STUDY ON BUILDING INFORMATION MODELING (BIM) PROCESS FLOW IN CONSTRUCTION INDUSTRY: A MODEL EXPLORATORY APPROACH TO RESEARCH

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ABSTRACT

BIM is a technology that uses parametric modeling to minimize the time spent in coordination of design details like locating and moving architectural elements and the corresponding required documentation changes. It also has the added benefit of allowing the entirety of design development to occur in three dimensions possibly leading to better quality designs and enabling timely creation of realistic renderings. It allows greater control of document information, such as schedules, and can produce and manage information like occupancy plans for use in the long term facility management process. Currently, the facility delivery process remains fragmented and it depend on paper-based modes of communication. Errors and omissions in paper documents often cause unanticipated field costs, delays and eventual lawsuits between the various parties in a project team. In using CAD, we are essentially drawing the same way we did on paper – in two dimensions. The only difference is that now the drawings are electronic and easier to manipulate and reproduce. We can move entire walls with a few clicks of the mouse where as on paper the entire sheet had to be redrawn. This drastically speeds up the process but also creates some challenges as well. One of the common problems associated with 2D- based communication during the design phase is the considerable time and expense required to generate critical assessment information about a proposed design, including cost estimates, energy use analysis, and structural details. So BIM is the new thing can solve these problems. The Objectives of this study are to explore, appraise and synthesize relevant literature with specific focus on BIM's process flow and develop 3D parametric model, to test the BIM's process flow and develop 3D parametric model using Revit Software. The 3D parametric model helps different parties to better understand the style, especially details of the design. 3D parametric modeling facilitates the design of substantial and intricate models with 3D however impose a mode of modeling and also planning. The ability to extract geometric and also property information from a building model easy use in design, investigation, construction planning or with operations. Using walkthrough tool, it allow visualizing inside the building and it helps to check error inside the building. So with these 3D parametric modeling hopes it can help to solve problems before and during the early phases of design and save time of the project.

ABSTRAK

BIM adalah teknologi yang menggunakan pemodelan parametrik untuk mengurangkan masa yang digunakan dalam penyelarasan maklumat reka bentuk seperti mencari dan bergerak elemen seni bina dan perubahan dokumentasi yang diperlukan sepadan. Ia juga mempunyai manfaat tambahan membenarkan keseluruhan pembangunan reka bentuk berlaku dalam tiga dimensi mungkin membawa kepada reka bentuk yang lebih baik dan membolehkan penciptaan tepat pada masanya pentafsiran yang realistik. Ia boleh mengawal maklumat dokumen , seperti jadual dan boleh menghasilkan dan menguruskan maklumat seperti rancangan penghunian untuk digunakan dalam proses pengurusan kemudahan jangka panjang. Pada masa ini, proses kemudahan penghantaran masih berpecah-belah dan ia bergantung kepada mod pandangan yang berasaskan kertas komunikasi. Kesilapan dan ketinggalan dalam dokumen kertas sering menyebabkan kos yang tidak dijangka bidang , kelewatan dan tindakan undang-undang akhirnya antara pelbagai pihak dalam pasukan projek. Dalam menggunakan CAD, kita pada dasarnya melukis dengan cara yang sama yang kita lakukan di atas kertas - dalam dua dimensi. Satu-satunya perbezaan adalah bahawa kini lukisan elektronik dan lebih mudah untuk memanipulasi dan pengeluaran semula. Kita boleh bergerak ke seluruh dinding dengan beberapa klik tetikus manakala di atas kertas, keseluruhan lembaran terpaksa dilukis semula. Secara drastiknya mempercepatkan proses tetapi juga mewujudkan beberapa cabaran juga. Salah satu masalah yang biasa dikaitkan dengan komunikasi berasaskan -2D semasa fasa reka bentuk adalah masa yang agak besar dan perbelanjaan yang diperlukan untuk menjana maklumat penilaian kritikal tentang reka bentuk yang dicadangkan, termasuk anggaran kos, analisis penggunaan tenaga, dan butir-butir struktur. Jadi BIM adalah perkara yang baru boleh menyelesaikan masalah ini. Objektif kajian ini adalah untuk meneroka, menilai dan mensintesis literatur yang berkaitan dengan fokus khusus kepada aliran proses BIM dan membangunkan 3D model parametrik , untuk menguji aliran proses BIM dan membangunkan model parametrik 3D menggunakan Perisian Revit. Permodelan parametrik 3D ini membantu pihak yang berbeza untuk lebih memahami gaya, terutamanya butiran reka bentuk. Pemodelan parametrik 3D memudahkan reka bentuk model yang besar dan rumit walaupun 3D mengenakan mod model dan juga merancang . Keupayaan untuk mendapatkan maklumat geometri dan juga daripada model bangunan mudah digunakan dalam reka bentuk , penyiasatan, perancangan pembinaan atau dengan operasi. Dengan menggunakan ikon *Walkthrough* , ia membolehkan menggambarkan keadaan dalam bangunan dan ia membantu untuk memeriksa kesalahan yang terdapat di dalam bangunan. Jadi dengan ini model parametrik 3D berharap ia boleh membantu untuk menyelesaikan masalah sebelum dan semasa fasa awal reka bentuk dan menjimatkan masa projek.

