CHAPTER II

LITERATURE REVIEW

2.1 Building Information Modeling

Building Information Modeling (BIM) defined as a sharable collection of building data, including a three-dimensional (3D) computer model of the entire project or collaborative platform to process produce, communicate and analyze the construction project using a digital information model throughout the project construction. The model contains information related to the structure, which includes physical/functional characteristics and project life cycle information. It was also developed to solve the issue of collaboration, coping with intensive information, reduce project time and cost, and improving construction performance. With BIM technology, one or more accurate virtual models of a building are constructed digitally.

The technical marketing Manager of Autodesk, Inc., Governati (2012) explain BIM is not just tool but a process that support virtual designing construction methodology and beyond to the operation and maintenance of the building.

Eastmant et al (2011) defines BIM as a"verb or adjective phase to desribe tools, process and technologies that are facilitated by digital machine readable decomentation about building, its performance, planning construction and operation. The result of BIM activity a "Building Information Model". BIM software tools are characterized by the ability to compile virtual models of the buildings using machine readable parametric object that exhibit behavior commensure with the need to design, analyze, and test a building design. Arayics et al (2012) explain that BIM is the utilization of a database infrastructure to encapsulate built facilities with specific viewpoints of stakeholders. BIM can be viewed as a combination of advanced processes and technology that offer a platform collaboration between different parties in the construction project and can help by providing the required value judgments that satisfy their owner and occupation for creating a move sustainable construction. In other word building information model is representing the building digitally and assisting the exchange of information (RAIC,2007) and performs as a database for sharing and using any information related to the building (Figure 2.1)

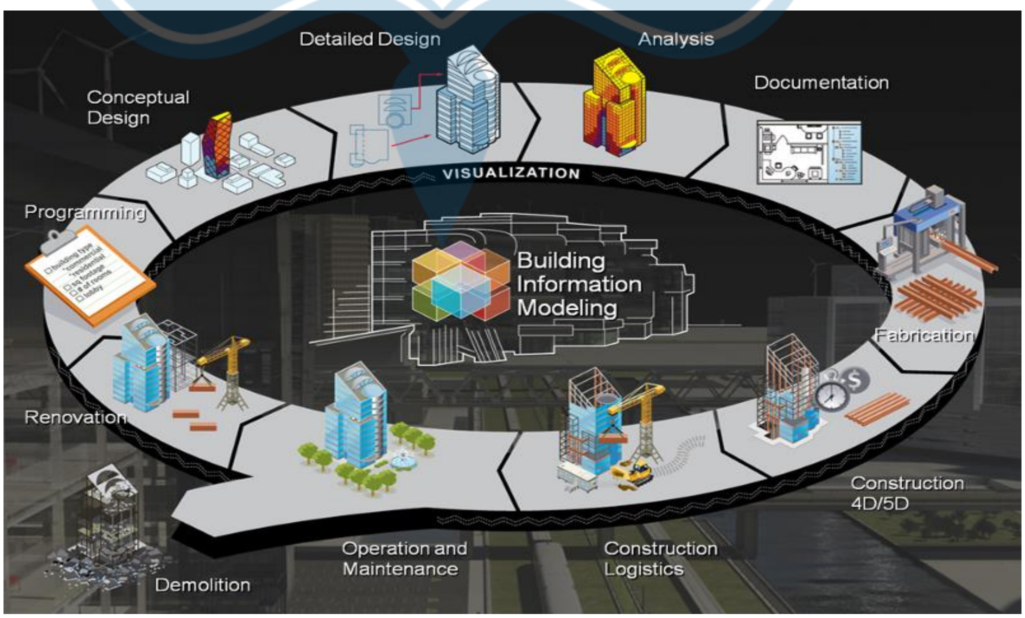

Figure 2.1 Building Information Modeling Cycle

BIM production process includes building geometry, geographical information, and the quantity and quality of building components. BIM can be used to demonstrate all building life cycles such as construction processes and facility operations, quantity and quality of a material can be easily excavated, to achieve progress with the model drawings of the actual parts used to construct a building.

