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[1.] Ho Kui LAN, [2.] Abdelnaser OMRAN, [3.] Mohd Hanizun HANAFI, [4.]Syaihan Sajidah Muhamad KHALID,
[5.] Sharifah Nabila binti Syed ZAINEE, [6.]Lai Boon HOOI

BUILDING INFORMATION MODELLING (BIM): LEVEL OF UNDERSTANDING AND IMPLEMENTATION AMONG CIVIL AND STRUCTURAL ENGINEERS IN PENANG

[1.] Blk 27, New Upper Changi Road #07-692 Singapore 462027, SINGAPORE
[2.]School of Economics, Finance and Banking, College of Business, Universiti Utara Malaysia, Sintok, 06010, Kedah, MALAYSIA
[3-5.]School of Housing, Building and Planning, Universiti Sains Malaysia, MALAYSIA
[6.] Tunku Abdul Rahman University College, 77, Lorong Lembah Permai Tiga, 11200, P. Pinang, MALAYSIA

Abstract: Building Information Modeling (BIM) has gained the attention in the construction industry. BIM represents the development and use of computer-generated n-dimensional models to simulate the planning, design, construction and operation of a facility. It helps construction professionals to visualize what is to be built in simulated environment using 3D modeling. In this paper, the level of understanding of BIM among clients, users, architects, consultant engineers like civil & structural, mechanical & electrical engineers, and contractors in Penang will be identified. Another objective is to identify main factors of organisational change towards enhancing the implementation of BIM in Malaysia. First presented is the definition and concept of BIM with its advantages and implementation in construction. Then the role of civil and structural engineers in the construction industry will be further elaborate and research will be discussed based on the results collected by using qualitative method using interview. It is analyse from 4 respondents in the construction industry who knows about BIM. At the end, the result will be discussed and further explained.
Keywords: Building Information Model (BIM), Understanding, Organisational Change, Civil & Structural Engineer

1. INTRODUCTION

Building Information Modeling (BIM) technology uses software to plan, design, construct, and operate project facilities. Therefore, it is a data-rich, object-oriented, intelligent and parametric digital representation of the facility which is different from the traditional method. The principal difference between BIM and 2D CAD is that the building by independent 2D views such as plans, sections and elevations. In addition, data in these 2D drawings are graphical, in contrast to the intelligent contextual semantic of BIM models, where objects are defined in terms of building elements and systems (CRC Construction Innovation, 2007). It carries all data related to the building, including its physical and functional characteristics and project life cycle. A building information model characterizes the geometry, spatial relationships, geographic information, quantities and properties of building elements, cost estimates, material inventories and project schedule (Bazjanac, 2006). The construction documents such as the drawings, procurement details, submittal processes and other specifications can be easily interrelated (Khemlani *et al.*, 2006).

2. LITERATURE REVIEW

2.1.Level of understanding of BIM

However, there is no statistic regarding the application and implementation of BIM among the construction players in the Malaysia as surveyed (Tan, 2011). Thus this research is carried out with the objective to identify the level of understanding of BIM among civil & structural engineers in Penang, Malaysia. Another objective is to identify main factors of organisational change towards enhancing the implementation of BIM in Malaysia.

2.2.Implementation of BIM in various countries

The governmental institutions in the other countries are interested in bringing the construction sector to a higher level within the technological operability (Mulenga & Han, 2010). "The Building SMART Nordic focuses mainly on the implementation of BIM standards in real projects, through common and national projects. Finland is a pioneer in BIM and has progressed beyond the pilot phase. According to Mulenga & Han, (2010), Finnish AEC industry is leading the use of BIM worldwide. Sweden is also trying to promote BIM and it is currently developing an information handbook on IFC (Industry Foundation Classes) standards and it is involved in a two year build project with Finland, using web services and model servers.

However, in Sweden the major contractors are playing an important role in the construction sector, and have most likely influenced the use BIM in Sweden. The Danish government is trying to set the technological operability in construction through government initiative "Det Digitale Byggeri" (Mulenga & Han, 2010). Norway's BIM projects are supported by the whole industry and the government. Statsbygg decided to use digital BIM based on international standards with the final goal to use BIM in all Statsbygg's projects and building processes.

