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Building Information Modeling and Fire Protection

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Introduction

In the design and construction industry, the use of Building Information Modeling (BIM) has expanded significantly. According to McGraw-Hill Construction, the percentage of design and construction companies using BIM has increased from 17 percent in 2007 to 71 percent in 2012. And the firms that are using BIM report they are using BIM in over 60 percent of their projects. As the use of BIM increases, fire protection professionals will need to understand how this technology will impact fire protection design.

This paper will discuss the use of BIM technology in building design and construction, particularly with respect to fire protection. Since the use of BIM is relatively new in the field of fire protection engineering; this presentation will define BIM, how BIM is currently being applied and the benefits of BIM.

Additionally, this paper will describe how BIM has expanded the design process from typical 2-dimensional drawings to design documents that have three, four and five dimensions. It will also discuss issues code officials/authorities having jurisdiction should considering when reviewing projects that incorporate BIM Models.

The last part of this paper will provide recommendations that the Society of Fire Protection Engineers (SFPE) encourage on future additions to the current BIM models. These recommendations will assist the fire protection community in keeping pace with the level of design and information provided by other engineering disciplines.

What is BIM?

Basically, BIM is a digital representation of the physical and functional characteristics of a facility. It also serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle from inception to demolition.

Moreover, BIM is an interactive electronic database that can be shared by all building stakeholders involved in the design, construction or operation of a facility. These stakeholders include the owner, architect, fire protection professionals, engineers, contractor and the building's facility management personnel. These stakeholders can also include the fire service and code enforcement officials.

Through the use of software, BIM provides the ability to electronically insert, extract, update, modify, store and track detailed information relative to the design, construction, specification, cost, operation, maintenance, use, and management of a facility. It can also include product specifications, information about applicable codes and standards, product installation manuals, parts inventory, maintenance schedules, warranties and virtually any information desired about the building or its contents. Basically, it serves as an electronic archive for all of this information and has the capability to search, correlate and analyze this information in whatever format is available and interoperable with the standard(s) and software contained within the BIM.

In the future, BIM has the capability be used to provide immediate information to emergency responders for pre-planning or emergency operations. It also has the capability to provide code officials a way to easily monitor the status of a) code reviews during the design phase, b) acceptance tests during the construction phase and c) inspection reports throughout the life of the building.

One of the most popular features of BIM is the capability to illustrate every aspect of a facility in three dimensions (3D). Thus, instead of using conventional detailed architectural drawings or CAD two dimensional (2D) layouts, BIM can electronically demonstrate precisely how the different elements of a building come together and relate with each other, including its architecture, structure, mechanical, electrical and other systems and features.

BIM also permits a user to take an electronic “virtual tour” of a new building while it is being designed. For example, a code official can “visually” evaluate the means of egress in 3D. Furthermore, BIM can include a fourth dimension (4D) to analyze scheduling and a fifth dimension (5D) to analyze cost. Other dimensions to perform code analysis, energy audits, etc. are being developed and there appears to be no limit to the potential capability of this technology.

Additionally, the use of BIM has been demonstrated to provide significant overall cost savings because of the more efficient management of information related to facility design, construction and life cycle operation.

Benefits of BIM

BIM has enabled the architectural, engineering, and construction industry to produce accurate representative models of the built environment. For example, an owner determines a new facility is needed. An architect develops the general building envelope while the consulting engineer designs the building systems. The intent is to completely build the building electronically first and work out problems in an electronic environment before constructing the facility.

During the construction phase, it is not uncommon that unforeseen conditions and coordination issues will be kept to a minimum since problems were more easily distinguishable during the production of the model. These conflicts historically increased both the overall project cost and construction timeline, so it is in the best interest of the design team to minimize these occurrences to reduce overall project cost while resulting in a higher quality facility. As such, projects have less change orders and a minimum number of Requests For Information (RFIs).

Furthermore, the design and construction of a facility requires the integration of several different design professionals, contractors and other interested parties. Communication between all interested parties can be challenging, and the use of BIM software can more clearly and concisely communicate design intentions and coordination problems in the field.

When looking at fire protection aspects, fire protection and life safety components can be better represented in a BIM model. For instance, the graphical and physical representation of a smoke control system can be evaluated and validated with a number of different fire scenarios within the model. Building construction type and location of passive fire protection elements can be accurately depicted and tracked so they are maintained by the building owner.

During building commissioning BIM can assist in recording the standards of performance for building systems, and to verify what is constructed meets those standards. BIM also assists all building stakeholders in documenting the continuity of the project as it moves from one project phase to the next.

The overall return of investment to the owner should be realized as the use of BIM becomes more prevalent in the design and construction industry. Fire protection and life safety design should continue to be an integral part of BIM software. Continued attention needs to be made to improve the modeling of sprinkler, fire alarm, special hazard, smoke management systems, structural, passive fire protection, and egress analysis. The continued integration of all these components along with the many other building systems will allow for a more comprehensive tool for the life of the building.

One of the top benefits from BIM is the fact that the 3D design aspects of the BIM process allows for the early clash detection with other systems. The location of sprinkler system risers and bulk mains can be coordinated with other trades. Or the location of a fire pump with respect to water-based fire suppression system piping and associated valves will be better represented by showing how all this essential fire safety equipment will fit in the pump room.

In addition the 4D and 5D information process that includes scheduling and cost considerations will be helpful when changes to the design are needed. This will be helpful when different code equivalencies are being discussed. The BIM model information also has the capability to provide the owner with final cost data for fire suppression, detection and alarm systems, and to some extent life safety parameters; however, current BIM models do not have the modules available to easily import this information. As time goes on, information will become more available and model elements will be developed by the manufacturers for use by the general industry.

