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Enhancing Planning and Scheduling Program by Using Benefits of BIM-Based Applications

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Abstract
2D drawings are commonly being used to present the work process of 3D objects in the construction industry. The engineers require having sufficient knowledge to interpret these drawings for use in various areas of the work especially for providing planning and scheduling programs. In the construction projects, construction managers face many problems such as over budget projects, schedule errors, omission of some activities like safety tasks that originate from poor planning methods. Therefore, the study is going to examine alternative tools for better understanding of real project tasks sequences and procedures. One of the most reliable applications is introduced by the Building Information Modeling approach (BIM) that develops four-dimension model based on a combination of three dimension models with time. The benefits of BIM-based on 4D modeling not only improving the perception of planners and construction teams but also facilitate the procedure of planning and scheduling like automatically clash detection, introduce parallel activity and etc. .This study discusses the development and implementation of this innovative approach in construction planning. The research was carried out based on questionnaire survey within construction companies in Singapore. The data was analyzed using descriptive statistical analysis and been ranked with Average Index method.
Keywords: Planning, scheduling, BIM-Based Application

1. Introduction

Allen, J. and Koomen, J. (1983) mentioned that the sequence of activities must be identified to demonstrate the process of the work from the first that the particular of the project purpose will be attained. Sequence of tasks in construction involves with space, resources, time, procurement, dimension constraints, and other issues in the project process. In conventional planning and scheduling methods, Gantt chart was not able to portray the links of relationships between the sequential activities. In recent, planner and project engineers use Critical Path Method (CPM) scheduling applications, e.g. Primavera or Microsoft Project Software for monitoring, tracking and controlling the project time and resources (Charles Eastman, 1999). All the above conventional methods were based on 2D information and all data extract from two-dimensional (2D) drawings in the construction industry. 2D drawings are commonly used for training of fresh graduate engineers and planners. Interpretation of 2D drawings by planners and schedulers are difficult to understand due to lack of Supplementary data, and visualization capabilities. More challenges face in the way forward for planners and schedulers with little or no practical experience to illustrate the complex construction projects (Junshan L. and Roger K. 2012).

Furthermore, some general problems such as fragmented nature, lack of collaboration and integration between involved parties, the considerable amount of missing data and the lack of capability of applicable visualization are among of major issues that can be arise by utilizing the conventional approach in complex construction project to provide a planning and scheduling program. In order to obtain fewer conflicts and more collaboration between planner's team and with other participants in construction project and more realization, the BIM-based method can be used as a new technology.

1.1 Literature review

The BIM approach has been established since 1970 when industry was commencing to utilize ingenious CAD system as most useful method in different level of manufacturing and production (Eastman, 2008).Various definition of BIM is introduced to exhibit the utility of this approach in industry. BIM is an approach that can be able to manipulate parametric objects to produce particular model that are interpreted by the rules embedded in them (Eastman, 2008). In addition, Smith and Edgar (2008) defined that BIM is a "digital representation of physical and functional characteristics of a facility".

The foundation of BIM scheduling linked to time and visual presentation that refer to 4D modeling or 4D CAD. However, this approach is widely discussed in some research studies and literatures (e.g. McKinney and Fischer 1998, Koo and Fischer 2000, Kamat and Martinez 2002, Kähkönen and Leinonen 2003, Heesom and Mahdjoubi

2004 and Chau et.al. 2005 among others). BIM-based applications provide scheduling animation in 3D model and present the being built building from start to finish. It helps in communicating the completion dates to owners, gives subcontractors and trades people a better understanding of the scope and timing of their work, and helps field personnel verify the project is on track. 4D modeling in BIM is considered as a main connection tool between 3D modeling in design level and planning scheduling in construction level. 4D modeling assist to improve realizing of schedule consequence by giving a graphical presentation and preparation of an opportunity to distinguish unexpected problems and incompatibility conflicts. Therefore, this approach facilitates the scheduling process and help to distinguish of potential time-space conflicts (Koo and Fischer 2000).
Figure 1 shows the construction project life cycle that need continuous scheduling and update (Brad Hardin, 2011).By proper scheduling, project planners can compare various schedules easily, and they can quickly recognize whether the project is on track or not (Hergunsel. 2011).

