begins, that the HVAC and plumbing contractor can prefabricate many of his assemblies off site. Ideally, the main design model will also include all HVAC and plumbing details, but what normally happens is that the HVAC and plumbing contractors design their systems using their own software, and then feed the results to a surface modeller which is well set up to run clash detection analyses.

2.7 Estimating

While one can view estimating as just another analysis tool, this is a subject important to all contractors and subcontractors, and BIM brings good news to this field. An accurately built model, made in sufficient detail to incorporate individual, suppliable objects, can, as part of the parametric data for each object, include a link to a costing database—whether to a local file, updated as needed or to a supplier's database for upto- date pricing at any time. Given a complete model, it knows exactly how many of which items it consists of, and the take-off becomes nothing more than selecting the right menu item and clicking the mouse. A quantity take-off generated by a computer from a construction model is much more reliable that one generated by traditional methods, which rely on the estimator marking the paper drawing with a felt pen (to indicate items already taken off) or, if using CAD, with textures to show the item has been counted. When one makes mistakes in traditional quantity take-offs, they are usually in this area: one misses something, or something is taken off twice. The computer, on the other hand, using the 3-D model, does not make such counting errors. If viewed only as an estimating tool, which is faster: taking-off traditionally from a 2-D drawing, or building a BIM 3-D model from which to run a takeoff?

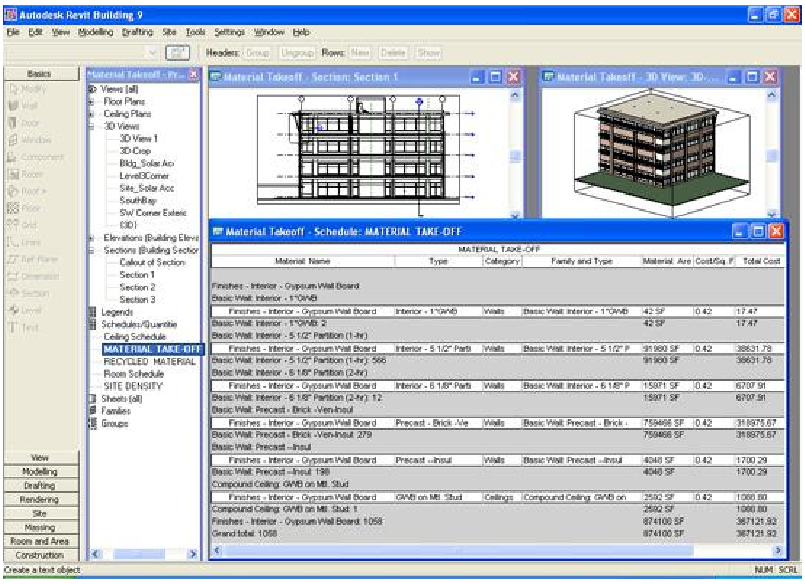

Fig. 7. Automatic Cost Estimation by BIM software

Most likely the former, but don't forget that estimating is only one of the model's many uses; it is now available for all other benefits as well. Automatic quantity takeoff based on the 3-D model does, naturally, not replace estimating as such. What is got from the model is the complete shopping list in accurate quantities and with accurate pricing (though, keep in mind the garbage-in/garbage-out principle). With this in hand, it is still required to have an experienced estimator to view the 3-D model in some detail— specifically in areas of staging, possible congestion on the site, need for scaffolding or other material that may or may not be modelled in the BIM tool, etc.—who then, based on his own understanding of the project and knowledge about costs, can make a realistic, accurate estimate.

3. BIM for Architects, Engineers, Contractors and Subcontractors

3.1 Architects & Engineers

Designers and their allied engineers are right behind the owners in seeing the advantages and benefits of BIM.Not only will BIM allow the designers to try, and test, various conceptual design approaches, but once the concept has been settled on - and bought into by the owner - the architect can now construct the building virtually, and in such detail as needed to answer their or the owner's questions in areas of

- Optimum building orientation
- Optimum building material
- Energy efficiency
- Green requirements
- Construction cost
- Construction schedule
- Operating costs

By providing clear insight into these issues, before ground is broken, BIM affords the design team a high degree of certainty and of "know before you go." And when the later conflicts are minimized, errors and omissions can also be minimized, and so as the risk of liability.

3.1.1 Design process

Architects are artists at heart. And as artists, they like to conceptualize. They like to assess different aesthetic approaches; or they like to design something with unorthodox materials, perhaps even based on untried-as-yet shapes or layouts (think Sydney Opera House or the Walt Disney Concert Hall in Los Angeles). The 2-D drawing world does not lend itself to conceptualizing; it soon grows too costly, especially if the design is out of the ordinary. Often, in order to get the design across, the architect will then resort to actual three-dimensional mock-ups of the project— expensive at best, cost-prohibitive at worst. And how many concepts would the architect like to try? How many 3-D mock-ups can the firm, or the owner, afford? At the conceptual stage, the architect should have the freest reins possible, those with the fewest cost- and time-constraints. And this is what the BIM not only promises but delivers to the designer. Spending as much time—within reason, of course— as the architect needs and wants, BIM will enable him or her to play around with various designs, approaches or materials, and actually see (and allowing the owner to see) not only what the design will look like, but also how it will perform as a building. Basically, at this stage, BIM gives the architect much sought after (and dreamed of) freedom to create.

3.1.2 Team Design

Once the building concept has been agreed upon by designer and owner, the wise architect now invites as many of the players as he or she can contractually involve; at minimum the consulting engineers, the general contractor, specialty contractors (HVAC, plumbing) and as many other subcontractors as possible. With the conceptual questions settled, this team will then knuckle down to build the actual—buildable— structure in virtual 3-D space. Make no mistake, the architect does take the lead in this, but he or she will work very closely with the engineers (civil, structural, etc.) who will not only have input to give in the overall design but will also extract applicable portions of the design (such as structure) for detailed analyses in their own systems. The architect, at the team design phase, is also wise to welcome points and suggestions provided by both the general contractor (who *knows* what it takes to build the thing) and the subcontractors present, who will also speak from a very practical angle when they suggest that what the architect just proposed might in fact not work or will generate conflicts farther down the line.