The BIM concept illustrates the construction virtually before actual physical construction, to reduce uncertainty, improve safety, solve problems, simulate and analyze. BIM also prevents errors by allowing conflict or clash detection where visual computer models provide an overview of the team in which parts of buildings such as pipes and structural buildings intersect.

In implementation BIM divided into several levels BIM 3D, 4D, 5D, 6D, 7D, and 8D. BIM 3D is an object-based parametric modeling visualization such as building modeling, existing conditions, animation and rendering, 4D is the order and scheduling of materials, workers, area areas, time, etc., 5D including cost estimation, Detailing, value engineering, prefabrication solutions such as MEP systems and others, 6D enters into operation or focus on management facilities, 7D focuses on sustainable matters such as life cycle costs, energy efficiency, and environmental impacts, and the last one is 8D that provide safety building that is safety and comfort during the building is established and functioning.

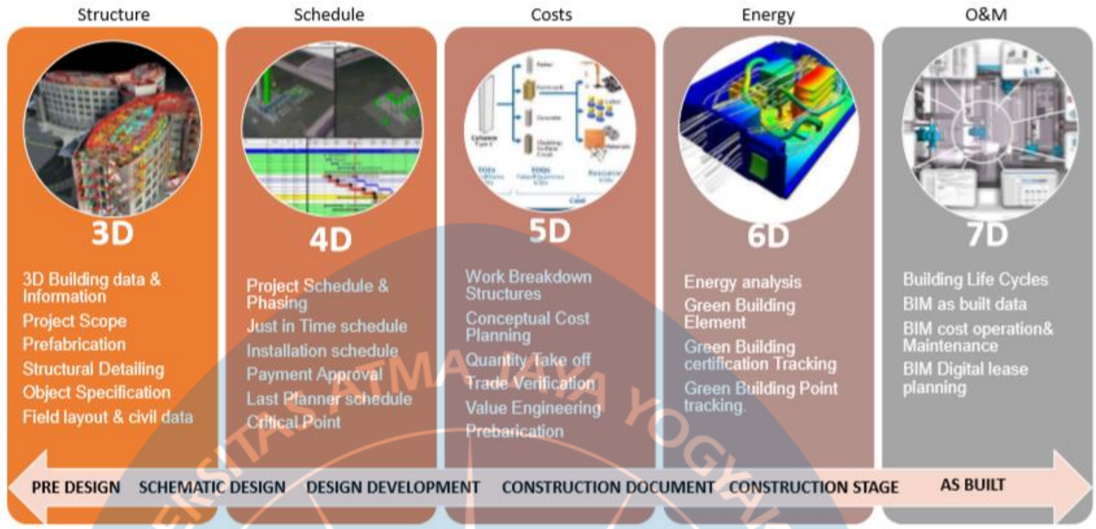

Figure 2.2 Building Information Modeling Dimensions

2.2.1. BIM History

The History of BIM was conceptualized in the 1970s and was initially called the Building Description System (BDS) (Eastman et al., 1974). The term "construction model" was first used in 1985 in architectural design paper on computer-aided drawing and computer-aided design (Ruffle, 1985) and in 1992, the term "construction information model" was first used in a paper on automation in construction (van Nederveen et al., 1992). It wasn't until 10 years later, however that the terms Building Information Model and Building Information Model (including the BIM acronym) were popularly used. It was in 2002 that Autodesk published a paper entitled "Building Information Modeling" and numerous software developers and vendors became interested in the field and the concept was standardized as the common name for the

Digital representation of the building process (Laiserin, 2008). Other related type terminology was used by different makers—"Virtual Building" by Graphisoft and "Integrated Project Models" by Bentley systems. Systems. Graphisoft developed early device solutions longer than the rivals on the market and was responsible for ArchiCAD, which was then "one of the most advanced BIM solutions on the market" (Laiserin, 2003). It was considered the first BIM implementation in 1987 and was the "first computer-aided design (CAD) product on a personal computer capable of creating 2D and 3D geometry, and the first commercial BIM product for personal computers" (Forbes et.al, 2010).