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LIST OF ABBREVIATIONS

BIM	Building Information Modeling
CAD	Computer Aided Drafting
AEC	Architecture, Engineering and Construction
3D	3 Dimensional
2D	2 Dimensional

CHAPTER 1

INTRODUCTION

1.1 DEFINITION OF BUILDING INFORMATION MODELING

BIM is a technology that uses parametric modeling to minimize the time spent in coordination of design details like locating and moving architectural elements and the corresponding required documentation changes. It also has the added benefit of allowing the entirety of design development to occur in three dimensions possibly leading to better quality designs and enabling timely creation of realistic renderings. It allows greater control of document information, such as schedules, and can produce and manage information like occupancy plans for use in the long term facility management process. A transition to BIM in the professional world requires a paradigm shift in terms of the design process and especially time spent in different project phases (Holness, 2006). Adaptation of the technology in design programs may also require a shift in curricula and projects in order to create graduates skilled in application of this type of computer software. Using a Building Informative Modeling (BIM) from the beginning of a project helps engineers and designers make better decisions earlier in the process. A BIM's 3-D graphics of buildings and systems are generated by data that can be easily changed as the project moves along. Most BIM software links intelligent objects together, so when a change is made to one object, parametric changes are made to any other objects that are linked. For example, if an engineer changes the airflow of a diffuser, the corresponding duct, diffuser and neck sizes automatically change (Dennis, 2010).

1.3 PROBLEM STATEMENT

Currently, the facility delivery process remains fragmented and it depend on paper-based modes of communication. Errors and omissions in paper documents often cause unanticipated field costs, delays and eventual lawsuits between the various parties in a project team. In using CAD, we are essentially drawing the same way we did on paper – in two dimensions. The only difference is that now the drawings are electronic and easier to manipulate and reproduce. We can move entire walls with a few clicks of the mouse where as on paper the entire sheet had to be redrawn. This drastically speeds up the process but also creates some challenges as well. One of the common problems associated with 2D-based communication during the design phase is the considerable time and expense required to generate critical assessment information about a proposed design, including cost estimates, energy use analysis, and structural details. So BIM is the new thing can solve these problems. With BIM technology, one or more virtual models of building are constructed digitally.

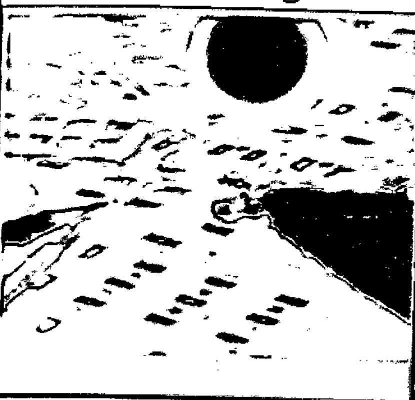
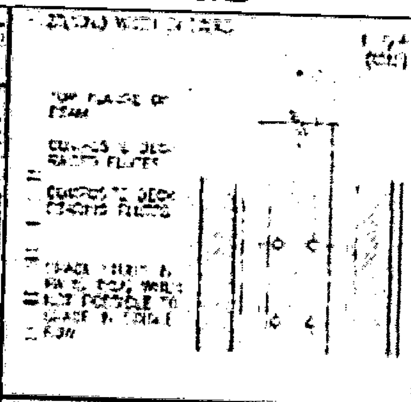
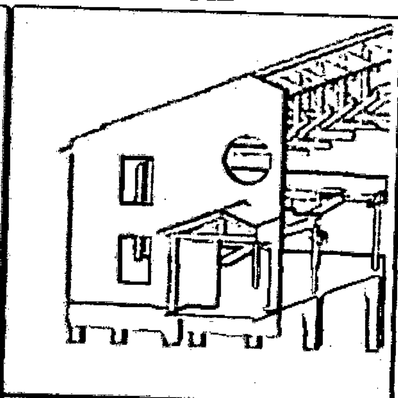
Hand Drafting	CAD	BIM
		