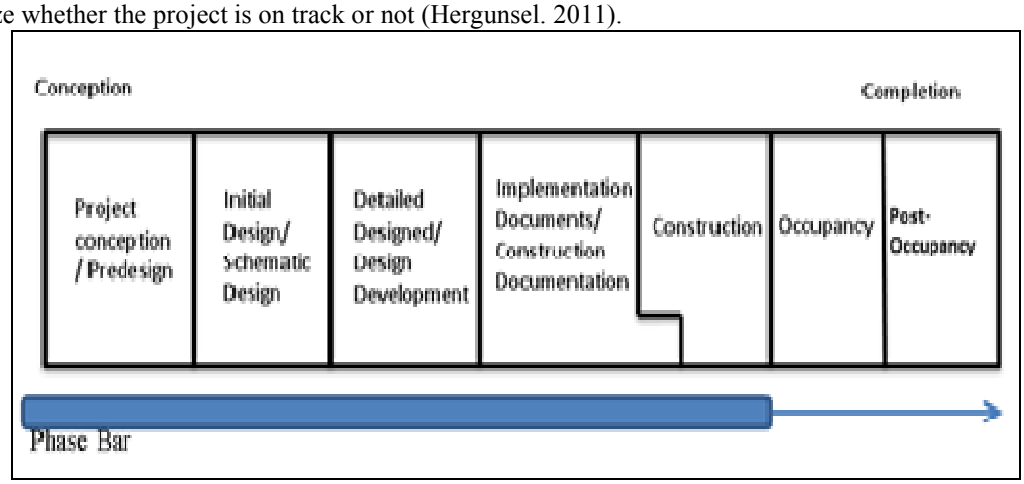

Figure 1: BIM schedule updating in a continuous task (Brad Hardin, 2009)

The BIM-based model components can also contain production rate information (for all the associated tasks) that will permit a line of balance schedule analysis; this approach allows the fine-tuning of tasks based on their location in the project and production rates, and helps to eliminate start and stop cycles within tasks (Willem Kymmell, 2008).
Furthermore, 4D BIM-based which; advance with time plus BIM-based 3D model can be used as a visualization application for identifying the safety issues that will be required at different times. The temporary safety related structures such as rails, fences can be modeled in the BIM-based and monitoring and controlling of safety on site by utilizing 4D model can improve overall safety of the personals related to the work. On the other hand, integration 4D modeling with safety into the scheduling process and use planning as a tool to decrease the rate of accident on the site can collaborate monitoring of safety program that is applied on the site and performed the defect identification of the program on time before the accident and injury. In addition, 4D modeling is multilateral model that can be helpful for engineers in different parts of the jobsite safety (Hergunsel, 2011).
According to study in [12], for every construction planner, the most important task is preparing the schedule. The schedule is one of the deriving factors in the success of any project and is a critical component to all team members. At the onset of a project (and often before that), a member of the construction management team creates the schedule that is specialized engineer who play a major role in the construction process to identify the sequences of the work process and investigate the priority of any task in each particular dates. Hence, schedulers' effort can lead to implement the work effectively and attain the purpose of the project on time and within budget. This schedule typically reflects experiences with construction timing, material lead time, weather, crew, and equipment concerns. Therefore, new engineer or planners needed to be trained with this new technology and it applications. The new technology of BIM-based can inculcate the interest of planners to resolve the construction project problems with better project planning and scheduling.

1.2 Problem Statement

Duncan (1996) argued about conventional construction planning techniques in terms of basic theory and approved the inefficiencies of these methods in the construction industry. Inadequate knowledge of planners, unavailability of data between different activities and also neglect of the physical correlation between activities lead to affect conventional planning method and make them inoperative. According Whilst Sriprasert and Dawood (2002),three main deficiencies of traditional planning methods are as following:

- Insubstantial pattern of planning and negligible or insignificant short term planning

- Lack of a systematic approach to manage executive process
- Insufficient control measurement and utilizing corrective action rather than learning process

Santos, A et al. (1998), identified the barriers that planners face to clarify different stage in construction by using traditional methods that are following:

- Extension of planning procedure on informal foundation
- Lack of practical implementation of schedule
- Creating of schedule base on the experience and not in the real data that are related to the project goal
- Systematic defect in the short term plan
- Insufficient resource for scheduling

In this circumstance of construction projects, researchers are required to introduce the new technique and approach to modify the process of planning and scheduling. One of the most practical approaches is BIM that is going to improve the information flow, manage knowledge and also control the planners' concept to achieve most appropriate and reliable planning program (Ballard, 1999).