2.2.2. BIM Benefit

The benefits of BIM in development that can improve project management and coordination with each side, reducing cost and time and increasing broader efficiencies, change the design and construction process, accurate geometric representation of part of the building, improved production quality, better procurement decisions.

A building information model can be used for the following purposes:

- Visualization: 3D renderings can be easily generated in-house with little additional effort.

- Fabrication/shop drawings: it is easy to generate shop drawings for various building systems, the sheet metal ductwork shop drawing can be quickly produced once the model is complete.
- Forensic analysis: a building information model can easily be adapted to graphically illustrate potential failures, leaks, evacuation plans.
- Cost estimating: BIM software's have built-in cost estimating features. Material quantities are automatically extracted and changed when any changes are made in the model.
- Construction sequencing: a building information model can be effectively used to create material ordering, fabrication, and delivery schedules for all building components.
- Conflict, interference and collision detection: because BIM models are created, to scale, in 3D space, all major systems can be visually checked for interference

According Cooperative Research Center for Construction Innovation (2017), the benefits of Building information modeling are: faster and more efficient processes, better design, controlled whole life cost and environmental data, improved output quality, automated assembly, better customer service. BIM allows faster making decision, eliminates abstraction more easily and incorporates various disciplines, including design and documentation, reduce the time on market, and reduce the cost of design. It can also be used for detecting clashes and optimizing design.

2.2.3. Use of BIM in Construction Management

There are many uses of Building Information Modeling for each project participant. During the design phase, the use of BIM can maximize its impact on a project since the ability to influence cost is the highest. BIM can provide solutions to issues before problems become high cost impacts to the project. This can be realized through the cooperation and coordination of the entire project staff. Therefore, it is extremely important to have a good collaboration. The use of BIM especially enhances the collaborative efforts of the team. The architect and engineer can test their design ideas including energy analysis. The construction manager can provide constructability, sequencing, value and engineering reports. BIM can also start 3D coordination between subcontractors and vendors during early stages of design. The owner can visually notice if the design is what he is looking for. Overall, the BIM promotes the collaboration of all of the projection participants.