Before 1982	1982 to Current	2000 on
Triangle and tee square	AutoCAD® software	Revit
Hand-drawn technical artwork	Digital-drawn technical artwork	Database of building objects
Lines, arcs, circles, hatch, and text	Lines, arcs, circles, hatch, and text	Walls, beams, columns, windows, doors
2D and isometric views	2D, 3D, and some solids	2D, 3D, 4D (plus time), 5D (money and time), Dn (energy, materials, and so on)
Noncomputable data represented in technical artwork	Noncomputable data represented in technical artwork	Database of structure that can digitally interact with many other BIM processes and applications
Highly trained and skilled professionals must interpret the artwork and manually use the information.	Highly trained and skilled professionals must interpret the artwork and manually use the information.	Highly trained and skilled professionals use the information in an automated format with BIM.

Table 1.1: Compares drafting, CAD, and BIM. Notice the structural engineering profession has never seen a change like BIM before. The change from board drafting to CAD cannot compare to the change from CAD to BIM.

Building Information Modeling (BIM) radically transforms the process by which building structures are designed and constructed. This unit highlights some of the areas in which BIM aids in coordination, which can help save time and expand the way structural engineering information is presented and delivered. This concept of new ways for structural information to be delivered is built around the idea of building lifecycle management.

1.3 AIM

i. To develop Building Information Modeling (BIM) flow chart to capture structure information for existing building.

1.4 OBJECTIVES

The objective of this study on the performance result of Building Information Modeling (BIM) in construction industry. Referring to the statement, the objectives have been identified are as follows:

i. To explore, appraise and synthesize relevant literature with specific focus on BIM's process flow and develop 3D parametric model.
ii. To test the BIM's process flow.
iii. Develop 3D model using Revit Software.

1.5 SCOPE OF STUDY

The main of this research is to develop Building Information Modeling (BIM) flow chart. This research will involve structural components of the building only. This case study will be conducted in Kuantan, Pahang and involve a number of respondents to be interviewed. Revit Suite software will be used in this study to compare the result between conventional CAD and BIM method. From this study we will see the process flow for both method and can identify the differences.

CHAPTER 2

LITERATURE REVIEW

2.1 OVERVIEW OF BIM

Documents include 2D drawings, written specifications, manually calculated bill of material quantities, etc. Although computers have automated the process of document production, the data exchange and management procedures are still focused on paper-based documents because of the legal implications for digital exchange of project data that are still new within the AEC industry (Jongeling, 2006). Other researchers and industry experts have argued that most design communication is still done using 2D drawings and other text documents (Foster, 2008). This finding is also confirmed by another study where the slow pace of BIM adaptation was explained using the issues of overcoming the 2D versus 3D working cultures that are still relatively new within the industry (Kivinemi et al., 2008)

However, BIM as both a technology and a process provides an array of technological advantages over conventional CAD documentation and project management and delivery. As opposed to previous 3D CAD systems that used polygonal surface modeling, BIM applications utilize parametric modeling. Parametric modeling involves the use of relational databases containing information regarding the elements of a structure and their relationships. The capture and management of object relationships is useful in enabling a high level of model analysis beyond object properties. BIM applications are based on object-oriented technology, a technology based on the use of digital representations of the physical elements of the building such as walls, doors, floors, etc. (Khemlani et al., 1998).