The importance of a schedule in regard to BIM-based is to inform the team better and track progress from the beginning to the end of the project. In addition, the refinement of the schedule relies on the accuracy of the construction manager to review the new design documents each time and judge the projected availability of additional equipment, material quantities, etc.

In construction projects, it is common for construction managers and clients face many problems such as over budgets, schedules errors, omission of some activity, and safety tasks that the origin from inappropriate method of planning and scheduling. This is due to the inadequate t tools for better understanding of real project sequences and procedures. Therefore, this research paper interested to highlights what are the benefits of BIM-based approach for planning and scheduling.

2. Research Methodology and Respondents Background

To achieve the aim of this research, the chosen methodology for this study is based on the questionnaire survey. The survey respondents were chosen directly from the construction companies in Singapore. The construction companies in Singapore have been implementing BIM-based approach in recently. The survey included managers, architectures, engineers, planners.

All of these participants were selected through random sampling. The questionnaire was piloted with a group of 3 consultant companies to assess its validity before it was distributed. The 32 questionnaires were distributed among the construction companies that 72% of total questionnaire were fulfilled. All questions were structured to enable a logical quantitative analysis of the result. The data were analysed by using Statistical Packages for Social Sciences (SPSS). The study used two methods in analysing the data gained from the respondent. Step one presents the data in a descriptive form, where responses on each item were presented and described in percentage and means index. Whilst for step 2, the evaluation was made by ranked analysis using Average Index method. All result, with Average Index (AI) scores more than 3.5, were accepted as the beneficial factors. The following formula was applied in Average Index methods. By referring to Majid and McCaffer (1997), the rating scales used for the questionnaires in this study are mentioned in table 1.

Table 1. Classification of the Rating Scores

Rating Scale	**Average Index**
Very low or extremely in effective	$1.00 \leq A1 < 1.50$
Low or ineffective	$1.50 \leq A1 < 2.50$
Medium or moderately in effective	$2.50 \leq A1 < 3.50$
High or very effective	$3.50 \leq A1 < 4.50$
Very high or extremely effective	$4.50 \leq A1 \leq 5.00$

3. Results and Findings

The results processed by applying Statistical Package for Social Science (SPSS) version 19 of software to facilitate the understanding of data and information, which gained from the questionnaires.

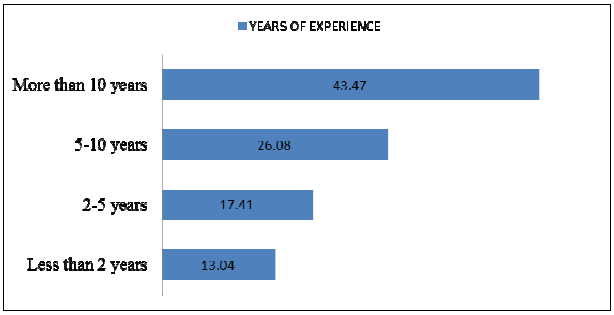

Figure 2. Years of experience of the respondents

Fig. 2 shows the years of experience of the respondents in the construction industry. Majority of the respondents have more than 10 years of experience representing 43.47% of the total respondents that present the respondents have adequate experience in the construction industry.

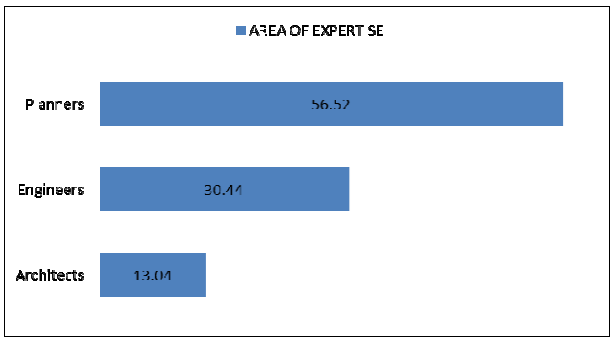

Figure 3. Area of expertise of the respondents

Fig.3 portrays the distribution of respondents in respect of their area of expertise. 56.52% that presents the majority of the respondents are Planners, 30.44% are engineers while the lowest group are from Architects who formed 13.04 % of the respondents.