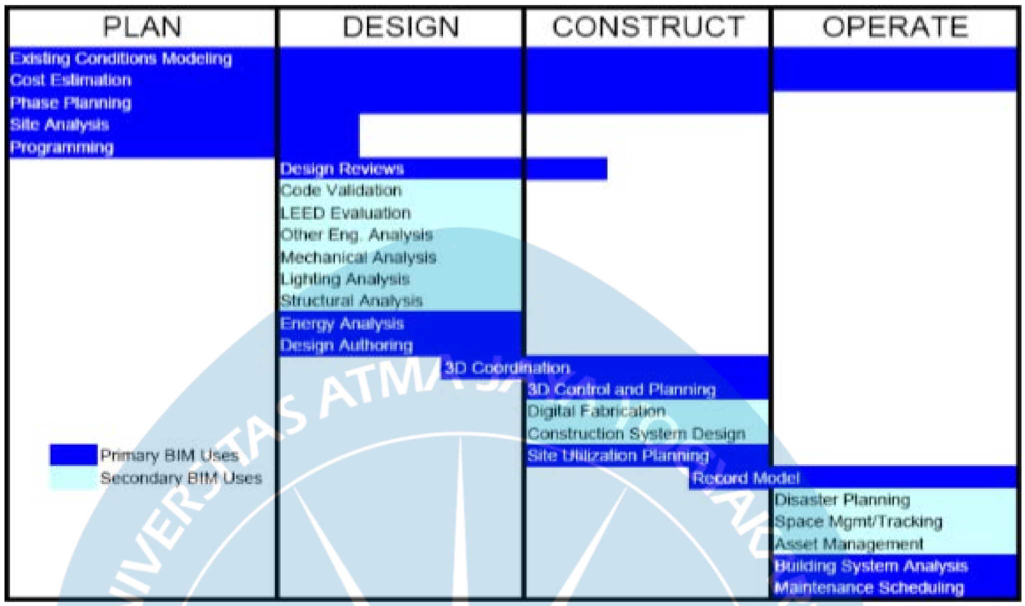

Figure 2.3 BIM uses throughout a Building Lifecycle

2.2.4. Building Information Modeling Software

There are various Building Information Modeling tools is available nowadays, the following table lists the BIM software and the main function which cover Structural, Architectural, MEP and 3D modeling software.

Product Name	Manufacturer	Primary Function
Cadpipe HCAV	AEC Design Group	3D HVAC Modeling
Revit Architecture	Autodesk	3D Architectural Modeling and parametric design
AutoCAD Architecture	Autodesk	3D Architectural Modeling and parametric design

Table 2.1 Building Information Modeling Software

Revit Structure	Autodesk	3D Structural Modeling and Parametric design.
Revit MEP	Autodesk	3D Detailed MEP Modeling
AutoCAD MEP	Autodesk	3D MEP Modeling
AutoCAD Civil 3D	Autodesk	Site Development
Cadpipe Commercial Pipe	AEC Design Group	3D Pipe Modeling
DProfiler	Beck Technology	3D conceptual modeling with real-time cost estimating
Bentley BIM Suite (MicroStation, Bentley Architecture, Structural, Mechanical, Electrical, Generative Design	Bentley Systems	3D Architectural, Structural, Mechanical, Electrical, and Generative Components Modeling
Fastrak	CSC (UK)	3D structural Modeling
SDS/2	Design Data	3D Detailed Structural Modeling
Fabrication for AutoCAD MEP	East Coast CAD/CAM	3D Detailed MEP Modeling
Digital Project	Gehry Technologies	CATIA based BIM System for Architectural, Design, Engineering, and Construction Modeling
AutoCAD Civil 3D	Autodesk	Site Development

Table 2.1 Building Information Modeling Software (Continue)

Cadpipe Commercial Pipe	AEC Design Group	3D Pipe Modeling
DProfiler	Beck Technology	3D conceptual modeling with real-time cost estimating
Bentley BIM Suite (MicroStation, Bentley Architecture, Structural, Mechanical, Electrical, Generative Design	Bentley Systems	3D Architectural, Structural, Mechanical, Electrical, and Generative Components Modeling
Digital Project MEP Systems Routing	Gehry Technologies	MEP Design
ArchiCAD	Graphisoft	3D Architectural Modeling
MEP Modeler	Graphisoft	3D MEP Modeling
HydraCA	Hydratec	3D Fire Sprinkler Design and Modeling
RISA	RISA Technologies	Full suite of 2D and 3D Structural Design Applications
PowerCivil	Bentley Systems	Site Development
Site Design, Site Planning	Eagle Point	Site Development

Table 2.1 Building Information Modeling Software (Continue)

Tekla Structures	Tekla	3D Detailed Structural Modeling
Affinity	Trekkigence	3D Model Application for early concept design
Vico Ofice	Vico Software	5D Modeling which can be used to generate cost and schedule data
RISA	RISA Technologies	Full suite of 2D and 3D Structural Design Applications
PowerCivil	Bentley Systems	Site Development
Site Design, Site Planning	Eagle Point	Site Development
Tekla Structures	Tekla	3D Detailed Structural Modeling
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Revit MEP	Autodesk	3D Detailed MEP Modeling
SDS/2	Design Data	3D Detailed Structural Modeling

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Table 2.1 Building Information Modeling Software (Continue)

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And in the next table is the Building Information Modeling software that used it makes shop drawing and Fabrication

Fabrication for AutoCAD MEP	East Coast CAD/CAM	3D Detailed MEP Modeling
CAD-Duct	Micro Application	3D Detailed MEP Modeling
Duct Designer 3D, Pipe Designer 3D	QuickPen International	3D Detailed MEP Modeling
Tekla Structures	Tekla	3D Detailed Structural Modeling

Table 2.2 Building Information Modeling Software Fabrication

The following table is Building Information Modeling software that are used in the construction management and scheduling stages.