3.2 General Contractor and Sub contractor

3.2.1 Involving contractors in planning phase

Entering the nuts and bolts world, the general contractor is, as a rule, third man in. And this is where change orders normally occur. With BIM, those problems are fairly avoided, while an eraser can still be of use. For it is the contractor who, with a critical and experienced eye, looks at the model and points and says, “There, right there. Won’t work. You’ll have a crane there while pouring the slab.” And the designer will look at him, and the engineers will look at him and then at the model and suddenly nod, and any subcontractor present will nod, too, and then the designer, finally, as well; and so, then and there, they can arrive at a working alternative and incorporate that into the design.

3.2.2 Take-off and estimating

As with other subcontractors, an accurately detailed BIM 3-D model will give not only the location and interrelation of each wall-and-ceiling item, but also the “recipe” of what exactly comprises each component for an accurate take-off quantity. Given this a clear view of the construction sequencing, the BIM 3-D model will then afford the estimator a firm basis for a good bid. Pat Arrington of Commercial Enterprises, Inc. in New Mexico is investigating BIM primarily from that angle: "Using BIM, if the process is followed, there is going to be very little chance of not having the right components covered in estimates. "I think that the virtual graphics of BIM will allow perhaps even a neophyte, or at least a less experienced person, to understand the complexity of a job and to put all requisite components together. "Years back, we were only covering up framing. Today we have firewalls, sound walls, smoke walls and positive-pressure walls to seal and keep out contaminants from another source—even negative pressure walls, things we did not have before. Our trade has become a lot more complicated. If LEED and green building are also incorporated into the mix as well, one will almost need BIM to visualize the project and make sure all the pieces are included." As an aside Arrington adds, "We also have millions of dollars in negotiated work with the GSA, which requires BIM as part of the contract to aid facility management. I believe that the big school districts are now also beginning to ask for BIM for the same reason."

3.2.3 Visualisation/Communication

BIM's inherent 3-D rendering of the project, and in detail, promotes communication and understanding of what the project is all about. And the more complex or sophisticated the work is that the wall and ceiling contractor is to perform, the more important grows this feature. Miller says, "I believe that the sophistication of the drywall company is going to determine the degree to which they'll benefit from BIM. "We make a lot of panels, floor panels, wall panels— some structural, some space dividers—and roof trusses, and here is where I believe BIM is going to help us, because we will be able to see the building clearly and precisely, where and how the panels and trusses are to be installed."

3.2.4 Information

Another perhaps not-so-apparent benefit of BIM to the contractor is the greater understanding of the project as a whole that he or she will gain by having access to all the information about the project. Any question will be answered by access to the BIM 3-D model that will show all the rough openings, all the outlets, all those things that are typically missing from a set of drawings. Easy access to information is huge. If all these things are figured out ahead of time, one will save a lot of time in the field.

3.3 Owner/Facility Managers

One of the boons of the detailed BIM 3-D model is that at the end of the job, if constructed as per the model, which is often verified during construction by laser scans, we now have an accurate *as-built* model that will include most, if not all, of the data a facility manger needs to take over and operate the building, including energy and other performance data. This is one of the main reasons that many authorities today will not award a non-BIM contract; they require a full BIM as-built model at the end of the job for their facility management. Some see this as a gentle way for the government to ease the construction industry into the use of BIM, focusing on an easy-to-implement aspect of the technology, and that is probably not so far off the mark.

4. Case Study: One Island East Project, Hong Kong

This case study documents the implementation of BIM to manage the functional and financial relationships between design, construction, and facility management on a large, complex project by an owner-developer. The owner identified the potential of BIM to manage information more efficiently and save time and cost over the project life cycle. The brief project data is as follows:

Project name: One Island East, Hong Kong, China
Project scope: $300M, 1,517,711 SF commercial building
Structure: Reinforced concrete
Exterior: Aluminium curtain wall
Owner: Swire Properties Limited
Contractor: Gammon Construction Limited
BIM scope: Design coordination, clash detection, and work sequencing

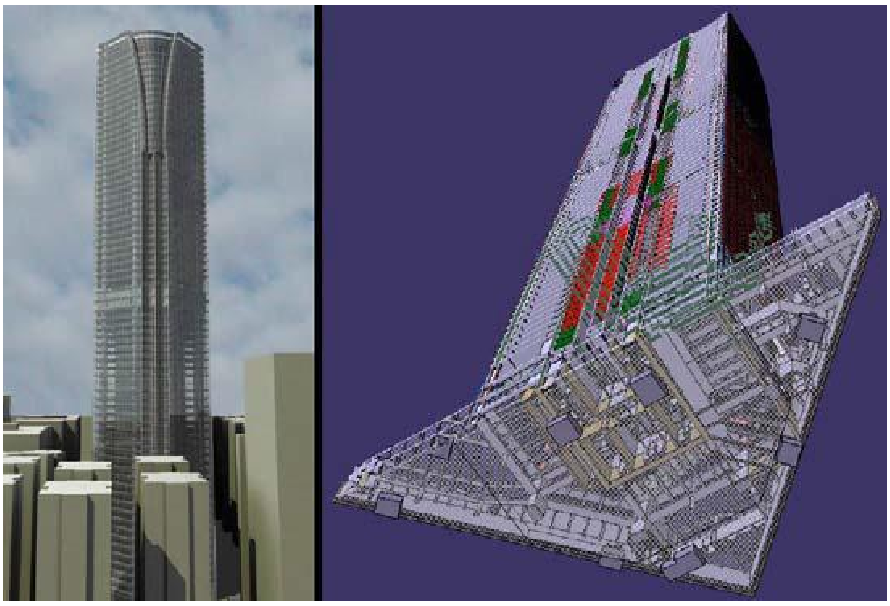

Fig. 8. Building Information Model of One Island East (OIE) Project (Courtesy of: Gammon Construction Limited, Hong Kong)

