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3D-Modeling for Life Cycle of the Structure

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Abstract. Owners and construction management are in permanent search to increase competitiveness, reduce cost and time and maintain a high quality of products and services. In this objective project management tend to organize work execution by implementing comprehensive, linked and sequential processes, making full use of every work effort and limiting work duplication and rework. Since the '90s, the 3D-modeling is used to coordinate, plan, build and manage future structures. The BIM approach proposes to stakeholders to participate in an intelligent centrally shared 3D-model making use of every contribution to this model, facilitating the coordination, solving the interfaces, reducing duplication efforts and carrying the developed data information throughout the life cycle of the structure and beyond the construction phase. Completing a complex structure requires an important level of design management and coordination of the interface between architect, designer, mechanic, electrician, and other designers. Basic input is required from equipment suppliers. Now, for a good reason, everyone in charge of the process is focused on achieving their process with less cost and less time. Thus, he inadvertently reduces the effort associated with surrounding or subsequent actions, and focuses on his main result. For example, structural engineering developing a 3D-model will focus on clean structural design focusing on structural continuity, geometry identification, and calculation model for finite elements of software. Likewise, a mechanical engineer will model plumbing and mechanical networks for fabrication and installation purposes. It is the same with other design disciplines.

Keywords: 3D-modeling, life cycle, building information model (BIM)

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3D-моделирование для жизненного цикла сооружения

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Реферат. Собственники и руководители строительства находятся в постоянном процессе повышения конкурентоспособности, сокращения затрат и времени, поддержания высокого качества продукции и услуг. Цель управления проектами – организовать выполнение работ путем реализации комплексных, связанных и последовательных мероприятий, в полной мере использовать ограничения дублирования переделок. С 1990-х годов 3D-моделирование используется для координации, планирования, создания и эксплуатации будущего сооружения. BIM-подход предлагает заинтересованным сторонам участвовать в общей интеллектуальной 3D-модели, облегчая координацию, решая интерфейсы, уменьшая усилия по дублированию и сохраняя информацию о разработанных данных на протяжении всего жизненного цикла конструкции и по завершении этапа строительства. Для выполнения сложной структуры взаимодействия необходимы высокий уровень управления проектированием и координация интерфейса между архитектором, конструктором, механиком, электриком и другими проектировщиками. От поставщиков оборудования требуются основные входные данные. В связи с этим каждый ответственный за процесс нацелен на достижение собственного результата с меньшими затратами и временем исполнения. Тем самым он непреднамеренно сокращает усилия, связанные с сопутствующими действиями, и сосредоточивается на своем основном результате. Например, структурная инженерия, разрабатывающая

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3D-модель, будет нацелена на чистый структурный дизайн, ориентируясь на непрерывность конструкции, идентификацию геометрии и модель расчета для конечных элементов программного обеспечения. Точно так же будут моделироваться водопроводные и другие сети для изготовления и монтажа.

Ключевые слова: 3D-моделирование, жизненный цикл, информационная модель здания (BIM)

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Foreword

3D-models and associated data can provide rapid material take-off and cost estimates. Changes in estimated quantities can be effectively tracked and corrected in a timely manner with each design change. The cost of purchased equipment and paid subcontractors can also be specified in the model. Availability, quality control, and work acceptance can be linked to the model and automatically return a progress report. Visually, on-site 3D-model with attributive information (such as cost code and work breakdown WBS codes) will help you properly report costs and minimize errors in cost management and scheduled reporting. The 3D-model will help in estimating and managing costs, known as 5D BIM.

While currently the center of a construction project is oriented to a document control center, the building information model (BIM) proposes the use of a central shared 3D-model with attributed information as an efficient replacement. Construction productivity has been flat for decades, according to McKinsey research (Fig. 1) [1]. The concept-and-design phase is where the most project value can be gained or lost. A better project management and technological innovation is required to improve the productivity. This article is to highlight the concept and the utility of BIM [2, 3]. It is designated to project managers, owners, educational, design or construction professionals to improve making a preliminary decision.

