

# Transformation from 2D structural drawing to building information model: Perspectives from a small-scaled company

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**Abstract.** Building information modelling (BIM) is one of the revolutions in construction industry. BIM is one of the long-waiting solutions for construction industry in order to solve the arisen quality and effectiveness problems. Many researchers have proved the benefits gained from BIM. In this paper, the structural package available in BIM platform is summarized and its maturity is discussed. The BIM projects in Malaysia are listed and it showed a low local BIM implementation. In the perspectives of engineers, migrating from 2D drawing to building information model is discussed with the faced problems and challenges. The technical supports such as internet supports, cloud system and etc. was lacked for small-scaled companies; and self-transformation plan is not available which is believed to minimize the lost during transformation. From structural engineers' perspective, a better visualization with building information models is critical to address these major problems occurred throughout the migration. However, more time are expected to be consumed in producing the models as it was found that there is a low level of model sharing between engineers and architects. Although the BIM implementation in Malaysia is still in a low level, it is advised that industry players and government should work together to migrating from traditional method to BIM environment.

## 1. Introduction

Building information modelling (BIM) comes across to minimize the problems which may potentially arise during construction, and reduce the cost through virtual construction during planning stage in architecture, engineering and construction (AEC) industry. As the virtual model is completely developed, this building information model has accurate geometries and applicable input data for design, quantity, fabrication and construction activities in order to make it tangibly exists [1].



BIM has been discussed actively and excitedly in last 10 years where AEC industry was seeking for a long period to solve the quality problem while increase the productivity [2]. It is also noticeable that BIM can alter the workflow and project delivery processes [3]. Moreover, the model also can be transferred after construction for maintenance purposes. From the study [4], BIM projects were able to reduce the project time by 7% compared to traditional method, achieve a save of 10% in contract value due to early found of clash activities before construction, and obtain up to 80% time savings in generating a cost estimation.

Questionnaire surveys were conducted in United State in order to understand the BIM effect in AEC industry [5]. A sample size of 302 was collected and it was found that architects were the BIM heaviest users. A 66% of the respondents believed BIM helped them to increase the chances for winning a project and 79% stated that BIM improved project outcomes with decreased the problems raised during construction. The value in using BIM and the factors contributing to success have been determined [6]. They believed the benefits gained from BIM but some of AEC players still retain traditional drawing method.

Malaysia, one of the developing countries that affected by the BIM wave as the AEC industry is active throughout the development process. BIM has been promoted in Malaysia through myBIM center of Construction Industry Development Board (CIDB) with provided training and incentives. There were several projects that involved BIM implementation, namely Multipurpose Hall of Universiti Tun Hussein Onn Malaysia, National Cancer Institute of Malaysia, EduCity Sports Complex Nusajaya, and Ancasa Hotel Pekan [7].

BIM has been implemented in Malaysia AEC industry. The effect on the changes is needed to be investigated especially from the perspective of structural designers, one of the AEC players. This paper addresses a study of the change to BIM environment which affecting the routine works of designers. BIM projects in Malaysia have been listed and BIM implementation has been discussed in the perspective of engineers.

## 2. Structural Analysis

Structural design is involved at the tendering process where the building safety should be obtained for occupants. Structural analysis is a main design stage to adequately transfer the building loads to foundations without significant changes of physical shape of the building. Stability and load transfer are concerned in design of structural members.

### 2.1. BIM platform

There are several platforms that allow BIM users to work with, namely Autodesk (Revit, Autodesk BIM 360, Navisworks), Bentley (AECOSim Building Designer), Graphisoft (Archicad), Tekla (Tekla BIMsight), etc. There are summarized in Table 1.

### 2.2. Available structural package

A good amount of structural package is available in the market to assist designers with adequate structural analysis. Table 2 summarizes the structural analysis packages that available in the market and their file setting.

