Application of BIM model in technical infrastructure design for NEWCITY Thu Thiem residential project

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Abstract.
In the field of construction, many new technologies have been developed and applied to the design, construction and management of construction works. One of these new technologies is the application of Building Information Model (BIM). BIM is applied in all fields of the construction industry from design, construction management, gives almost absolute accuracy, saving time and costs in survey, design, construction and project management and brings us economic benefits very clearly. BIM helps to reduce costs, construction time, reduce construction risks and design changes. Based on the results of the BIM model, the projects are estimated easily, estimating a suitable capital arrangement plan, avoiding unnecessary risks. In Vietnam, there have been a number of investors are applying BIM in technical infrastructure works, especially buildings in recent years. However, high cost and qualifications of engineers are barriers for applying BIM. There are few technical infrastructure projects that are applied BIM, especially in infrastructures field. This paper researches the application of BIM for in technical infrastructure design for the NEWCITY Thu Thiem, Ho Chi Minh City, Viet Nam. An diagram of implementing BIM process in design and process for design coordination for operating the design and coordination between the stakeholders is built. Software are applied as well as exported files with levels of detail (LOD) and levels of information (LOI) from 200 to 400 to helping stakeholders to retrieve, check, handle information and interacting by the parties during life cycle of the project.

Keywords:
BIM
Construction Management
Infrastructure Design
Residential Project
**Introduction**

BIM is a new technology, developed on digital technology basis, being deployed and widely applied in the construction industry in many countries. BIM is considered as one of the important solutions to approach the 4.0 technology revolution of the construction industry in Vietnam. There are many different definitions of BIM as Autodesk [1], UK's strategic plan for BIM [2], In the US national BIM standard [3]. Although there are many different definitions of BIM, the most common way to understand BIM is the process of creating and using a digital model for the entire life cycle of a building, from design, construction, to construction, operation, maintenance and dismantling works.

All information and data related to the building during its entire life cycle is stored and exploited through a unified and linked information model. Any changes to any component in the model will be updated automatically for the entire system. Therefore, the application of BIM will facilitate the exchange and cooperation between the parties involved, optimizing the design, construction and management of the project. BIM Database used throughout the life cycle of the project (Fig. 1) [4]

During the design phase, BIM is used to create a three-dimensional (3D) model containing the building's information. This model is used to demonstrate the design, analyze and select the optimal design option, observe, detect conflicts between disciplines, automatically create and update drawings, calculate blocks, quality, cost estimation, performance analysis. The application of BIM in design brings the following benefits: Visualization; Increased productivity and design quality; Improved volume measurement and cost estimation; Enhance the sustainability of the building; Enhance cooperation. However, the application of BIM still has many challenges, related to 04 factors: People, technology, process and legal [5].

Currently, BIM has been applied compulsorily in the construction industry in many countries such as the US, UK, Singapore, and some other countries at different levels. In Vietnam, the application of BIM in design, construction and operation management is being implemented with the project on
BIM application in design, construction and operation activities approved by the Prime Minister approved on 22/12/2016.

![BIM database used throughout the life cycle of the project [4]](image.png)

After that, the project implementation plan and provisional guidance on the application of BIM in the pilot phase were also issued by the Ministry of Construction [6]. Therefore, the application of BIM in design, construction and operation management activities in Vietnam has a basis for development.

**Modeling in BIM**

**Application process**

The BIM application process can be applied throughout the life cycle of the project. Depending on the goals of each phase of the project in construction investment sequence and the order of project implementation in order to apply the BIM process appropriately.

**General application process**

Construction investment sequence and general application process of BIM are showed in Fig. 2.
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Figure 2  Construction investment sequence and application process of BIM [6]

With the IPD Design and Construction Project (Without Bidding)
BIM process for design, construction (non-bidding) IPD projects are illustrated in Fig. 3.

Figure 3  BIM process for design, construction (non-bidding) IPD projects [6]

With the IDP Design, Bidding and Construction project Pre-bid period: (Fig. 4)

Figure 4  BIM process for IPD design and construction before bidding [6]
Construction period (Fig. 5).