2.3.Role and responsibilities of civil & structural engineer in construction

The construction industry consists of a large variety of organisations which aims to erect, alter or refurbish different building or civil engineering structures. Building clients or developers responsible for the developing of these building or civil engineering structures, their policies and procedures may differ substantially, but the need for aesthetically striking, quality, functional buildings that is economical and cost effective, remains the same (Seeley, 1997).

Civil engineering is a field which involves designing, constructing, and maintaining the natural and physical environment. Their work is not limited to planning and designing, they also prepare property descriptions, deeds, final cost estimates and right-of-way maps. Structures made by civil engineers include dams, pipelines, tunnels, and bridges and any man-made structure. Structural engineering, on the other hand, is the analysis and design of structures which resist or support loads, ensuring they will not collapse and can withstand forces against them.The role of civil and structural engineers in building and construction is to improve the environment human live in by designing and creating projects that provide safety to the general public. Many engineers use computer aided design and drawing facilities to provide high quality of service in a timely manner. The responsibilities of Civil and Structural Engineer are as following:

1. Administer all engineering activities for medium to large civil projects and supervise efficient working of manpower and financial investments.
2. Assist all design personnel and engineers in various quality improvement processes and provide consultations to various departments on all technical aspect and perform regular analysis on same.
3. Provide expert technical knowledge to various civil engineering departments and manage all facilities for projects and develop effective relationships with new and existing clients
4. Ensure signature on all civil contracts and design all equipment specification for projects and evaluate all supplier data and perform appropriate tests.
5. Maintain knowledge on all technologies and establish budget and staffing requirements for all projects as per schedule.
6. Analyse all project requirements and prepare all required technical papers and recommend modifications and changes if required and participate in various design meetings to negotiate with all subcontractors.
7. Evaluate all civil processes and ensure efficient quality control on all projects and provide support to engineering team

2.4.Benefits of BIM

BIM is a multi-dimensional model that acts as a communication and information resource over the lifecycle of a construction project. It consists of 3-dimensional (3D) design functions, cost estimating functions and programming and scheduling functions. The construction industry has relied on hard copies of 2D drawings to depict the work to be executed. They formed part of the contract documentation that were assessed by building codes and used for facilities management (Eastman, 2007). However, with BIM, it is all the information used computerised portrayal of construction project, structured according to some building product data model (Matipa, 2008). BIM solves these problems through various characteristics. BIM uses geometric shapes and three spatial dimensions (3D) to create building models through parametric modelling. This is called object-orientated modelling and 4D and 5D simulation (Ashcraft, 2007). The application of BIM has the result of many advantages, such as:

2.4.1. Greater speed

The multi-dimensionality of BIM allows various deliverables and documentation to be prepared simultaneously to the design of the building. Furthermore, the use of object-oriented design and the re-use of information accelerate the creation of drawings (Ashcraft, 2007).

2.4.2. Uniform design base

As information is exchanged between different parties, errors might be transferred with it. BIM ensures that all parties work on the same base model, that coordinates building objects created across various disciplines which will quickly expose errors (Howell and Batcheler, 2005).

2.4.3. Cost estimating

The model is able to produce cost estimates, bills of quantities and bills of materials which will be automatically updated as the model or any linked cost information changes (Ashcraft, 2007). This reduces human errors that could have crept in when producing these manually.

2.4.4. Visualisation and constructability review

Contractors use BIM models to review the constructability of the building or structure, and identify the challenges involved in the erection of this structure. It also helps to solve the contractors sequence and scheduling difficulties through the incorporation of 4D simulation (Ashcraft, 2007).

2.4.5.Controlled whole-life costs and environmental data

Environmental performance is more predictable, lifecycle costs are better understood. Digital product data can be exploited in downstream processes and be used for manufacturing or assembling of structural systems.

2.5. Factors of Organisation Change towards BIM

The development of BIM will influence the organisational culture, which affects can be identified within the business process, technologies used and peoples work practices. While these aspects ultimately contribute towards the organisational readiness to accept BIM, there are several factors in ensuring the successful implementation process of BIM(Arayici, Khosrowshahi, Ponting, & Mihindu, 2009).

2.5.1. High-profile communication

In line with raising awareness for top-to-bottom buy-in in an organization, it is important that organizations communicate their ambitions and accomplishments related to BIM, not only internally but externally. A high-profile communication plan demonstrates to all stakeholders the organization's commitment to BIM, helps to inject energy into the transformation, and bridges the gap from executive theorizing to a daily reality.