Table 1: Available BIM platform

Platform	Package	Benefits
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		Multidiscipline solution for AEC	Open BIM	Own library	Free tool	Design review, comments, marks up	Visualization of modifications	Clash detection	Building performance analysis	Mobile application
Autodesk	Revit	/	/	/				/	/	
	Navisworks		/			/		/		
	Autodesk BIM 360		/			/	/			BIM 360 field
Tekla	Tekla BIMsight		/	/	/					BIMsight note
Graphisoft	ArchiCAD		/							BIMx
Bentley	AECOSim Building Designer	/	/						/	

### 2.3. Maturity of design packages

Other than structural analysis, software developers are now working towards the feature of open-code file format of Industry Foundation Classes (IFC) created by buildingSMART which can be viewed in most of the platforms or software. IFC has features of 3D elements, ability to store data, filterable, reference model representation, global access by software developers, enable fast code implementation and able to localize national standards. The available structural packages listed in Table 2 are all able to import or export IFC files. Structural packages are unable to be excluded from the integration in BIM community as the model needs the inputs from structural analysis.

The accuracy of structural analysis in obtaining a safe and reliable building is the main characteristic that should be achieved before integration into BIM environment. Elimination of some structural packages from AEC industry may also happen if failure occurred in engaging with BIM atmosphere. Therefore, both accuracy and engagement with BIM should be obtained to survive in current AEC industry.

## 3. Review in Malaysia

There are completed or on-going projects that implement BIM which are summarized in the following contents. Other than review published projects, reanalysis of the completed project with several structural package also has been conducted to know the capability of these package in BIM environment. Malaysia government is enforcing to use BIM for those local authorities with city status by 2021 where national BIM e-submission is required [8].

### 3.1. Previous investigation

Review on previous studies in Malaysia is conducted and summarized accordingly. The level of implementation is discussed and the BIM projects are documented in following contents.

Table 2: Structural analysis package that available in market

Structural analysis package				Intermediate / convertor	Landing environment / files / platform
Software	Platform	File type			
		Original	Available		
Orion	Tekla/CSC	Orion	.cxl .dxf	Orion-Revit Integrator (add-in of Revit)	Revit
ProtaStructure	Prota	Prota	-	ProtaBIM	Revit, Archicad, Tekla structure, IFC
Tekla Structure	Tekla	Tekla	-	IFC insert IFC export	IFC2X3 IFC4
ROBOT	Autodesk	ROBOT	.RTD .STR	ROBOT, Add-in, integration	Revit
STAAD (Staad Pro, staad pro advanced, RCDC, Staad foundation, Microstran)	Bentley	STAAD	.STD	Structural Synchronizer	IFC ISM
RAM (RAM Structural system, RAM Connection, RAM Elements, RAM Concept, Structural component Visa)	Bentley	RAM	.rss	Structural Synchronizer	IFC ISM
SCIA	Nemekschek	SCIA	.esa	BIM Toolbox	IFC2X3
RFEM / RSTAB	Dlubal	-	.asf	Results Explorer (Structural Analysis Toolkit of Autodesk)	Revit IFC
FEM-Design	StrucSoft	-	-	StruXML Revit add-in Tekla StruXML	Revit, Tekla structure

### 3.1.1 Level of BIM implementation

Level of BIM implementation has been assessed with literature review and interview method [9] where it was found difficulties in implementing process due to the lack of national standard to comply with. Many local companies developed their own strategies to adopt BIM technology. From traditional method to BIM, small or medium scale projects may come across as the best practice in reducing the risk in migration. Some factors of the low BIM implementation and suggestions to overcome have been reported through a questionnaire survey [10]. Construction players also need to perform their roles in promoting BIM, rather than government work alone in the implementation process.

Recent publication on level of BIM implementation has been established in Melaka, Malaysia [11]. There was a number of 46 questionnaires were used for analysis for a population of 90 construction companies in Melaka. The lack of awareness was found as the main factor in delaying the BIM implementation. Hence, organizations were advised to practice BIM and initiatively develop own

transformation plan to overcome the faced challenges. Hence, it could conclude that Malaysia is in low level of BIM implementation [12]. In order to successfully implement BIM, a framework has been proposed, as shown in Table 3, initiated by Jung and Joo [13] and reported by Bui et.al. [14].