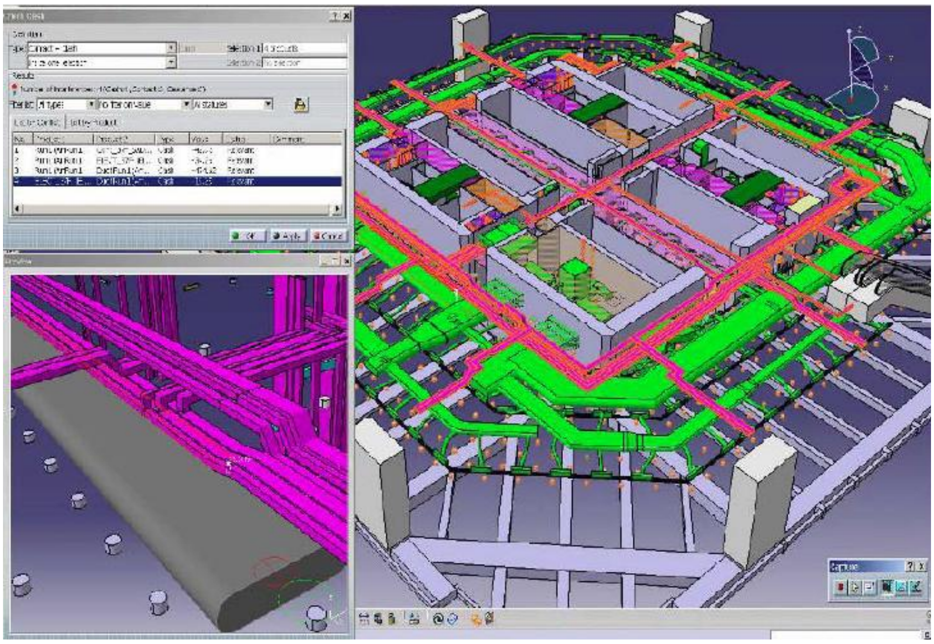

Fig. 9. Automated Clash Detections in OIE Project (Gammon Construction Ltd, HK)

The One Island East (OIE) is a large commercial office building with seventy floors. Figure 8 shows a building information model of this facility.

Almost all coordination issues were managed using BIM. As shown in Figures 9-12, through BIM, over 2000 clashes and errors were identified prior to bidding and construction, which means that a substantial cost savings was achieved, compared to the incomplete design information inherent in a traditional 2D process.

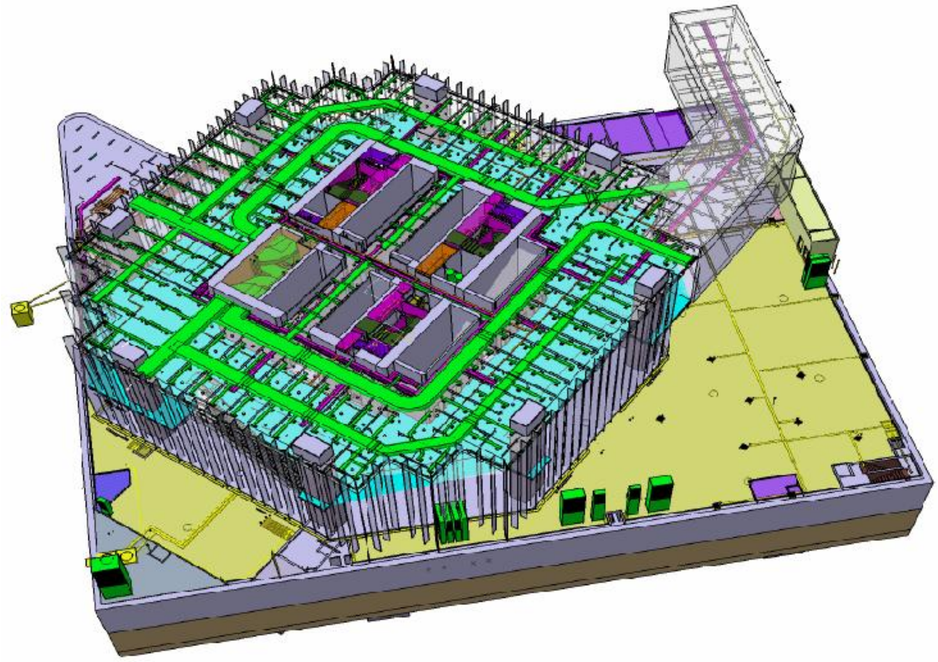

Fig. 10. Interactive Coordination Process: Virtual Building Team Walked Through Three Times a Week