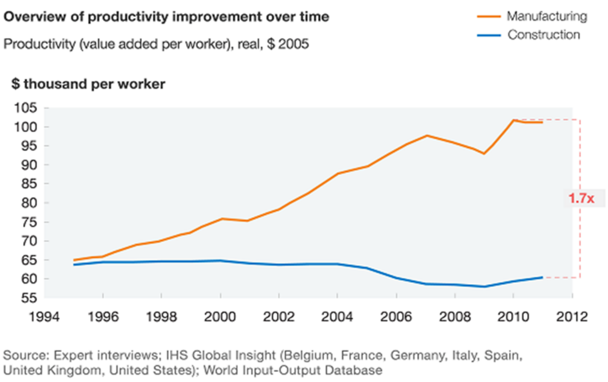

Fig. 1. Productivity in manufacturing versus productivity in construction per McKinsey and Company

Case study

The execution of a complex structure requires an important level of design management and interface coordination between the architect, structural, mechanical, electrical and other designers. Key input data is required from equipment vendors. Now for a good reason each process responsible targets achieving his process at lower cost and shorter time. By doing so, he unintentionally, reduces efforts in surrounding or succeeding activities and focus on his main deliverable. The structural engineering, for example, developing a 3D-model will target a pure structural design focusing on structural continuity, geometry identification and calculation model for finite element software. Similarly, the mechanical engineer will model plumbing and mechanical networks for fabrication and installation purposes. Same with other design disciplines.

Or many of these efforts, if maintained or amended slightly forward, can be a major preparation to an efficient engineering interface resolution management. Looking further, these same 3D-models, if handed over adequately to construction and operations, will provide a great input to use.

For instance, construction can use the 3D-model to plan construction sequences, concrete lifts, dimensioning of formwork, detailing of reinforcement steel or steel structure installation sequence. Visualization of the construction sequence and timing window of each subcontractor can help identify any error or omission in the sequencing. Visually allocated space can be analyzed to fit construction equipment and identify accesses. The land surveying team will reduce his efforts in geometry calculation and use the model for the layout erection and verification. Surveying equipment has developed their interface software and machinery to accommodate BIM. The 3D-model will be linked to a construction schedule known as 4D BIM.

The 3D-models and associated data can produce quick material take-off and cost estimates. Changes to estimated quantities can be efficiently monitored and timely adjusted with each design change. Cost of procured equipment and paid subcontractors can also be posted in the model. Readiness, quality control and work acceptance can be linked to the model and return the work progress report automated. A visual availability on site of the 3D-model with attributed information (like cost code and Work Breakdown Structure (WBS) codes) will assist in correctly reporting costs and minimize errors to cost control and time sheet reporting. The 3D-model will assist in estimates and cost management known as the 5D BIM.

After the construction is achieved, the final as built models can efficiently be used in the facility management and maintenance. The building space usage and management can be efficiently planned on the virtual model. It assists in analyzing the energy building performance and conduct required optimization. The maintenance team equipped with virtual reality tools can maximize the efficiency of maintenance works. Service quality of freeways and even city roads with cameras linked to GPS can report repair and maintenance needs. The 3D-model and attributed data will assist in the facility's operation, sustainability and maintenance. This is known as the 6D BIM (Fig. 2) [4].

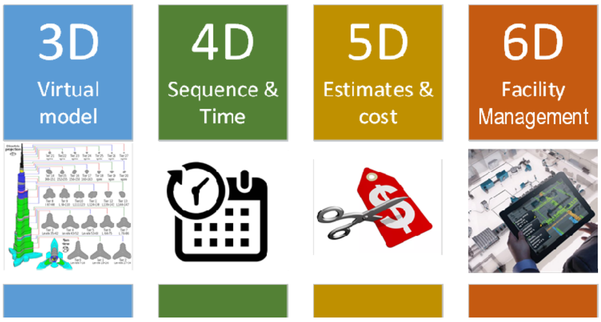

Fig. 2. The six dimensions of BIM

So, what is BIM

The building information model, called BIM, is a model-based organization of structures' production and management processes. It is a centralized integrated model and data environment for stakeholder's collaboration. Developing 3D-design in a single software is just the level-1 of BIM. BIM is a hub of execution collaboration, interfaces and continuity. The 3D-model and its attribute data become the core of the information and exchanges (Fig 3). BIM is not a new software, it is a logic optimization of the efforts and extending the use of existing software by using the 3D-model and information data as a shared core [5]. More and more BIM applications are opening the possibilities for more collaboration, accessibility and functionality in all aspects of management [6, 7].