Present Use of BIM in Fire Protection Engineering

To date there has been limited interaction between the fire protection engineering community and the BIM software and platform development. The BIM community and individual software developers have generally focused on the larger design disciplines (e.g. architecture, structural, and mechanical/electrical engineering) along with the development of tools to transition from design and construction to building operation.

By comparison, fire protection engineering is a much smaller application and has therefore not been a priority for the BIM software and tools development. However, as BIM tools continue to evolve there is significant opportunity for the fire protection engineering community to become involved in the process and to influence how software/tools incorporate the fire protection engineering discipline. This includes fire suppression systems design, fire alarm and notification systems design, life safety and code compliance, and performance-based design.

Life Safety Drawings

Typical Life Safety Drawings have historically incorporated items such as locating rated walls, identifying occupant loads, egress paths (means of egress, common paths of travel, dead ends), exit signs and fire extinguishers. The enhanced features of a BIM model will be able to quickly identify additional features that are not readily identified in typical CAD drawings, such as door hardware (e.g., self closers, positive latching, astragals, delayed egress, access control, door holders, magnetic door locking devices, etc.).

BIM has the capability to link the data from the architectural model to develop a separate life safety model that could be transferred down to a 2-D drawing for use by the code official. If the architectural model changes, corresponding changes would have to be made to the life safety model.

The architectural model will greatly enhance the input data immediately available to the fire protection engineer for evaluation of code compliance. However, in the short term, because of code nuances, the evaluation of the data and conclusion reached will not be immediately available from the model.

Fire Suppression System Design

Although, fire sprinkler system design is fairly evolved, there are still basic limitations such as the typical lack of populated symbols libraries including many missing symbols for basic systems components. Sprinkler system capability has typically been included within the BIM software as part of a larger mechanical/electrical/plumbing (MEP) package, which is generally focused on other MEP design elements, although the BIM platform is typically used for conflict checking of sprinkler system piping and equipment with other design entities.

Another option for sprinkler system design is to use a third party design program that is compatible with the base design BIM platform/software. These third party programs include benefits such as integrated hydraulic calculations, although the often changing BIM platforms can sometimes make compatibility with remaining design team documents/models difficult.

The lack of specific software capabilities often results in the FPE using BIM software as a basic drawing tool as opposed to being able to benefit from the basic BIM principles and the collaborative platform. There is potential to develop specific tools within the BIM platform to automatically incorporate system design and performance characteristics such as hydraulic and water supply calculations, remote area calculations, etc.

Fire Alarm Design
In general, the currently available BIM software packages have very limited capabilities in relation to fire alarm system design. There are typically limited symbols lists and similar to suppression system design, the lack of software capabilities often results in the FPE simply using the BIM software as a basic drawing tool. There is potential to be able to develop specific tools within the BIM platform to automatically incorporate system design and performance characteristics such as battery and power calculations.

Performance-Based Fire Protection Design
There are generally no direct performance-based design capabilities within currently available BIM software packages; however, given the flexibility and premise for embedding/connecting calculations, there is some far reaching potential to incorporate inputs such as atrium smoke control analysis calculations, fire effects, and egress modeling directly into BIM models. While the development of these types of embedded capabilities is likely well into the future, there is current potential/capability to export BIM model information for direct import into some fire models to create building geometries and similar physical parameters. As the necessary file standards are further defined, the ability to transfer more detailed parameters and properties should also be possible.

The Future

As BIM becomes utilized on more private and public projects, the design and information input into the model will continue to grow. Fire protection engineers will need additional support from fire protection manufacturers and BIM program developers to keep pace with the level of design and information provided by other engineering disciplines to the model.

Additional support will be needed from program manufacturers to develop BIM programs and training specifically for fire protection systems. Fire protection specific BIM programs or add-ons should be developed with features that are useful to fire protection engineers and designers. Features may include:

- Intelligent information about a specific piece of equipment (i.e. click on a sprinkler and immediately be presented with the orifice, orientation, k-factor, SIN, etc.)
- Strobe candela rating selection and visibility model
- Intelligibility and audibility calculation based on actual building model
- Door hardware (e.g. self-closing, positive latching, astragals, delayed egress, access controlled, door holders, etc.)

Additionally, although manufactures of fire protection systems have made major strides over the last couple of years in the development of BIM compatible details for major fire protection equipment, there is room for improvement. Eventually these details will have intelligence in that they would include size, model number, flow characteristics, power requirements, etc.

There is also a need for a consistent level of design among fire protection engineers. While there are exceptions when a detailed design is necessary, inconsistent level of design causes stakeholder confusion. For example, some stakeholders may be expecting full layout design of a sprinkler system in the model while the fire protection engineer is developing a performance design. Other stakeholders may be expecting performance design with full layout design by the installation contractor. If the fire protection engineer performs a full layout in the model, the stakeholder ends up paying additional cost that was not anticipated.

In addition, there is a need for the development of interfaces between BIM and commonly used FPE programs such as fire and evacuation models. This would provide a great opportunity for fire protection engineers develop design scenarios and evaluate trial designs in a performance-based design.

BIM also has the capability to provide interfaces that will assist the fire service plan an effective intervention strategy. For example, fire lanes, access to fire department connections, use of standpipe valves, and ladder truck placement can assist the fire department in pre-fire planning and eventually fire department operations during actual emergencies.

Bibliography

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