Figure 5
BIM process for IPD design in construction phase

Application system of software in BIM
BIM is a software system, used by engineers, departments, and specialties at different stages in the construction process...

CDE is the environment for collecting, managing, transmitting and storing the data (geometric and non-geometric) of the project. CDE is the backbone of BIM. Information generated by the participants must be exchanged on the CDE. Each project has a unique CDE to help project members easily collaborate with each other and avoid information duplication and confusion. CDE is usually set up at the beginning of the project, going from design – construction – handover, continuously maintained during the operation of the project and stores all information about the project (Fig. 6-7).

Figure 6
Common Data Environment (CDE)
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Figure 7
Cloud model of BIM system

Levels in BIM from 2D to 7D
Levels in BIM from 2D to 7D are showed in Fig. 8.

BIM APPLICATION OF TECHNICAL INFRA-STRUCTURE DESIGN FOR NEWCITY THU THIEM RESIDENTIAL PROJECT

Project introduction
New City Thu Thiem project is located in subdivision 7 of Thu Thiem New Urban Area (727 hectare), located on the
frontage of 17 Mai Chi Tho Street, District 2, Ho Chi Minh City. Investor is Thuan Viet Trading Construction Co., Ltd.

New City Thu Thiem has total project area more than 2,74 hectare ~ 2,94 hectare. Total construction area is 19,320.9 m2. Construction density is 24.78% of the whole area. Area for utility & community service: 4,392.5 m2 to build and develop utility service infrastructure, serving the needs of the population's well-being., including Kindergarten (1,260,6m2), Medical area (278.75m2), Community living room (967m2), Public utility infrastructure (1,886.2m2) (Fig. 9)

Overall diagram of BIM for infrastructure design of NewCity Thu Thiem project

Overall diagram of BIM for infrastructure design of New City Thu Thiem project is built as Chart 1.

Process for design coordination

The design coordination process to organize and implement the design of technical and traffic infrastructure according to the BIM model for the New City Thu Thiem Project for the purpose of operating the design and coordination between the stakeholders is built Chart 2.

Application of software in BIM model

Currently, there are many software applications in BIM. Depending on each major and each subject, appropriate software
is used. To application of BIM to design infrastructure for the New City Thu Thiem project, the softwares applied for infrastructure design as follows: Revit, Navis works, Autodesk BIM 360, ALLPLAN BIMPLUS, Tekla BIM sight.

Chart 1
Overview diagram of implementing BIM process in design
Chart 2  
Chart of design coordination process

Steps for design implementation
Step 1 - Initialize the project
Before starting the project, it is necessary to consider the options applicable in the design process such as using
sample projects, project linkage and teamwork. Then proceed
to set up the project and create the construction site.

Step 2 – Build the 3D Model

The preliminary design begins with the study of the
building’s geometry and the determination of the elevation
grids and locating axes of the building. Proceed to build the
basic building components. Build 3D models in Autodesk Revit
software from 2D drawings. 3D CAD models are created from
existing 2D drawings (architecture + structure). Parameters
included in 2D drawings such as position, type of component,
size, quantity of each component, etc... built fully and shown
on the 3D model. This work is done by Autodesk Revit 2020
software. This software manages elements based on IDs and
classifies elements according to the types of components we
often use (manholes, pipes, etc.) sewers, water supply and
drainage pipes, pavement layers,...). Continue to evolve the
design by adding more detailed components. Then, perform model
refinement to finalize the design. In order for subsequent
applications to be able to recognize and thereby automatically
export the results to Excel, building a 3D model must adhere
to a few basic principles: The drawing tools in Revit must
selected as specified. Elements in the Revit model is selected
from the respective Families.

Step 3 – Customize in Autodesk Revit 2020 software

Customize in Autodesk Revit 2020 software to provide work
titles and related work names in accordance with Vietnam
standard. work sharing, duplicate or monitor, coordinate,
check for conflicts to share work or project information to
other members of teams, monitor, timely alert to changes and
control conflicts between the components in the model.