Product Name	***Manufacturer***	***BIM Use***
Navisworks Manage Navisworks Scheduling	Autodesk	3D Pipe Modeling
Project Wise	Bentley	3D Detailed MEP Modeling
Digital Project Designer	Gehry Technologies	3D Detailed Structural Modeling

Visual Simulation	Innovaya	3D Detailed MEP Modeling
Solibri Model Checker	Solibri	3D Detailed MEP Modeling
Synchro	Synchro Ltd.	3D Detailed MEP Modeling
Tekla Structures	Tekla	3D Detailed Structural Modeling
Vico Office	Vico Software	

Table 2.3 Building Information Modeling Software construction management and scheduling stages

2.2.5. Roles of Associated Personnel in BIM Process

a) Architect / designer

The architects have been chosen in particular as they play a key role in the design process and have a wide responsibility of the design and building. The role expands to involve not only technical activities but other areas of competency including organizational politics, business strategy, consulting and leadership, and technology.

b) Client / owner

A project owner plays several roles during the course of the project, including that of a Chairman, Team Leader, Troubleshooter and a representative for the project team as well as the client. Define Goal and Project Scope, Establish and Manage Human Resource, Ensure Effective Communication, Manage Risk and Manage Schedule and Budget of a project.

c) Detailer/fabrication

A digital design-to-fabrication workflow creates opportunities for improved collaboration among architects, fabricators and builders. Using coordinated data within a fully informed building information model can improve the constructability, reduce the cost, and enable design innovations for creating unique and repetitive building components

d) General Contractor/builder

In general, responsibilities of contractors in BIM process include the following:

1. Creation and information developed during construction
2. Coordination of construction sequencing and scheduling activities.
3. Facilitate the use of composite trade models in construction coordination/clash detection meeting and provide the detection report.
4. Coordination of software training ad establishing protocol software for construction team for efficient delivery of projet

e) MEP Engineer

BIM gives mechanical, electrical, and plumbing (MEP) engineering professionals the ability to better predict the outcome of their systems before they are built. By creating and analyzing designs in a model, MEP professionals can deliver sophisticated, sustainable building systems more quickly and economically than ever before, increased visibility facilitates coordination and collaboration with architects and other engineers to significantly reduce errors and improve the accuracy and reliability of MEP engineering design and documentation

f) Structural Engineer

The role of the structural engineer in BIM is important: his decisions will largely influence the cost and construction sequence of the basic structure. The sizes of the elements are determine in construction, the choice may result in a bonus of an extra story if floor thicknesses can be reduced.

g) Supplier & Manufacture

BIM allows product suppliers and manufacturers to supply detailed 'virtual products' to architects, engineers and detailers as easily as they traditionally provided data or 2D. CAD details with a The consequent benefits of relationship building and product loyalty in specification.

2.2 Implementation BIM

BIM is an approach to building design, construction, and management. Though it is not itself a technology, it is supported to varying degrees by different technologies (Autodesk, 2003).

2.2.1. Visualization

Building Information Modeling is a great visualization tool. It provides a 3D virtual representation of the building. During the bidding phase of the project, the construction manager can provide rendering, walkthroughs, and sequencing of the model to better communicate. Visualization provides a better understanding of what the final product may look like. Furthermore, virtual mock-ups such as laboratories or building envelope can be provided to the designer and the owner. This would help to visualize, better understand, and make decisions on the aesthetics and the functionality of the space the virtual mock ups help to communicate and collaborate among the project participants. It promotes planning, and sequencing the curtain wall construction. Virtual mock up is cost efficient in comparison to a physical mock-up, a physical mock-up may still be required if a member such as casework drawer or an assembly of the building such as a curtain wall need to go through a series of physical tests. Hence, virtual mock-ups could become a good standard to initiate the mock up process and an actual mock-up may be necessary after the virtual mock up is approved.