2.5.2. Training & education

BIM practitioners will need the training and education to support their adoption of BIM into their daily work projects. BIM training and education programs also drive and motivate practitioners, building up valuable intellectual capital in an organization.

2.5.3.Policies & strategies

Approaches and benefits for adopting BIM that aligns with the overall goals and objectives of the organization for competitive positioning, operational excellence, and effective delivery.

2.5.4. Change management

The BIM change and adoption program built to deliver the expected benefits in operational performance through program coordination, knowledge transfer, performance management, and education and training

3. RESEARCH METHODOLOGY

This study aims to determine the level of understanding of professionals in the construction industry about Building Information Modelling focusing in Penang. The preliminary study to obtain the initial data was carried out which comprised of definition and concept of BIM, the level of understanding, the implementation of BIM, the roles and responsibilities of C&S engineers in implementing BIM and the benefits of BIM. Several interviews were conducted for this study and the respondents consist of four experienced civil and structural (C&S) engineers working in construction industry in Penang Island. Data was collected from the interview sessions conducted and the four engineers were selected randomly. The four engineers are experienced and working for more than 10 years in the construction industry in Penang Island. They are also having knowledge about BIM or at least know about BIM.

4. RESULT ANALYSIS

Closed-interviews were held by three sessions; two respondents in the first session and one respondent for second and third session; and the result found and analysed after some explanations from both parties. Four respondents were managed to be interviewed, coming from two different civil and structural (C&S) consultant's firm in Georgetown, Penang. Two of the respondents are the principal engineers and the remaining two are design engineers who are familiar with BIM. All respondents have working experience of more than ten years in C&S works either in Malaysia or other countries. Below are the details of the respondents that managed to be interviewed.

Table 1. Presents the Respondents' Background

	Respondent 1	Respondent 2	Respondent 3	Respondent 4
Position	Principal Engineer	Design Engineer	Design Engineer	Principal Engineer
Company	CAA Engineering Consultancy	SW Consultants & Associates Sdn Bhd	SW Consultants & Associates Sdn Bhd	SW Consultants & Associates Sdn Bhd
Educational background	MSc. Engineering USM	BSc. Civil Engineering USM	BSc. Civil Engineering UTM	33 years working experience.
Accreditation	BEM M.I.E.M	BEM	BEM	BEM M.I.E.M A.M.I.C.E

Table 2. Level of understanding of BIM

	Respondent 1	Respondent 2	Respondent 3	Respondent 4
1.What is BIM?	Heard about it but not into details	Structural design software.	Structural design software.	Never heard of BIM
2. Familiarity	Esteem towards the software; mainly familiar for structural design and mechanical works.	Use to design. Every single line carry some data/s.	Use to design. Advance software of handling data.	Not familiar
3.Understanding	It is a modelling software of a building to coordinate all elements.	It is a 3D-communicate with AutoCad, Revit and others. Easier to imagine the whole structural of the building.	Generate 3D & modify working drawing for construction. Easier not to change manually from tabular.	Modelling for building works. (after some explanation)
4. Application in related field of work. When?	Merely 10 years	Since 2005	Since 2005	-
5. Effectiveness in construction industry	The software is esteem where a plan can be transformed into a different dimension.	Time saving. Use in many projects; Gamuda, IJM.	Time saving. Rarely detail and leave it for contractor/s to amend.	-
6. Implementation in company	Yes.	Yes.	Yes.	Half-way
7. Procedures towards the well implementation	It is user friendly. Before this, have to use grid line to design. Now, just copy the plan/s from architect and design.	Attend course for beginner. Training to improve skills.	High maintenance software per year. Need to upgrade & update annually.	-
8. Explanation & introduction to colleague	They should know since engineers need to use it.	Do some modules with colleague.	Explain on some examples of the projects.	Take a lot of time to consume understanding to others.
9. Suitability in current construction industry	Yes, suitable but need to be upgraded.	Yes, all the upline & downline should use it to update data/s from the very beginning of the work.	Yes, it is a future software.	It is suitable.
10. Initiator parties	Government of 50% of the initiator. Singapore used it a while ago.	Architects at most. They do the pre-design and distribute raw data to consultants.	Paymaster or client.	Architects; for building.
11. Impact to construction industry	Gives good impact with good time consuming. Consultants & client/s can do amend the structure.	Impact by cost. It should be recovered from the project itself. Design effectively.	Time consuming on design & changes can do faster than manual drawing. Perfection of design.	High cost demand for maintenance. No value in the future, in term of the software.
12. Suitable project/s to implement	High-rise project but still have to re-check the design drawing manually. Cannot 100% depend on software.	Hospitals and service projects.	Oil & gas; currently high demand.	Infrastructures & large projects of structures.