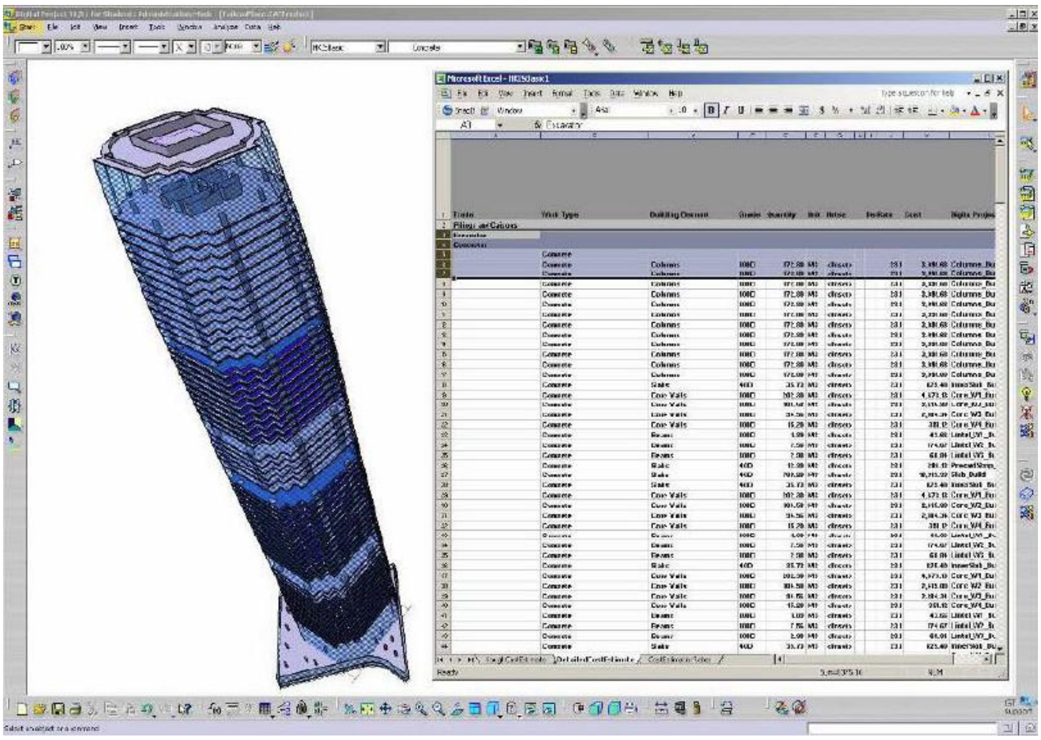

Fig. 11. Preparation of Automated Estimates (Gammon Construction Ltd, HK)

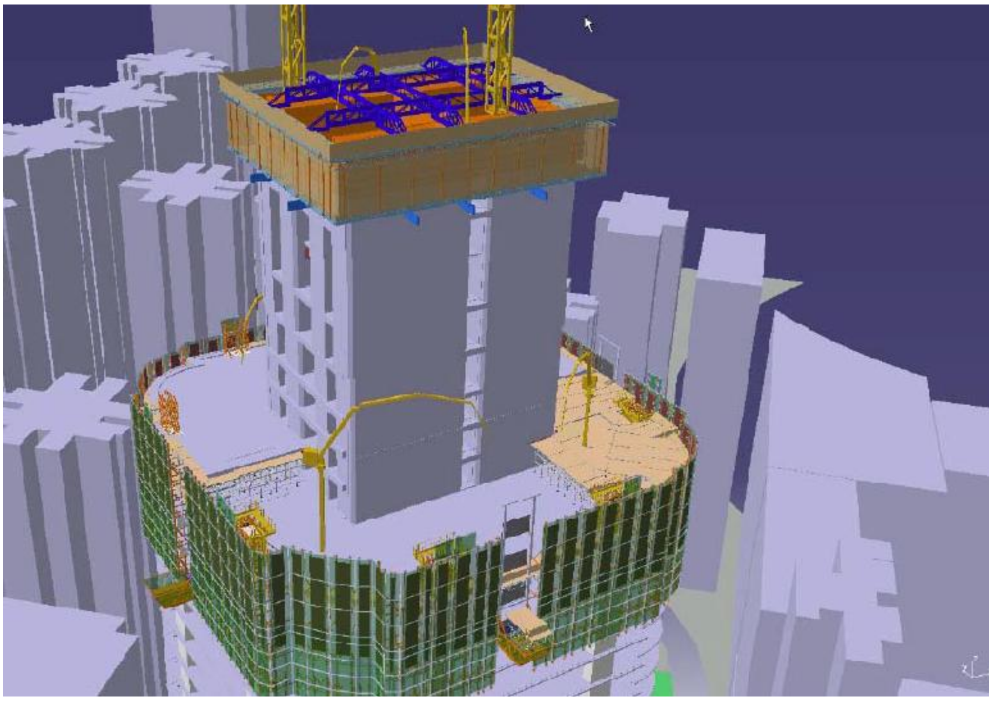

Fig. 12. Construction Sequencing Model (Gammon Construction Ltd, HK)

5. BIM use to Construction Industry: A Survey

Becerik-Gerber and Rice (2010), two American BIM researchers conducted a survey on BIM use to the construction industry in U.S.A construction industry. Of the 424 responses, 9.4% construction managers, 9.9% contractors, and 2.4% subcontractors of the 424 respondents participated. The rest of the participation breakdown is provided in figure 13. Even though the study did not particularly focus on construction managers at risk, it provided a good insight on the BIM use, costs and savings.

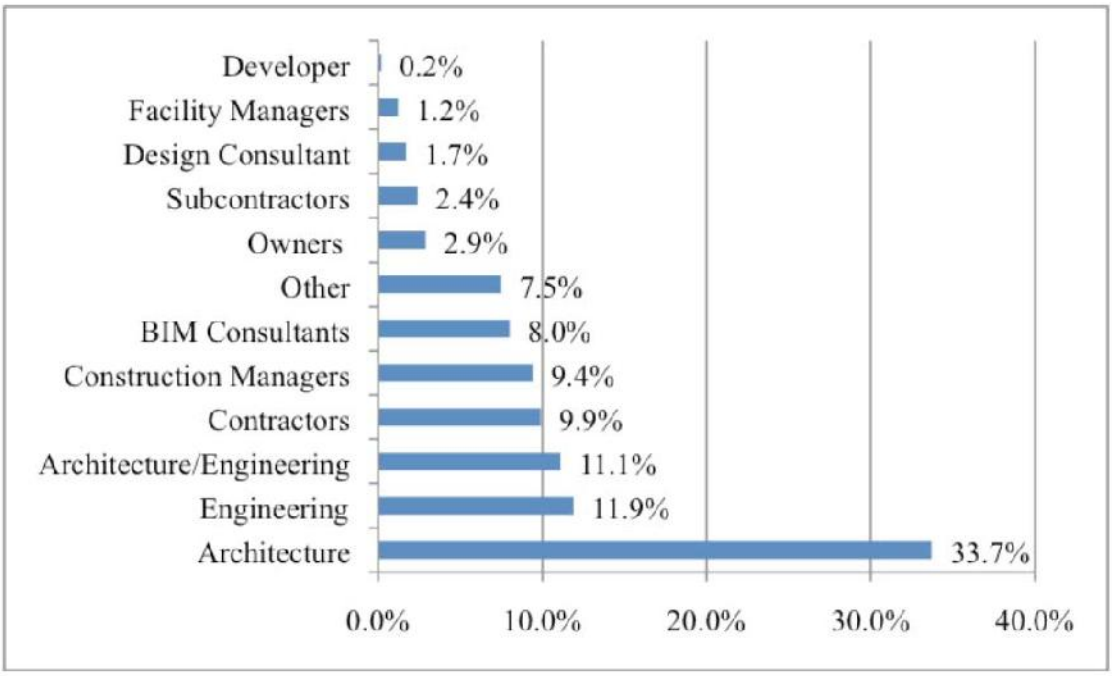

Fig. 13. Respondent Occupations (Becerik-Gerber, 2010)

The top uses of BIM for contractors were clash detection, visualization, and creation of as-built models. Based on the survey results, the industry wide uses of Building information model is listed in Figure 14.