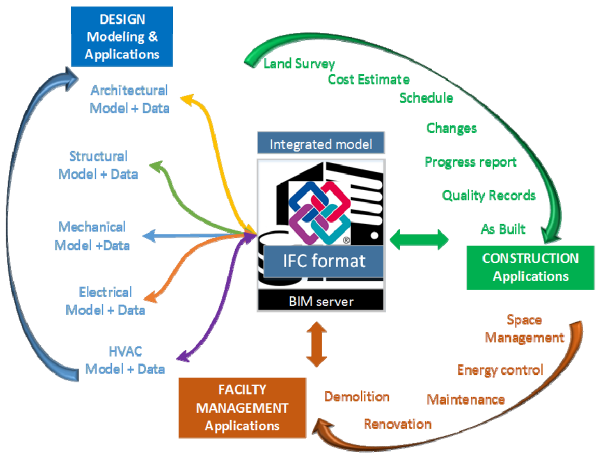

Fig. 3. BIM models + Data & BIM applications in lifecycle use

It is not new that, to reduce cost and time, organizations aim to develop management processes compatible and intercommunicating. Imagine now BIM creating this open space for development providing real visualization and applications with a wide range of services.

The sequence of design execution is planned based on the interface coordination and the input sequencing needs (Fig 4). Order of priority and early required information are scheduled to provide timely input to further development. Complete sequencing is planned to achieve the full scope of activities.

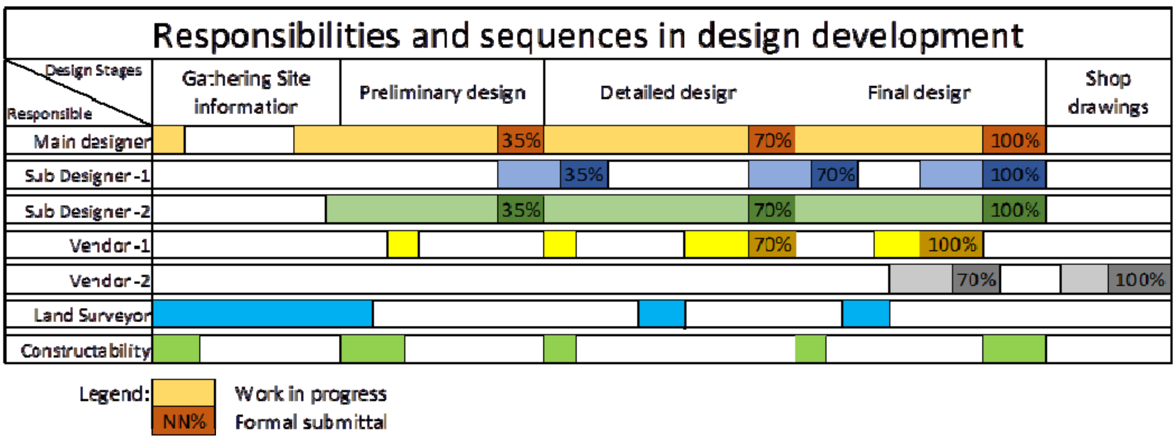

Fig. 4. Basic presentation of design planning

When BIM is advantageous

We provided above a brief description of BIM beneficial use. Owners and contractors need to run a cost-benefit analysis to assess the advantage of using BIM on their projects.

The complexity of the project including interfaces between different designers, prefabrication, crowded layout, complex existing conditions, overlay sequencing of work execution, use of automated execution processes, intelligent and geographically oriented construction tools and equipment, dynamic space changing, efficient facility management, highly responsive maintenance service, will definitely justify the implementation of BIM-technology.

The BIM literature describes the BIM-process as a front-loaded schedule of work. This means that significant cost is to be spent at the earlier stage of the work and namely the earlier design stage. Personally, we disagree with this statement. The work load distribution depends on how the owner or the designer organize their work execution. For instance, when the design is at a preliminary stage, input to BIM can be limited to a basic level of development like LOD-100 (Fig. 5).

Gathered site data and basic presentation of preliminary geometry (called 35 % design) can be enough at the preliminary stage. Even at a final stage of the design (100 %), the BIM model can be limited to a low (LOD-200) or medium (LOD-300) level of development [8]. This judgment shall be based on the specific needs to have a higher level of development for succeeding activities. It is common to limit the details of civil works to a LOD-300.

By organizing the LOD for each design development stage, efforts can be spread to minimize spending upfront when technical decisions are not yet finalized. This does not differ from the classic design execution approaches. With BIM, probably a slight increase in cost will be due to the learning curve in implementing the new technology. This cost increase shall be compensated by eliminating the waste of produced efforts at the design stage and making a further use of it during construction and facility management. The correct implementation of BIM will reduce cost in rework and planning errors.