Objects also include definitions of abstract concepts including: relationships such as connections and adjacency, object-oriented definitions such as wall type and door type, hierarchies such as containment and groupings such as zones and systems. Properties are attached to objects in order to identify and describe them in some way. The properties vary in terms of their type and detail. Typically these properties are defined in a BIM authoring application and can then be used by analysis and simulation applications to assess design performance such as thermal, structural and cost attributes (Eastman et al., 2008)

In the seven years since the term "Building Information Modeling" or BIM was first introduced in the AEC industry, it has gone from being a buzzword with a handful of early adopters to the centerpiece of AEC technology, which encompasses all aspects of the design, construction, and operation of a building. Most of the world's leading architecture, engineering, and construction firms have already left behind their earlier, drawing-based, CAD technologies and are using BIM for nearly all of their projects. The majority of other firms also have their transitions from CAD to BIM well underway. BIM solutions are now the key technology offered by all the established AEC technology vendors that were earlier providing CAD solutions. (Eastman et al., 2011)

It is important to keep in mind that BIM is not just a technology change, but also a process change. By enabling a building to be represented by intelligent objects that carry detailed information about themselves and also understand their relationship with other objects in the building model, BIM not only changes how building drawings and visualizations are created, but also dramatically alters all of the key processes involved in putting a building together: how the client's programmatic requirements are captured and used to develop space plans and early-stage concepts; how design alternatives are analyzed for aspects such as energy, structure, spatial configuration, way-finding, cost, constructability and so on. (Eastman et al., 2011)

2.2 PARAMETRIC OBJECTS

Eastman, Teicholz, Sacks and Liston (2011, p. 17) found the concept of parametric objects is central to understanding BIM and its differentiation from traditional 3D objects. Parametric BIM objects are defined as follows:

- Consist of geometric definitions and associated data and rules.
- Geometry is integrated non-redundantly, and allows for no inconsistencies. When an object is shown in 3D, the shape cannot be represented internally redundantly, for example, as multiple 2D views. A plan and elevation of a given object must always be consistent. Dimensions cannot be "fudged".
- Parametric rules for objects automatically modify associated geometries when inserted into a building model or when changes are made to associated objects. For example, a door will fit automatically into a wall, a light switch will automatically locate next to the proper side of the door, a wall will automatically resize itself to butt to a ceiling or roof, and so forth.
- Objects can be defined at different levels of aggregation, so we can define a wall as well as its related components. Objects can be defined and managed at any number of hierarchy levels. For example, if the weight of a wall subcomponent changes, the weight of the wall should also change.
- Objects' rules can identify when a particular change violates object feasibility regarding size, manufacturability, and so forth.
- Objects have the ability to link to or receive, broadcast, or export sets of attributes, for example, structural materials, acoustic data, energy data, and the like, to other applications and models.

Parametric modeling has been proposed as an effective means to embed domain expertise in models of buildings. As information technology becomes more powerful in terms of the ability to manipulate large parametric models, the potential grows to build increasingly sophisticated functional systems for designing, modeling and fabricating buildings. Implementing more powerful systems implies greater functional specificity, which requires elicitation and capture of increasingly detailed and complex domain-specific semantics and knowledge.(Ghang et al., 2005)

According to Autodesk the term parametric refers to the relationships among all elements of the model that enable the coordination and change management that Revit Structure provides. These relationships are created either automatically by the software or by you as you work. In mathematics and mechanical CAD, the numbers or characteristics that define these kinds of relationships are called parameters; hence, the operation of the software is parametric. This concept is important because it is this capability that delivers the fundamental coordination and productivity benefits of Revit Structure: change anything at any time anywhere in the project, and Revit Structure coordinates that change through the entire project.

The following are examples of these element relationships:

i. Pilasters are spaced equally across a given elevation. If the length of the elevation is changed, the relationship of equal spacing is maintained. In this case, the parameter is not a number but a proportional characteristic.
ii. The edge of a roof is related to the exterior wall such that when the exterior wall is moved, the roof remains connected. In this case, the parameter is one of association or connection.

Eastman, Teicholz, Sacks and Liston (2011, p. 39) Parametric object modeling provides a powerful way to create and edit geometry. Without it, model generation and design would be extremely cumbersome and error-prone, as was found with disappointment by the mechanical engineering community after the initial development of solid modeling. Designing a building that contains a hundred thousand or more objects would be impractical without a system that allows for effective low-level automatic design editing.