Table 3: The BIM implementation framework [13]

Technical (T)	<ol style="list-style-type: none"> <li>1. Data property</li> <li>2. Relation</li> <li>3. Standards</li> <li>4. Utilization</li> </ol>
Perspective (P)	<ol style="list-style-type: none"> <li>1. Industry</li> <li>2. Organization</li> <li>3. Project</li> </ol>
Construction business function (C)	<ol style="list-style-type: none"> <li>1. R&amp;D</li> <li>2. General admin</li> <li>3. Finance</li> <li>4. HR management</li> <li>5. Safety management</li> <li>6. Quality management</li> <li>7. Cost control</li> <li>8. Contracting</li> <li>9. Materials management</li> <li>10. Scheduling</li> <li>11. Estimating</li> <li>12. Design</li> <li>13. Sales</li> <li>14. Planning</li> </ol>

### 3.1.2 Previous building project - National Cancer Institute (NCI)

The first Malaysian project that implemented BIM was the building of National Cancer Institute [15]. The project details have been summarized in Table 4. NCI had been completed two weeks ahead from the expected completion date. There were 1800 clashes found and able to solve before construction. In this project, they utilized Revit (architecture, structure, M&E) and Navisworks.

### 3.1.3 Previous infrastructure project Pan Borneo Highway Sarawak (PBHS)

Pan Borneo Highway Sarawak (PBHS) is one of the BIM initiation project in infrastructure which can be referred as a national benchmark for infrastructure BIM [16]. The details of the project are tabulated in Table 5.

## 3.2. On-going BIM projects

There are some identified on-going Malaysian projects that utilize BIM as a working platform to integrate all relevant involved parties. There are several pilot projects that involved with BIM implementation for building construction, namely Healthcare Center Type 5 at Sri Jaya Maran, Pahang; Administration Complex Project of Suruhanjaya Pencegah Rasuah Malaysia (SPRM) at Shah Alam, Selangor; primary school of Meru Raya Ipoh, Perak; and primary school of Tanjung Minyak 2, Melaka Tengah [7,17].

For infrastructure, MMC-Gamuda is working as project delivery partner for KVMRT Sungai Buloh-Serdang-Putrajaya (SSP) line. The alignment is 52.2 km in length, 38.7 km elevated tracks and 24 elevated stations. It is divided into 19 work package contractors. This project is aimed to be completed

in 2022. Phase 1 will operate as early in July 2021 which is from Sungai Buloh station to Kampung Batu Station. This project is adopting BIM level 2. Moreover, Phase 2 of PBHS on maintenance and upgrade will also use the BIM approach to conduct the project.

Furthermore, several companies are actively applying BIM in their current projects, such as UEM Sunrise, MMC-Gamuda, IJM Construction, Sunway Construction, etc. All high-rise building projects are now adopting BIM since 2017 at UEM Sunrise. MMC-Gamuda is applying BIM into their MRT project. IJM Construction won the best project award for major buildings above RM100 million during Malaysian Construction Industry Excellence Awards 2019 with Equatorial Plaza using BIM platform for integration. Sunway Construction is one of the first to introduce virtual design and construction which is equivalent to BIM platform.

Table 4: Project details for NCI [15]

Project	National Cancer Institute (NCI)
Location	Putrajaya (2.926907,101.6739021)
Scale	70,000 m <sup>2</sup>
Duration	3 years
Client	Ministry of Health Malaysia and Public Works Department
Value	RM 690,000,000
Architect	Perunding Alam Bina
Contractor	Kiara Teratai – IJM Construction Joint Venture
BIM consultant	Precision Design Solutions Sdn Bhd
Energy consultant	IEN
Project delivery	Design and build
Description	A total of three building blocks where a hospital block comprising of one level sub-basement for radiotherapy treatment, one level of car park, four levels of oncology diagnostic and treatment services, as well as two blocks of seven levels wards.