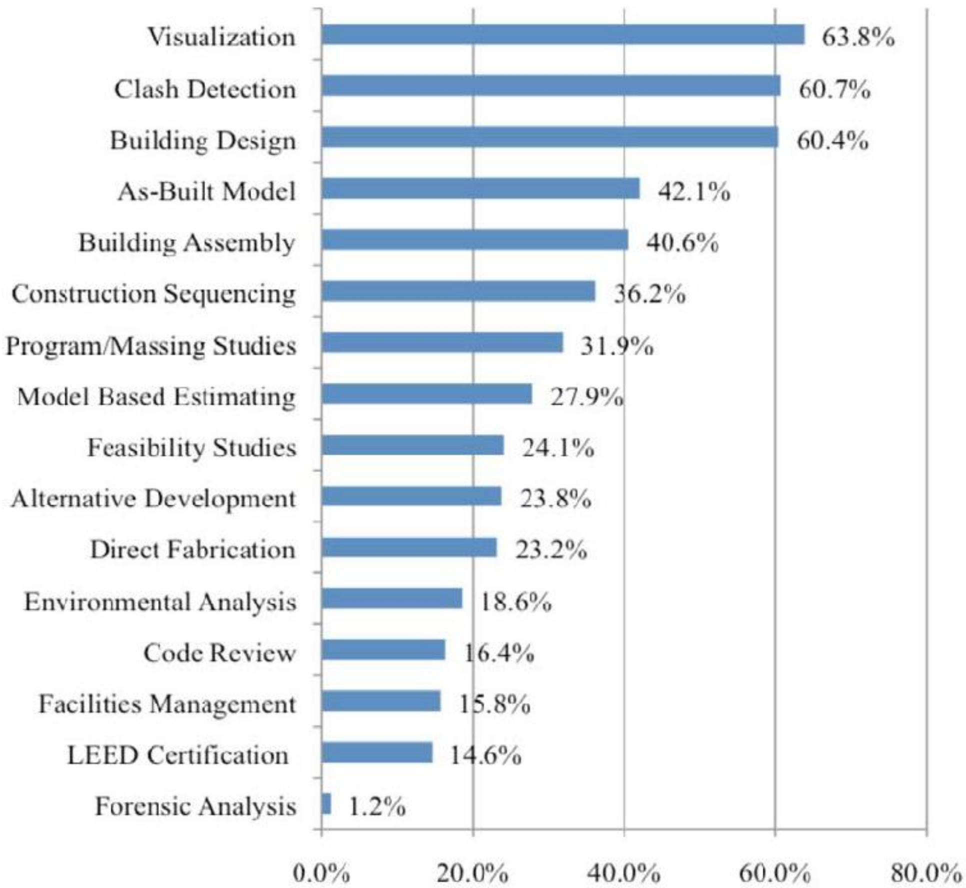

Fig. 14. BIM uses for the survey participants (Becerik-Gerber, 2010)

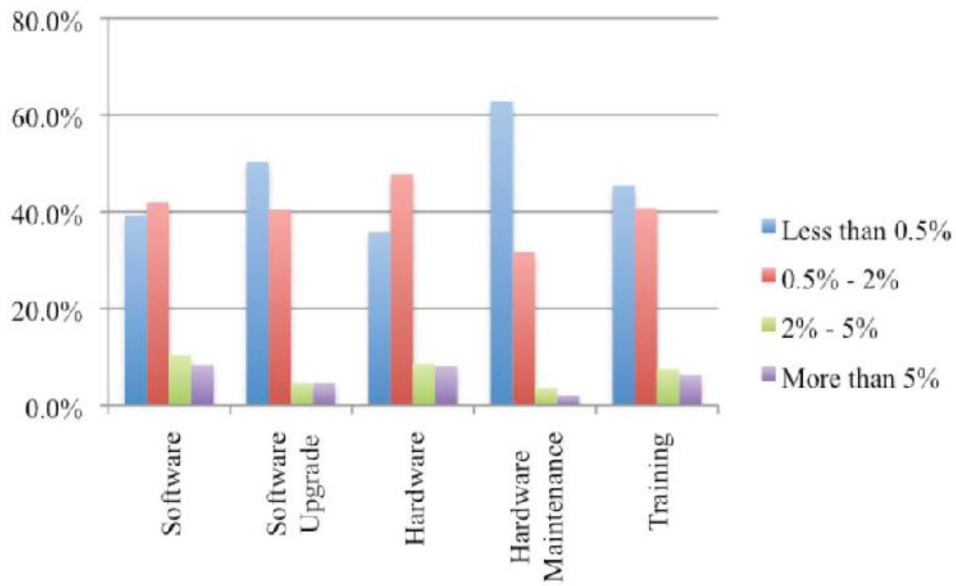

Fig. 15. Ratio of software, software upgrades, hardware, hardware maintenance, and training costs to overall net revenue (Becerik-Gerber, 2010)

The general trend in the construction industry is to handle the BIM process in-house. However, construction managers and contractors are more likely to outsource than the designers. The design and construction firms often pay for the software, upgrades, hardware, hardware maintenance and training costs. In other words, the firms are unable to pass on the costs of performing BIM services thru fees. They would make up for these costs in terms of their overhead cost. They also reduce the number of men-hours needed for drawing production The survey depicted in figure 14 below indicates that overall costs associated for the BIM technology is usually less than 2% of the overall net revenue.