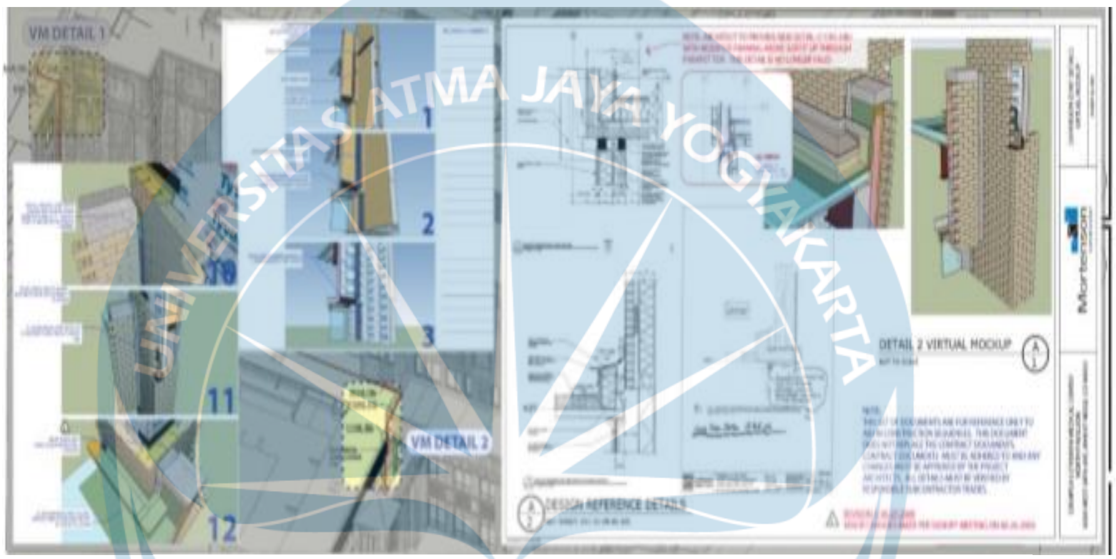

Figure 2.4 (Visualization 3D BIM and Shop Drawing)

2.2.2. Construction Planning

Construction planning is an ongoing effort to manage the progress of a construction project and react accordingly – dynamically adjusting to the "situation on the ground." Of course, a building's design is at the core of its project plan, and by adding schedule data to a 3D building information model (the building design) a 4D building information model can be created, where time is the 4th dimension. The construction planning involves the scheduling and sequencing of the model to coordinate virtual construction in time and

Space. The utilization of scheduling introduces time as the 4th dimension (4D). There are two common scheduling methods that can be used to create 4D Building Information Model. These are critical path method (CPM) and line of balance. In the Critical Path Method, each activity is listed, linked to another activity, and assigned durations. Line of Balance technique uses location as the basis for scheduling. This method is an alternate to the CPM. It is advantageous for repetitive tasks to increase labor productivity. In this method, activity durations are based on the available crew size and the sequence of the location. Productivity of the labor force can be altered as needed to accurately depict the construction schedule.

2.2.3. Cost Estimation

The two main elements of a cost estimate are quantity take-off and pricing. Quantities from a Building Information Model can be extracted to a cost database or an excel file. Cost estimating requires the expertise of the cost estimator to analyze the components of a material and how they get installed if the pricing for a certain activity is not available in the database, cost estimator may need a further breakdown of the element for more accurate pricing. For instance, if a concrete pour activity is taking place, the model may account for the level of detail for the rebar, wire mesh, pour stop, formwork, concrete etc., but not include it as part of the quantity take-off extraction. Cost estimator may

Need this level of detail from the model to figure out the unit price which consists of the unit material cost, unit labor cost, overhead and profit. The unit labor cost is driven by the mobilization and installation durations, and the labor wage while the unit material cost is the sum of the material costs used for the activity per unit. Once the unit price is attained, the cost of the entire activity can be attained by multiplication of the total quantity extracted from BIM and unit price.