Table 5: Project details for PBHS [16] (Akob et.al., 2019)

Project	Pan Borneo Highway Sarawak (PBHS)
Location	Sarawak
Scale	1060 km
Duration	2016 – 2021 (highway) phase 1
Client	State government and Public Works Department
Value	RM 16.5 billion
BIM resources	Using level 2 of BIM and provided up to level of development of 500. This project consists of five BIM modellers and one coordinator for each package, the total number of dedicated personnel is 55 BIM modellers, 11 BIM coordinators, 8 BIM specialists, 4 BIM lead family, 1 BIM lead coordinator and 1 BIM director.
Description	Construction of 786 km of a new 4-lane highway in 11 works packages.

### 3.3. From 2D to BIM

Shifting from traditional method to BIM affects positively as stated in previous research. The significant output should address the reduction of request of information and potential clashes during construction period. The transformation plan is essential to minimize the loss during migration from traditional method. Self-transformation plan by consultant firms may consume some budget before gaining profits. These budgets include the expenses of staff training program, purchase of BIM tools/software, upgrade

internet system, increase cloud spaces, etc. The cost always becomes predominant in BIM implementation for small-scaled companies [18].

From the point of technical support, BIM technology requires more on the internet system, cloud space, live communication environment, etc. These requirements seem like to be a burden for small scaled construction companies in developing countries [14] which they need to upgrade their system to support this technology. In turn, it will reduce the gained profit. These companies usually outsource to others and this would not help in sustaining their business in BIM world. In Sarawak, one of the states in Malaysia, the developments may focus in rural areas where there is a lack of proper communication system, like internet connection that used for project integration. The up-to-date BIM models may not delivery on time or not able to be applied in this context.

However, in term of structural analysis, BIM provides a clearer visualization in 3D version and may reach 4D (time), 5D (cost), 6D (sustainability) or 7D (facility management). Structural engineers may need more detail in analysis where 3D drawings are available for checking before construction stage. The small and unnoticeable areas may need designers' attention in the design stage. Therefore, it is believed that structural engineers may take more time in the design stage where it can be catch up in later construction time. As the structural design needs more time, workload may subsequently increase and may need to hire more engineers at early stage of transformation. Draughtsperson, who assists engineers, may also need to upgrade their drawing to 3D version and training courses are needed for the in-house promotion to BIM modellers or restructure the organization. This also needed to be considered in the company self-transformation plan.

Often, engineers are wasting their time in redrawing the proposed structure as architects are fail to share their 3D models. Therefore, it requires more time in analysis and provides 3D drawings. From previous research [19], the successful of information sharing is relied on the organisational behaviour supported by the collaborative constructs. The 3D drawings that produced by engineers may not compatible with architects as minor geometric mistakes may occur due to human errors.

#### **4. Conclusions**

This paper summarized the transformation from traditional method to BIM platform. The available structural packages in BIM environment have been studied and the completed and on-going projects in Malaysia were reported. There is a proposed framework for this migration where technical, perspective and business functions are the design parameters. The level of BIM implementation in Malaysia is still in a low level that both government and industry players should work together to make the transformation successful.

It is advisable to have company own migration plan in order to minimize the risks in the transformation process where in-house training and system upgrading should be performed to overcome the BIM wave. The backup solution should be applied for BIM non-applicable zone, such as rural area where technical supports are not parallel with the technology.

BIM serves as a platform to integrate all parties in construction which has been proven beneficial to AEC industry. It might be a challenge for small-scaled companies of developing countries in the transformation process from traditional 2D model to building information model. However, it should be positively solved for building a quality AEC industry.

#### **Acknowledgement**

Authors would like to acknowledge the supports from ADDA consultant firm in Kuching in completing the initial case study and the supports from Curtin University Malaysia.

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