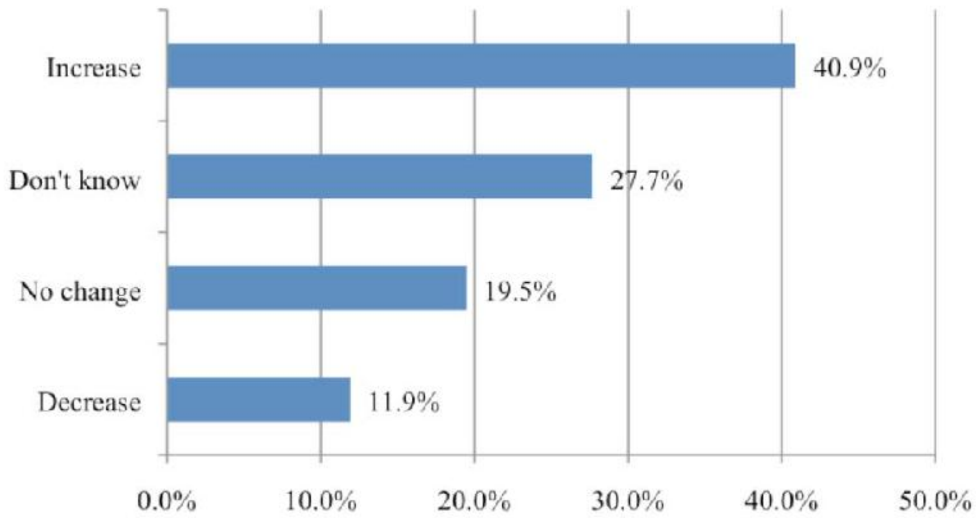

Fig. 16. Effect of BIM use on project profitability (Becerik-Gerber, 2010)

As the use of BIM has its own costs, it comes with rewards. Depicted in the figure 15, 41% of respondents stated that the BIM use increased the profitability of the project. Other BIM users may not feel change in project profitability and think that the BIM's advantages do not pass beyond marking, design, and visualization efforts. The first time users of the BIM may feel a negative impact on their profitability due to a new investment in technology and learning curve that comes with it. The consistent participants of the Building Information Modeling are likely to reap the benefits of BIM and notice increase in their profits. Lastly, the majority of the participants also indicated that the use of BIM reduced cost and schedule of the project. Overall, the cost of the BIM and its supporting technologies can be expensive to begin with. However, the powerful uses of BIM increases profits, lowers costs, and scheduling time.

6. BIM Implementation in Various Countries

6.1 BIM in Finland

In a survey conducted in 2007, the usage of BIM and IFC compliant BIM applications in Finland was estimated to be 33% (Kiviniemi, 2007). In the same survey it was observed that in Finland, 93% of the architect firms were using BIM for some parts in their projects whereas the engineer's usage was nearly 60%.

6.2 BIM in Denmark

The overall usage of BIM in Denmark is promising. According to a survey which was carried out in 2006 (cited in Kiviniemi et al., 2008), the most commonly used BIM application among architects was Architectural Desktop with approximately 35% of the firms using it. It was followed by Archicad, Revit and Bentley Architecture. The survey also showed that about 50% of the architects, 29% of clients and 40% of engineers in Denmark were using BIM for some parts of their projects in 2006.

6.3 BIM in UK

In contrast to most countries, the UK Government has actually mandated the use of BIM. In May 2011, the UK Cabinet Office published a “Government Construction Strategy” document that has an entire section on “Building Information Modelling,” within which it specifies that Government will require fully collaborative 3D BIM as a minimum by 2016. The document also acknowledges that the lack of compatible systems, standards and protocols, and the differing requirements of clients and lead designers, have inhibited widespread adoption of BIM, a technology which has the capacity to ensure that all team members are working from the same data. Therefore, the government will also focus on developing the standards that will enable all members of the supply chain to work collaboratively through BIM.

6.4 BIM in Singapore

The Building and Construction Authority (BCA) has announced that BIM would be introduced for architectural submission (by 2013), structural and M&E submissions (by 2014) and eventually for plan submissions of all projects with gross floor area of more than 5,000 square metres by 2015.

6.5 BIM in South Korea

Small BIM-related seminars and independent BIM effort existed in South Korea even in the 1990s. However, it was not until late 2000s that the Korean industry paid attention to BIM. The first industry-level BIM conference was held in April, 2008, after which, BIM has been spread very rapidly. Since 2010, the Korean government has been gradually increasing the scope of BIM-mandated projects. McGraw Hill published a detailed report in 2012 on the status of BIM adoption and implementation in South Korea.

7. BIM Risk

The first legal risk to determine is ownership of the BIM data and how to protect it through copyright and other laws. For example, if the owner is paying for the design, then the owner may feel entitled to own it, but if team members are providing proprietary information for use on the project, their propriety information needs to be protected as well. Thus, there is no simple answer to the question of data ownership; it requires a unique response to every project depending on the participants' needs. The goal is to avoid inhibitions or disincentives that discourage participants from fully realizing the model's potential (Thompson, 2001).

When project team members, other than the owner and A/E, contribute data that is integrated into the BIM, licensing issues can arise. For example, equipment and material vendors offer designs associated with their products for the convenience of the lead designer in hopes of inducing the designer to specify the vendor's equipment. While this practice might be good for business, licensing issues can nevertheless arise if the vendor's design was produced by a designer not licensed in the location of the project (Thompson and Miner, 2007). Another issue to address is who will control the entry of data into the model and be responsible for any inaccuracies in it. Taking responsibility for updating BIM data and ensuring its accuracy entails a great deal of risk. Requests for complicated indemnities by BIM users and the offer of limited warranties and disclaimers of liability by designers will be essential negotiation points that need to be resolved before BIM technology is utilized. It also requires more time spent imputing and reviewing BIM data, which is a new cost in the design and project administration process. Although these new costs may be more than offset by efficiency and schedule gains, they are still a cost that someone on the project team will have to bear. Thus, before BIM technology can be fully utilized, the risks of its use must not only be identified and allocated, but the cost of its implementation must be paid for as well (Thompson and Miner, 2007). The integrated concept of BIM blurs the level of responsibility so much that risk and liability will likely be enhanced. Consider the scenario where the owner of the building files suit over a perceived design error. The architect, engineers and other contributors of the BIM process look to each other in an effort to try to determine who responsibility for the matter had raised. If disagreement ensues, the lead professional will not only be responsible as a matter of law to the claimant but may have difficulty proving fault with others such as the engineers (Rosenburg, 2007).