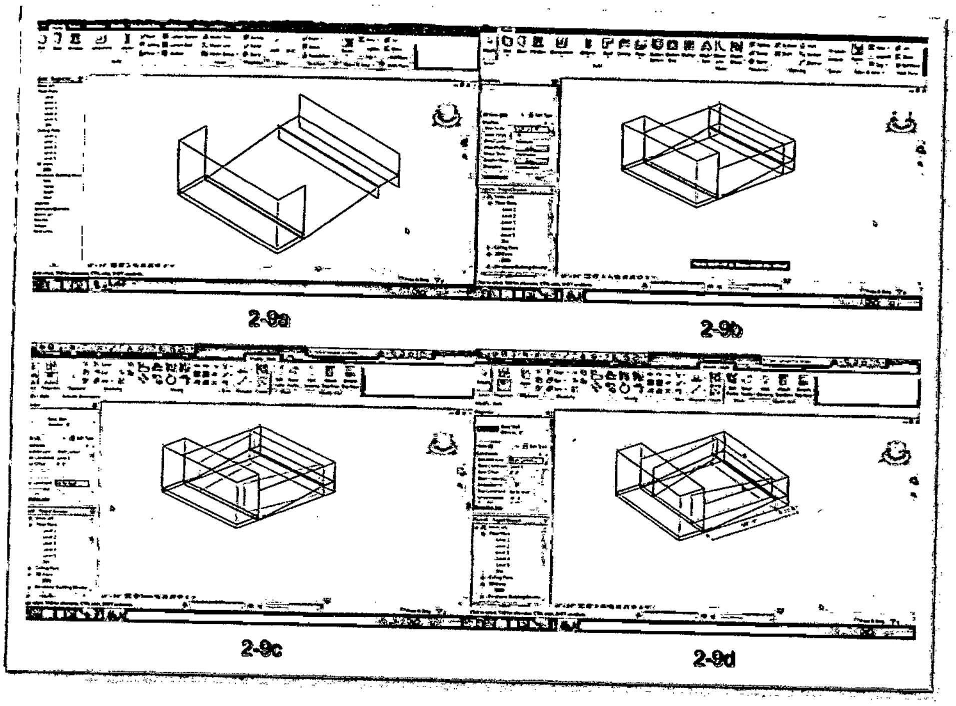


Figure 2.1: An example of parametric modeling: A theater is initiated with (2.9 a) a raised lobby at the rear, sloping house floor and raised stage at the front; (2.9b) the enclosing walls and roof are added; (2.9c) angled side walls are added, but do not naturally attach to the sloped house floor; (2.9d) these are aligned to the sloped floor.

2.2.1 ELEMENT BEHAVIOR IN A PARAMETRIC MODELER

Revit Structure uses 5 software element classes: host, component, annotation, view, and datum elements. This implementation provides flexibility for designers. Revit Structure elements are designed to be created and modified by you directly; programming is not required. If you can draw, you can define new parametric elements in Revit Structure.

Hosts include slabs, walls, and roofs. Components include beams, columns, and braces. Annotations are 2D, view-specific elements that help you produce your documentation.

Views are dynamic representations of the model and are always up-to-date. Datum elements are non-physical items used to establish project context. In Revit Structure, behavior of elements is largely governed by their context in the structure. The context is determined by how you draw the component and the constraint relationships that are established with other components. Often, you do nothing to establish these relationships; they are implied by what you do and how you draw. In other cases, you can explicitly control them, by locking a dimension or aligning two walls, for example.