5. RESULTS AND DISCUSSION

The level of understanding of all respondents is predictable due to the familiarity and existence of BIM is at the stage of introduction although BIM already had been explored for ten years in Malaysia. Three respondents are familiar with the software but one of them does not exactly know about it meanwhile a principal never heard of it. They agree on the same usage of BIM, mainly used to do design works of structural, and every single line that carried out by the drawings carry some data of the project.

Advance software of handling data have been introduced to the construction sector. All four respondents understand that the software was built for modelling the building structural works that coordinate all elements and it also the 'brain' to other software as such Autocad, Revit, Autopipe and others. It is more reliable to amend construction drawings or working drawings using BIM compared to manual change by only drawing software such as Autocad. Although they have experience in construction line of more than ten years, they seem to know about BIM about eight to ten years only. There are many advantages by using this modelling software as one of them is time saving. Normally, to amend a drawing, one party will redraw the detail and pass it to the other party to amend according to their specialized area and so do the other parties, but with BIM they only need one-time amendment to change the slots by all parties. Respondent 1 agreed on BIM where this software is very esteem; a plan can be transformed into a different dimension of the building's detail. Furthermore, it is user friendly that it can change a drawing into what we want it to be by using the command applied by the software. The building can be seen in different perspective and more imagination and understanding towards the project. However, to well-implemented it, company needs to spare some time and money; it is a one-off investment with high maintenance annually. All four respondents were 100% agreed on this issue but to upgrade the work stage internationally and always be updated to the technology, they have no other alternatives but to invest more on technology and human capital. Training has to be carried out to staffs and beginners to improve their skills of handling the software. It is user friendly that every party will collaborate with each other once architect take the first move on designing and spread the drawing to other parties to add and comment on the design. The first step to introduce BIM to colleague is to conduct modules and provide some examples of projects that have been using the software. Explanation should be clear although it is time consuming for everyone to well-understood the programme. One respondent said that everyone should know the software since engineers need to use it when designing. Current condition of construction industry is very suitable to apply BIM because it is future software of designing and implementing it nowadays can predict of what future will lead us. All the upline and downline management should be able to understand and able to use it to update every single data from the very beginning of the project. As said earlier, upgrade and update are needed to well-implemented BIM. Initiator is the most important person in managing a project. Hence, out of four respondents, two of them agreed on architect should be the initiator of BIM. Architects provide the raw design of space and building and pass it on to other consultants to add data and so on. Government is one of the initiator since Singapore is already implemented BIM and got the support from their government in using BIM. The implementation of BIM should covered high-rise, infrastructure and large projects, but currently, only respondent 3 believe that oil and gas sector is highly in demand of using BIM. BIM does provides good impact to construction industry as it will save more time in preliminary stage; designing and planning stage. Not to focus only on consultants, clients can also view, comment and amend the design with the help from expertise. It is one of the perfection in designing and effectively faster changes than manually design; traditional way of design. Cost of the software should be recovered by the project itself in order to not cut off other project's cost. The conclusion is the level of understanding is quite high among civil and structure engineers based in Georgetown, Penang. Three out of four engineers seem to understand the whole concept of BIM and already use it for at least a decade time in designing and constructing project. However, BIM need to be exposed more in the future so that everyone works in construction industry can work together and share the same dimension of viewing a project effectively.

6. CONCLUSION AND RECOMMENDATIONS

From the study, it can be concluded that the level of understanding of BIM among professionals (civil and structural engineers) in Penang Island is quite high. Three of the respondents interviewed know well about BIM and the remaining engineer is actually knows about BIM without realising it. However, BIM still should be promoted and widely exposed in the construction industry in Penang not limited to engineers only but to other professionals as well.

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