As the dimensions of cost and schedule are layered onto the 3D model, responsibility for the proper technological interface among various programs becomes an issue. Many sophisticated contracting teams require subcontractors to submit detailed CPM schedules and cost breakdowns itemized by line items of work prior to the start of the project. The general contractor then compiles that data, creating a master schedule and cost breakdown for the entire project. When the subcontractors and prime contractor use the same software, the integration can be fluid. In cases where the data is incomplete or is submitted in a variety of scheduling and costing programs, a team member - usually a general contractor or construction manager must re-enter and update a master scheduling and costing program. That program may be a BIM module or another program that will be integrated with the 3-D model. At present, most of these project management tools and the 3-D models have been developed in isolation. Responsibility for the accuracy and coordination of cost and scheduling data must be contractually addressed (Thompson and Miner, 2007).

8. The Future of BIM

To quote technology industry analyst Jerry Laiserin: “The real promise of BIM lies in its application across the entire project team, especially in the area of improved building performance.”36 To date, BIM has only offered glimpses of what 3-D modeling, and the requisite team spirit to make it work, are capable of. As more government agencies, like the GSA, specify BIM in their contracts, as more benefits surface, and as more owners see—and share—higher profits, BIM will find full traction and will reshape the industry. It is not a question of if, it is a question of when. The contractor or subcontractor that gears up now— or at the least fully informs himself or herself about what BIM can do for his or her company, or how a BIM-enabled company might better serve the industry— will soon be in high demand. Those who feel that the boat is doing just fine and should not be rocked may find themselves scrambling for BIM tools and rushing into perhaps ill-advised choices once BIM becomes a general requirement, be it for economic, green or other reasons. The important thing to realize is that BIM, at heart, is not just software, but a human activity that ultimately involves broad process changes in construction.

9. BIM: Year of 2020

By the year 2020 BIM will most likely have reached all the way into the building codes structure and the permits process. “Send me the model” may well be the immediate response to a permit request. More likely than not, the permit office now has an analyzer that will quickly (in a matter of seconds) verify that the model is to code, and one may receive permit in minutes, rather than weeks, after submittal. Lean Construction principles will have worked their way into a majority of projects, and the U.S. construction industry will, as a team-centric industry, be the most productive and the most proud in the world. It does not take a crystal ball, or even 20/20 vision, to see that.

10. AEC (Architectural, Engineering, Construction) Industry of Bangladesh: Status QUE

The architectural, engineering and construction industry is considered as one of the fastest growing and one of the largest sectors in Bangladesh. In terms of employment, it has been growing at 7.3 percent rate during 1991-2006 periods. The growth rate in terms of GDP has been 6.7 percent during 1995-96 to 2008-2009 (Report by WCC). This rapid growing industry is yet to adopt the latest building design, management and construction tool, BIM. Architects are recently trying to imply BIM in their planning, design and visualisation phase, while engineers and contractors are mostly dependent on paper based 2D CAD design and excel sheets.

Though architects have recently started using BIM, it's being used just for 3D visualisation purpose. After completing their planning and design, architects send them to engineers for structural, electrical and plumbing designs. If any deficiencies observed in the architects design then modification is needed in every phase of the paper work getting back to the originating designer. Every perspective, every detail is needed to be updated separately. This is a very time consuming process. Cost estimation is also done in a excel sheet, and any modification in this stage leads the change in whole design from the top. And then comes the execution phase. Since most of the contractors and subcontractors are mainly working based on their experience and do not have much sound academic knowledge about what they are doing there is a huge information gap between the contractors and the engineers. Most of the cases contractors have to keep a close contact with the engineer during the whole construction process. This obviously slows the construction work and increase the total building cost.

11. Necessity of BIM Application in Bangladesh

In May 2011 UK government published the "Government Construction Strategy" within this the announcement that:
'Government will require fully collaborated 3D BIM (with all project and asses information, document and data being electronic) as a minimum by 2016.'

So it can be easily assumed that within next few years BIM will be a must for all construction activity. As an emerging construction industry, we also should include this latest technology in our design and construction life cycle as soon as possible.

- As it is discussed earlier, BIM is the process and practice of virtual design and construction throughout a project's lifecycle. It is a platform to share knowledge and communicate separate necessities of all project participants. The problem of lack of communication between the designers to the subcontractor can easily be solved. Even it is possible that stack holders sit together in the development stage of the model and sort out their probable clashes and limitation.
- Secondly, unfortunately, for Bangladesh perspective, we are still not blessed to reach formal engineering education to all actively working contractors. It is often a case when these contractors fail to comprehend large CAD design sheets. More scary part is, in this case, due to the complexity in back calculating to the designer, the

contractors prefer to use their implicit knowledge eared from experience. But if this is an exceptional design and problems are covered up from contractors' end this way, this may sow the seed of huge problem for the future. BIM plays an important role here. Contractors can be involved and given out with visual aids that will tell them exactly what is needed to be done and how it is need to be done. On the other hand, for BIM, complaining back to the designer does not create the dilemma of time as only few central changes in the model can give revised out put all at a time. Knowing that, contractors are less likely to hesitate to report their problems than covering them up.

- Thirdly, many designers of Bangladesh suffer from lack of field experiences. That is the parent reason of having design segments which are very tough to execute, even at some cases impossible. This again involves halting the whole work to sending the complaint to the designer and waiting for him to find out a wise solution for it and then send those down to the site. Huge amount of Time-money is lost is such cases. And unfortunately, this is not a rare case here, it happens almost every day all over the country. So the authors suggest introduction of BIM in which contractors can sit with the designer and suggest him the probable problems that may arise. Even if this is not possible, when the work will be handed to the contractors, they can check the 3D modelling of the construction process and find out probable problems with that just like the way they would have founded it in the field. That saves time, money everything.
- Fourthly, another recurrent problem is wrong estimation or budgeting. For this problem, it is a "heads you win, tell I lose" call. If it is over estimated, the owner or investor is the loser. If it is under estimated, work gets stopped or contractors have to compensate. BIM can overcome this very easily by generating a pretty accurate estimation. It is trust worthy, as explained earlier, BIM modelling uses exact construction components with their exact properties. So estimation is just like counting every brick and every spall of plaster to its precision.