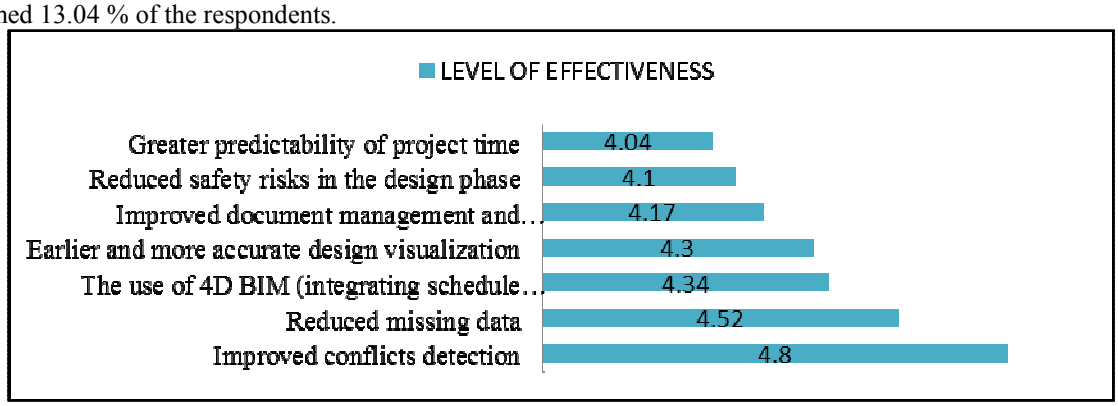

Figure 4. Level of Benefits and Effectiveness of BIM-based Applications

Figure 4 shows the level of effectiveness on benefits of BIM-based applications that are useful for planners and schedulers. The result has shown that the clash detection has the highest index of 4.8. This result indicating that this element was the main benefits gained in using BIM-based approach. Similarly, the results have shown a significance level of agreement that reducing missing data is another benefit of using BIM-based. Furthermore, BIM-based provide usefulness in the use of 4D BIM-based that have the ability of integrating schedule dimension.

Table 2. Correlation between BIM-based Benefits and Planners Realization

No.	BIM-based Benefits	Factors influence planners realization	Fig. No.
1.	Improve clash detection	• Identifying parallel activities • Identifying potential conflicts	6,7
2.	Reduce missing data	• Diminish omission of activities	Sample figure is not supply
3.	The use of 4D BIM-based (integrating schedule dimension)	• Visualising and interpreting construction sequence • Facilitates information sharing	6
4.	Earlier and more accurate design visualisation	Formalising design and construction information: • Forces users to visualize in their minds • Obviates interpretation process	7
5.	Improved document management and integration	• Producing of event documentation using for any claims like extension of time	Sample figure is not supply
6.	Reduced safety risks in the design phase	• Allows detection to hazards • Definition of safety tasks	8
7.	Greater predictability of project time	• Allows the generation of alternative scenarios • Decision making	Sample figure is not supply

In this study, Table 2 shows the correlation for planner visualization, in order to accommodate the project realization.

The following flowchart (Fig.5) exhibits the process of promoting the planning and scheduling method by integration of 3D model with the main project information such as time, cost, quality and safety that lead to create BIM model in the construction industry. BIM model simulate the progress of the work and assist the user to predict most reliable planning and scheduling.