Step 4 – Develop technical design documents

Create and present floor plans, elevations, sections,
details, statistical tables, and technical instructions in
accordance with technical design documents. Then proceed to
layout the drawings and export the documents into electronic
prints (.pdf) or print on paper. Export data from Autodesk
Revit 2020 3D models to other software according to business
requirements.

Step 5 – Project demonstration

Create 3D views; simulate photos and movies to present to
investors or other stakeholders.

Outputs and level of detail (LOD), level of information (LOI)

Infrastructure system

| LOD | LOD-LOI pavement surface |
|-----|---------------------------|
|     | Finishing pavement surface |
| 200 | LOD: Shows the overall surface based on centerline elevation and road slope. LOI: Exactly elevations at road centerlines, curbs, sidewalks, leveling elevations in interpolated areas |
| 300 | LOD: Shows the overall surface based on the elevation of the centerline and curb. LOI: Exact elevations at road centerlines, curbs, sidewalks, leveling elevations in interpolated areas |
| 350 | LOD: Shows the overall surface based on the elevation of the centerline and curbs exactly, details such as retaining walls, embankments, lakes. LOI: Exact elevation at road centerline, curb, sidewalk, details of median, roundabout island, interpolated leveling elevation in area |
| 400 | LOD: Shows the overall surface based on the elevation of the centerline; exact details of curbs, foundation bundles; details of retaining walls, embankments, lakes,.. LOI: Exact elevation at center of road, curb, sidewalk; details of median, roundabout island, leveling elevation. |
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### Table 2

| LOD - LOI | LOD: Show elevation at top surface, not show pavement structure. LOI: Precise elevation in surface finish, texture and material information are not shown |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 200       |                                                                                                                                                                                                  |

### Table 3

| LOD - LOI | LOD: Shows the top surface of the curb. LOI: Exactly elevation of surface finish, not show information of structure and material. |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 200       |                                                                                                                                                                                                  |
**Table continuation 3**

| LOD – LOI | Traffic structure |
|-----------|-------------------|
| **300**   | LOD: Show geometry of curb  
|           | LOI: Exactly elevation of finishing surface, elevation at bottom of pavement mound |
| **350**   | LOD: Show all layers of material  
|           | LOI: Exactly elevation of finishing surface, elevation of each layer of structure, information of material, quantity. |

**Water supply system and drainage system**

**Table 4**

| LOD – LOI | LOD-LOI of rainwater drainage, sewage drainage (manhole, outlet, box culvert) |
|-----------|---------------------------------------------------------------------------|
| **200**   | LOD: Shows outside size  
|           | LOI: length, width and height of manhole |
| **300**   | LOD: Shows the size of the outside, distinguishing the neck and body of the manhole  
|           | LOI: Length and width of body, Length and width of; height of body and height of neck manhole |
### Table continuation 4

| LOD - LOI | Cast-in-situation structures of rainwater drainage, sewage drainage (manhole, outlet, box culvert) |
|-----------|--------------------------------------------------------------------------------------------------|
| 350       | **LOD:** Shows exactly dimensions of manholes without rebar arrangement  
|           | **LOI:** Length and width of body; Length and width of manhole body; height of manhole neck and manhole body; material and volume of concrete, formwork |
| 400       | **LOD:** Shows exactly dimensions of manhole with rebar arrangement and manhole foundation  
|           | **LOI:** Length and width of body; length and of neck; height of body and neck; material and volume of concrete, formwork, volume of rebar and non-physical information such as manufacturer, name of construction organization |

### Table 5

| LOD - LOI | Supply water items |
|-----------|---------------------|
| 200       | **LOD:** Shows outside size  
|           | **LOI:** Diameter, length, slope, direction of water flow |
### Table continuation 5

| LOD - LOI | Supply water items |
|-----------|--------------------|
| 300       | **LOD**: Shows the tare dimensions and some water supply accessories  <br> **LOI**: Diameter, length to the center of manhole, slope, direction of water flow, elevation of culvert bottom, material |
| 350       | **LOD**: Shows dimensions of outside and full of accessories  <br> **LOI**: Diameter, length to center of manhole, slope, direction of water flow, elevation of culvert bottom, material, elevation; water supply spare parts, year of installation, manufacturer. |
| 400       | **LOD**: Shows dimensions of outside and full accessories, details of spare parts support  <br> **LOI**: Diameter, length to center of manhole, slope, direction of water flow, elevation of culvert bottom, material, elevation; water supply spare parts, year of installation, manufacturer, details of construction organization |
Storage and retrieve infrastructure items
We can show the details of each type of structure. Besides, we can view the drawings directly on the construction site through the link of the drawings uploaded on BIM Glue 360 (Fig. 10).