The value of BIM for owners is to save time and money on design and construction and make return benefice during the building lifecycle. General design-build contractors can also make benefice in implementing BIM through the design and construction phases.

BIM's challenges and opportunities

In many countries governments and authority agencies are lacking behind and haven't yet developed the legal environment for BIM implementation. The form of approval involving professional registered engineers is not yet formalized. Receiving work permitting from authorized agencies is not yet accepted in the form of a 3D-model (Fig. 6) [8, 9].

The majority of design engineers and technicians are not yet comfortable submitting a formal design in BIM formats with electronic signatures. Decisions are to be made regarding the format of the technical specifications. Most of the experimented construction personnel have not been trained to read and use BIM models. Many companies will need additional investments in training and equipment to implement BIM technologies.

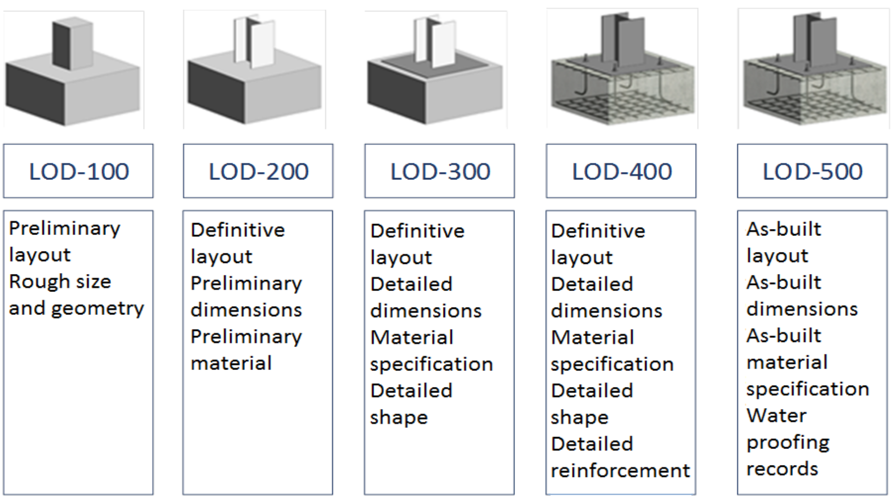

Fig. 5. Levels of development in BIM: LODs = LOD + LOI; Level of development = Level of details + Level of information

While the 3D-model is the core, applications have missed providing other alternative ways of accessing specific information. The table of contents or the structured trees for an alternative searching method like most of users are familiar with Microsoft Explorer.

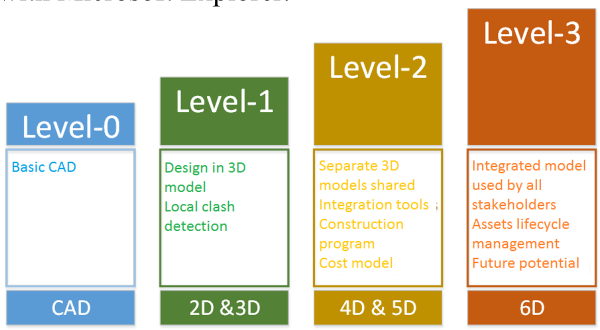

Fig. 6. Levels of maturity of BIM

Applications for access control and change authority is becoming an actual challenge. Open BIM versus closed BIM and information security and control, servers' locations and backup of information still to be elaborated to accommodate security needs.

Vanguard countries are developing digital standards to achieving compatibility, so companies can work with any software that fits their needs and stay compatible with each other.

Development and research companies are competing on completing missing BIM application to support the project lifetime processes. The open nature of BIM applications opens the opportunity for small developers [3, 10].

CONCLUSION

BIM technology is relatively recent and is still progressing. Software developers are creating new applications and advancing existing ones. Construction equipment is increasing automation and georeferenced reading which increase their productivity. Land surveying equipment increases its capability of scanning of existing conditions and reporting relatively clear 3D-shapes. Design 3D-models are downloaded in land survey machinery and easily used for the site erection. Execution schedule can be viewed in video format for better analysis and decision-making. Tablets with virtual reality are used for construction and maintenance activities. New application help identifying design clashes, quantity take off and costs. The work acceptance and quality control are documented with links and references to the virtual 3D-model. The technological progress is continuing its maturation and fine-tuning of these processes are progressing daily. Governments and organizations making use of this technology will be advantaged compared to others.

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