In Building Information Model, the data output is as good as the data input. It is significantly important to have the constructor and the designer to agree on component definitions. For instance, if an architect is using concrete slab to show the roof for modeling purposes, the roof quantity information will not be accurately accounted for quantity extraction purposes in the model. Overall, the BIM technology is a great tool to optimize the productivity of the estimators through quantity extraction from the model especially if the construction and design team work collaboratively.

2.2.4. Clash Detection

Clash detection remain the primary requirement of any multidisciplinary project wherein composite design needs to be inspected for the identification of clashes. Clash detection is method of inspecting and identifying the various interferences which frequently occur in coordinating

Process of 3D models. Clash occur when element of different models occupy the same space. A clash may be geometric, schedule based or change/updates not made to drawings. There are 3 main types of clashes that clash detection:

1. Hard Clash

   When two object pass through each other. Such as pipes passing through walls, lower ceiling light. Most BIM modeling software eliminated the like hood for this using clash detection rules based on embedded object data.

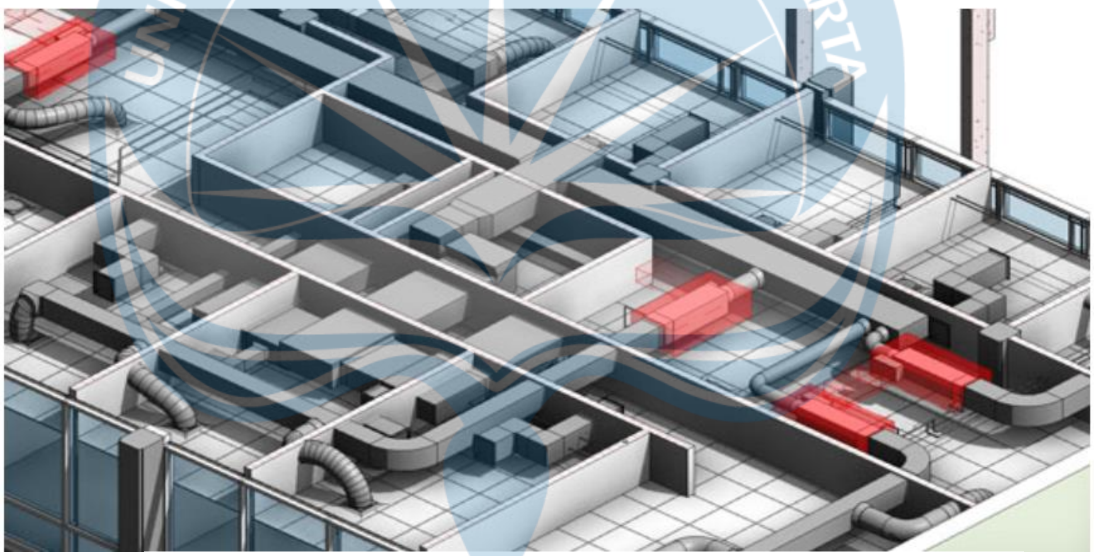

Figure 2.5 (Clash detection with Building Information Modeling)

2. Soft Clash

Clashes which occur when the object needs more positive spatial or geometrical tolerances, space and buffer within their buffer zone for improved accessibility, insulation, maintenance and safety. Such as A building being too close to a high tension wire.

3. 4D / Workflow

Clash resolve scheduling clashes and abnormalities as well as delivery clashes. This type of clash might involve the scheduling of contractors, the delivery of equipment like bulldozer, crane and materials, and general timelines conflict example work crews arriving when there is no equipment on site.