2.3 REVIT

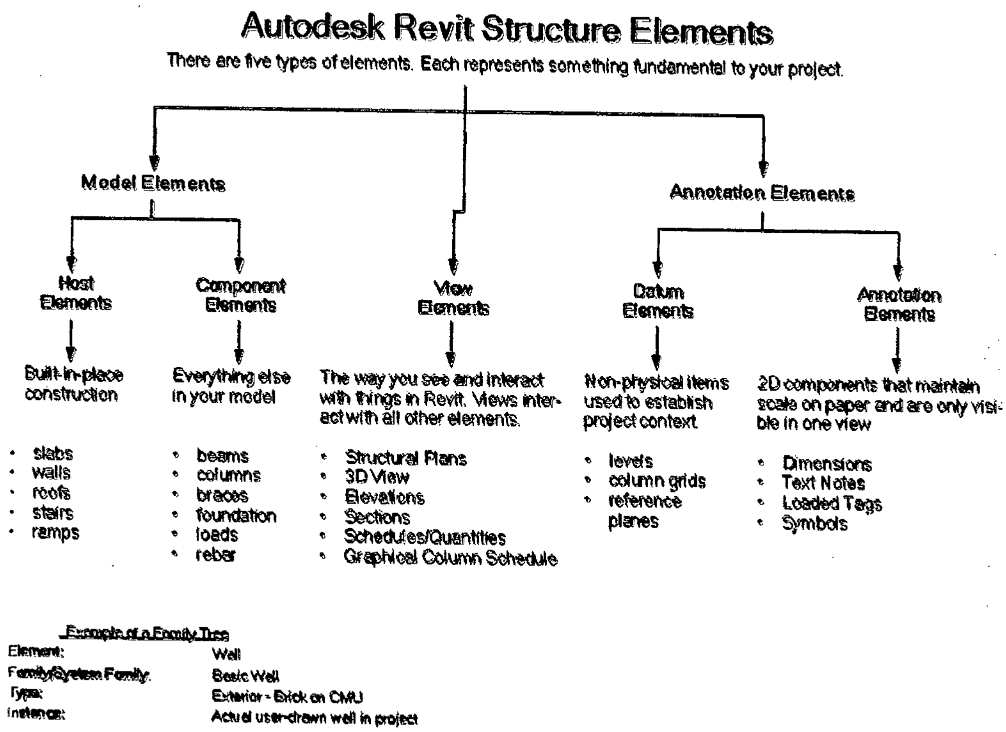


Figure 2.2: Revit Structure Term (Imperial Tutorial 4, .2006)

Eastman, Teicholz, Sacks and Liston (2011, p. 77) found Revit is the best-known and current market leader for BIM in architectural design. It was introduced by Autodesk in 2002 after Autodesk acquired the Revit program from a startup company. Revit is a completely separate platform from AutoCAD, with a different code base and fi le structure. Revit is a family of integrated products that currently includes Revit Architecture, Revit Structure, and Revit MEP. It runs on Windows OS and on Macs, using the Windows BootCamp® plug-in. It runs on both 32- and 64-bit processors and versions of the OS.

Eastman, Teicholz, Sacks and Liston (2011, p. 78) *as a tool:* Revit provides an easy-to-use interface, with drag-over hints for each operation and smart cursor. Its menus are well organized according to workflow and its operator menus gray-out non available actions within the current system context. Its drawing generation support is very good; its drawing production is strongly associative, so that drawing releases are easily managed.It offers bidirectional editing from drawings to and from the model, and also bidirectional editing from schedules for doors, door hardware, and the like.

Revit supports the development of new custom parametric objects and customization of predefi ned objects. Its rule set for defining objects has improved with each release and includes trigonometric functions. It can constrain distances and angles and the number objects in an array. It also supports hierarchical relations of parameters. Thus, an object can be defined by using a group of sub objects with parametric relations. It is more difficult to set up global parameters that can constrain assemblies of objects' layout and sizes. The release of the current API provides good support for external application development.

Revit has a very large set of product libraries, particularly its own Autodesk SEEK library for specification and design objects. It carries information for about 850 different companies, and about 13,750 different product lines (including over 750 light fixtures). The products are defined in a mixture of file types: RVA, DWG, DWF, DGN, GSM, SKP, IES, and TXT. They are accessible from Masterformat, Uniformat, and Omniclass Table 23

(Products) formats. There are about a half-dozen other sites with BIM products, where Revit objects dominate.

As a platform: Revit, as the BIM market leader, has the largest set of associated applications. Some are direct links through Revit's Open API and others are through IFC or other exchange formats. These are denoted (Dir) and (IFC), respectively. DWF is another interface for Revit, denoted (Dwf).

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

Methodology flow process is amongst the important component in conducting the research. In this chapter, this chapter discusses how the process of building a 3D parametric model. To achieve the objectives, the project is implemented in accordance with the planned methodology. Therefore, the methodology has been summarized in Figure 3.1