Figure 10
Retrieve information through Autodesk BIM 360 GLUE

Detailed drawing Structural of Manhole steel layout
drawing

Figure 11
Detailed drawing of rebars structure layout of manholes
Check and handle infrastructure items

We can easily detect the number and position of intersections between infrastructure items. From there, the designing engineer will come up with suitable and optimal intersection handling solutions (Fig. 12-15).

Check infrastructure items:

Figure 12
Checking interfaces by NAVISWORKS software

Figure 13
Interaction in parties using BIM 360 GLUE
Handling intersection between rainwater sewer and water supply pipe:

![Image of intersection between rainwater sewer and water supply pipe]

**Figure 14**
Detecting intersections between storm drains and water supply pipes

Handling errors:
After detecting the position of intersections, the designing engineer offers suitable and optimal intersection handling options and recorded on the system.

![Image of handling intersection between storm drains and lighting wires]

**Figure 15**
Intersection between storm drains and lighting wires treatment plan
Export volume and information of infrastructure items
Exporting information for infrastructure items

Figure 4
Display and export information of items

Exporting Drawings from Auto Desks Revit 2020

Figure 5
Drawings exported from Auto Desks Revit 2020

Exporting quantity for infrastructure items
We can summarize the volume of all detailed items. They
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are all in one file.

Interaction in the parties
Client, designing consultants, project management board and contractors can interact with each other through BIM 360 Glue to finalize the product with advantages as: Solve problems quickly, no need to wait for documents to be exported; Parties can work anytime, anywhere; Acknowledge the problem clearly; All data is saved for reference by all parties (Fig. 18).

CONCLUSIONS
BIM is a useful tool for building design because it accelerates the overall design process in close collaboration with stakeholders. It also provides simulation and analysis of building performance, allowing designers to improve designs and select optimal design options.

For traffic engineering infrastructure design, BIM helps to increase design quality, significantly reducing conflicts between design in the office and construction in the field. Designs made through BIM when there is an adjustment, the changed information will be displayed on that object in another design department. With the use BIM, together with
the integration of volumetric measurement software, this stage will be performed automatically, thereby reducing construction costs. In addition, the use of data on cloud computing technology in BIM also helps teams work together to design, deliver products and store more conveniently. The application of BIM helps to reduce the waiting time for unintended conflicts caused by design errors or inconsistencies between design and construction so that the project management board will monitor and supervise the implementation of design and construction smoothly, accurately, and to limit errors in deploying design drawings to construction, helping to detect and anticipate difficulties in the construction process right from the stage of accessing design documents.

References:
[1] Autodesk (2020), Bim: BIM: Definition and characteristics, https://knowledge.autodesk.com/search-result/caas/simplecontent/content/bim-definition-and-characteristics.html
[2] HM Government (2015), 3-Digital Built Britain Level 3 Building Information Modelling – Strategic Plan, UK Government, London
[3] NIBMS-US (2015), National BIM Standard—United States, https://www.nationalbimstandard.org/about.
[4] Dispenza, K. (2010). The daily life of building information modeling (BIM). Design News.
[5] Toan, N. Q., Hang, N. T. T., Duyen, D. H., & Nam, T. P. (2020, June). Application of Building Information Modeling (BIM) for automatic integration of construction costs management information into 3D models in consideration of Vietnamese regulations. In IOP Conference Series: Materials Science and Engineering (Vol. 869, No. 6, p. 062007). IOP Publishing.
[6] Ministry of Construction (2021), Publication of General Guidelines for the application of Building Information Modeling (BIM). Decision No. 348/QD-BXD dated 02/04/2021.