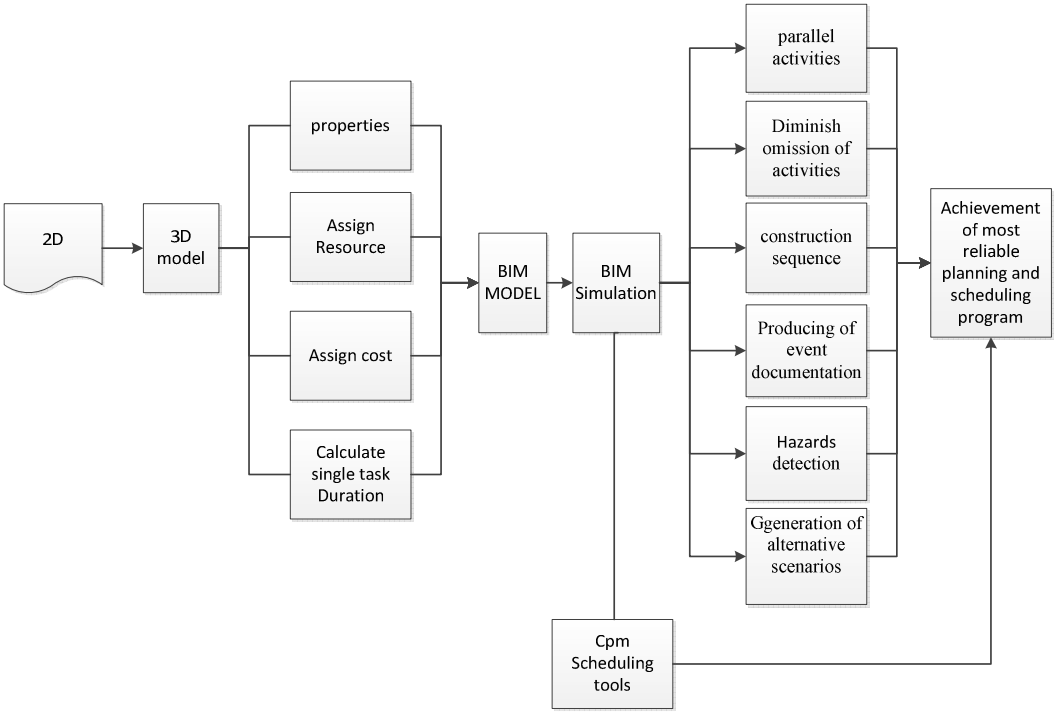

Figure 5. The Progress of BIM Application achievement

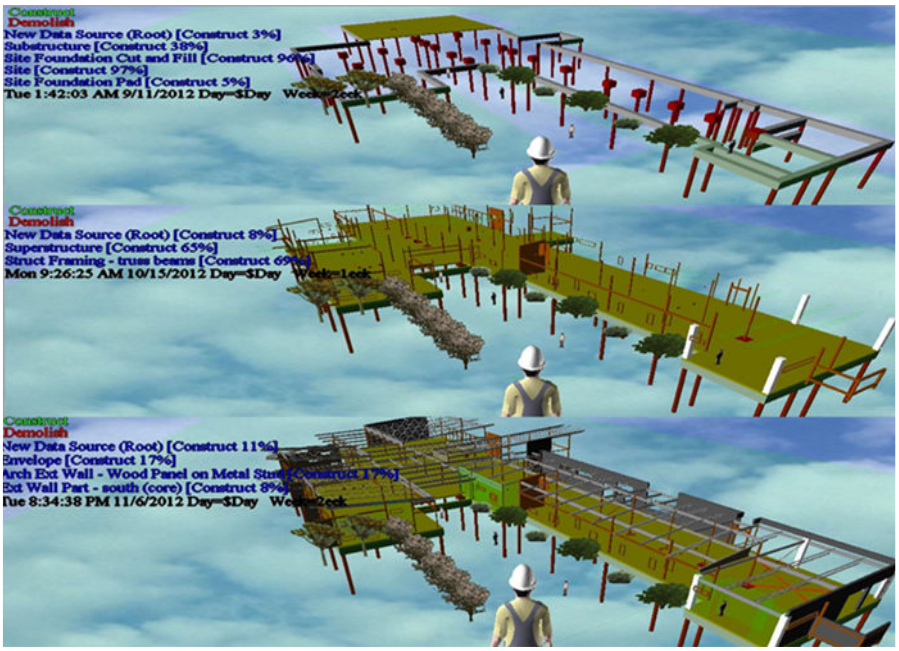

Figure 6. Sequence of Activities

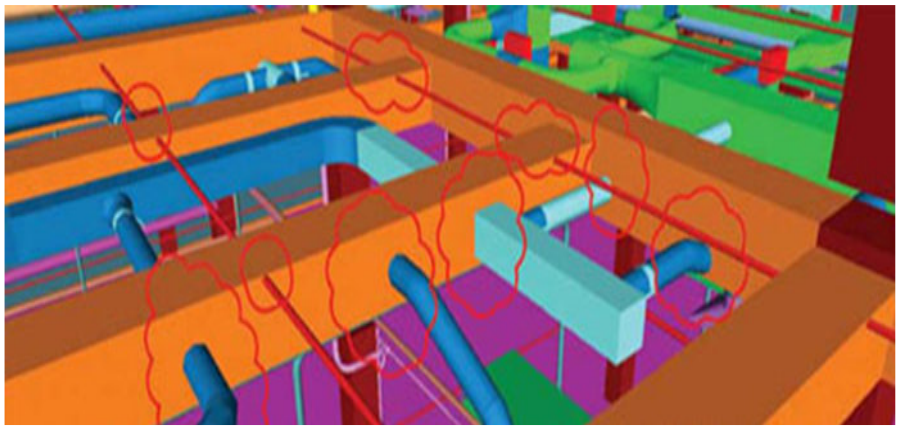

Figure 7. Clash Detection

In Fig. 6 and Fig. 7, parallel activities can be identified for clash detection. By using 4D BIM-based, visualisation and interpreting construction sequence can be made to integrate schedule dimension. Furthermore, formalising design and construction information also can be interpreted earlier whereby, by BIM-based it forced user to detail visualise that lead to accurate design.

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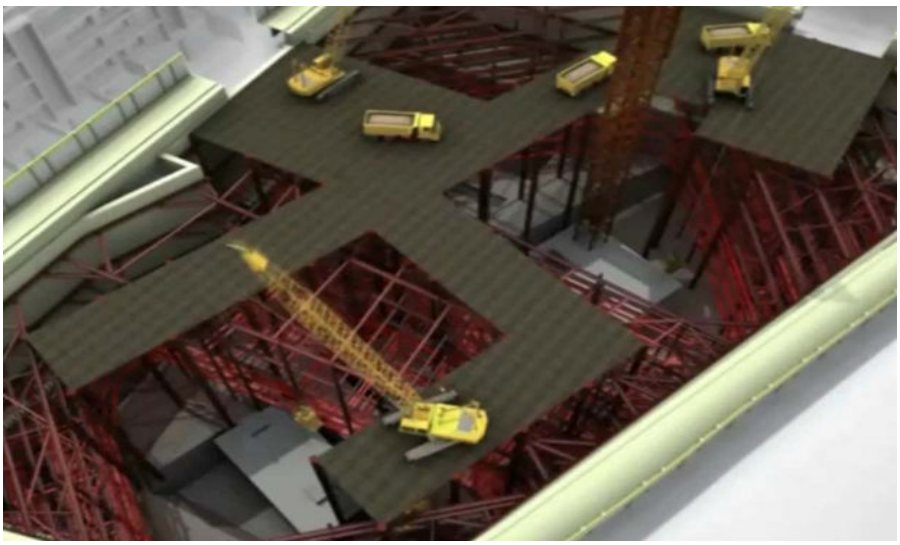

Figure 7. Hennesy Centre Safety and Site Logistics Planning (Collins, 2011)

Fig. 8 shows that BIM- based allow detection to hazard and define the safety task. BIM- based helps in reducing safety risks at design phase. As presented in the Table 2, the planners are able to identify parallel activities, construction sequence, claim documentation process, safety tasks, and various construction technologies as decision making methods. In comparison to 2D model, BIM-based also offers faster and more accuracy information visualization through it 4D model. On the other hand, the blunder or omission tasks can be minimized whereby BIM-based have the function to reducing the numbers of missing data. The specialty of BIM-based helps the junior planners' to be more capable in developing project scheduling and thus indirectly support their designation promotion

4. Conclusion

The highlighted factors in this research paper show the benefits of using BIM applications in the construction industry to create planning and scheduling program. This paper has proposed that by using BIM-based applications; it can be an effective to enhance planning and scheduling methods. Additionally, it helps to develop the skill of planners and/or schedulers. The evaluation results indicated that the BIM-based approach helped planners and schedulers to recognize construction sequence, parallel activities, diminish omission of activities, hazard detection, producing of event documentation, definition of safety tasks, etc. The proposed BIM-based approach is expected to help construction planners to overcome the difficulty of reading and interpreting 2D schedules and Work Breakdown Structures (WBSs); which consist of only activities and relationships between

them. Therefore, The BIM-based approach in planning and scheduling can be replicated effectively in other industries.

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