Above are the reasons that give the authors firm idea that BIM is a must introduction to Bangladesh as soon as possible. Successful communication-easily updatable corrections-real time visualization these three power tools make BIM a dire need of AEC industry of Bangladesh, in some cases more than any other developed countries.

12. Conclusions

BIM is the first truly global digital construction technology and will soon be deployed in every country in the world. Before applying this in our AEC industry, elaborate research is required for its proper application. Workshops and seminars should be arranged to discover the scopes of BIM in our country. Moreover government should take some steps to make this whole adaptation process easier. Introduction of it to basic engineering education can make BIM a hand-on-hand tool for every architect, engineer and contractor of the country. We are blessed with every required thing for this, we are just waiting for some wilful steps, may be of yours.

References

Foundation Of The Wall And Ceiling Industry (June 2007),"Building Information Modeling: Understanding And Operating In A New Paradigm" *513 West Broad Street, Suite 210 Falls Church, Va 22046-3257 (703) 538-1600*

Salman Azhar, Michael Hein And Black Sketo (2007) Building Information Modeling (Bim): Benifits, Risks And Challenges. *Mcwhortes School Of Building Science, Auburn University, Auburn, Alabama.*

Mehmet F. Hergunsel (May 2011) Benefits Of Building Information Modelling For Construction Mangers And Bim Based Scheduling, *Worcester Polytechnic Institute*

J. Wong And J. Yang(2010) Research And Application Of Building Information Modelling (Bim) In The Architecture, Engineering And Construction (EC) Industry: A Review And Direction For Future Research, *School Of Urban Development, Queensland University Of Technology, Australia*

Kihong Ku And Thomas Mills(2009) Research Needs For Building Information Modeling For Construction Safety, *Virginia Tech, Blacksburg, Virginia.*

Andy K. D. Wong, Prof. Francis K .W. Wong, Abid Nadeem " Comparative Roles Of Major Stakeholders For The Implementation Of Bim In Various Countries" *Department Of Building And Real Estate, The Hong Kong Polytechnic University, Hong Kong*

Md. Zakaria Ahmed, Md. Saiful A. Siddiquee, Md. Sadik Khan (2012) "Reliability And Construction Practices In Building Construction Industry Of Bangladesh" *Third International Conference On Construction In Developing Countries (Iccidc–Iii) July 4-6, 2012, Bangkok, Thailand*

Patrick C. Suermann, Raja R.A. Issa " Evaluating The Impact Of Building Information Modelling On Construction" *The University Of Florida*

Jennifer Whyte (16 July 2012) Building Information Modelling In 2012: Research Challenges, Contributions, Opportunities, Design Innovation Research Centre, *University Of Reading, Uk*

Khemlani, L.; Papamichael, K.; And Harfmann, A. (November 02, 2006). The Potential Of Digital Building Modeling.

Hajian, Hamid, And Burcin Becerik-Gerber.(September 2009) "A Research Outlook For Real-Time Project Information Management By Integrating Advanced Field Data Acquisition Systems And Building Information Modeling." *University Of South California.*

Appendix

BIM Tools:

There are plenty of Building Information Modeling tools. This subsection will identify these products. The following table, figure 17, depicts the BIM authoring tools and their primary functions. The list includes MEP, structural, architectural, and site work 3D modeling softwares. Some of these softwares are also capable of scheduling and cost estimation.

Product Name	Manufacturer	Primary Function
Cadpipe HVAC	AEC Design Group	3D HVAC Modeling
Revit Architecture	Autodesk	3D Architectural Modeling and parametric design.
AutoCAD Architecture	Autodesk	3D Architectural Modeling and parametric design.
Revit Structure	Autodesk	3D Structural Modeling and parametric design.
Revit MEP	Autodesk	3D Detailed MEP Modeling
AutoCAD MEP	Autodesk	3D MEP Modeling
AutoCAD Civil 3D	Autodesk	Site Development
Cadpipe Commercial Pipe	AEC Design Group	3D Pipe Modeling
DProfiler	Beck Technology	3D conceptual modeling with real-time cost estimating.
Bentley BIM Suite (MicroStation, Bentley Architecture, Structural, Mechanical, Electrical, Generative Design)	Bentley Systems	3D Architectural, Structural, Mechanical, Electrical, and Generative Components Modeling
Fastrak	CSC (UK)	3D Structural Modeling
SDS/2	Design Data	3D Detailed Structural Modeling
Fabrication for AutoCAD MEP	East Coast CAD/CAM	3D Detailed MEP Modeling
Digital Project	Gehry Technologies	CATIA based BIM System for Architectural, Design, Engineering, and Construction Modeling
Digital Project MEP Systems Routing	Gehry Technologies	MEP Design
ArchiCAD	Graphisoft	3D Architectural Modeling
MEP Modeler	Graphisoft	3D MEP Modeling
HydraCAD	Hydratec	3D Fire Sprinkler Design and Modeling
AutoSPRINK VR	M.E.P. CAD	3D Fire Sprinkler Design and Modeling
FireCad	Mc4 Software	Fire Piping Network Design and Modeling
CAD-Duct	Micro Application	3D Detailed MEP Modeling
Vectorworks Designer	Nemetschek	3D Architectural Modeling
Duct Designer 3D, Pipe Designer 3D	QuickPen International	3D Detailed MEP Modeling
RISA	RISA Technologies	Full suite of 2D and 3D Structural Design Applications
Tekla Structures	Tekla	3D Detailed Structural Modeling
Affinity	Trelligence	3D Model Application for early concept design
Vico Ofice	Vico Software	5D Modeling which can be used to generate cost and schedule data
PowerCivil	Bentley Systems	Site Development
Site Design, Site Planning	Eagle Point	Site Development

Fig. 17. Various BIM tools