Study on the Data Exchanges between Building Information Model and Fire Dynamics Simulator

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Abstract. This paper studies the methods of the application of the Building Information Modeling (BIM) in the fire data simulation. Through the analysis of the input data files of Industry Foundation Classes (IFC) standard of BIM and the Fire Dynamics Simulator (FDS) model, it was found that both of them used the means of object-oriented information organizing in order to describe the building model. This paper brings forward the design plan of the data exchanges between BIM and the FDS model through the Drawing Exchange Format (DXF) which achieves the data sharing and exchanges based on the IFC standard so as to directly transform the BIM to fire and evacuation model of FDS, which can provides the reference and technical support for the building fire protection design.

1 Introduction

During the process of fire data simulation, the fire engineers have always been troubled by the arduous modeling task and the accuracy of the models. With the continuous development and deep research of the Building Information Modeling (BIM), the various features of BIM provide new technologies and methods for traditional building fire protection design, especially for the fire data simulation in recent years.

2 BIM and its data format

The concept of BIM was initially put forward in the 1980s, which is the inevitable product of the combination of the information and digital technologies. The aim of BIM is to achieve the digital expression of all the building information (elements and functions), build up an abundant database and provide policy support for the decision making of all participants within the whole architectural life cycle [1]. The BIM technology has already triggered great changes in construction industry of the developed countries in Europe and America from its appearance since 2002. Nowadays, it also sets off the waves of reform in China. The Revit software developed by the Autodesk Company is one of the main representatives of the application of BIM [2]. The figure 1 is the BIM of an office building.

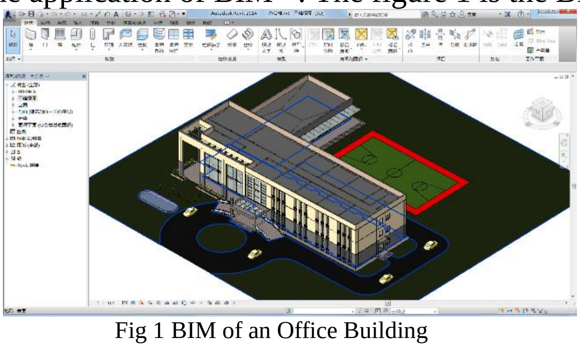

Fig 1 BIM of an Office Building

2.1 IFC data format

The definitions of BIM data adopts the Industry Foundation Classes (IFC) standard. IFC provides the data definitions mode and information exchange format for BIM. The modeling data uses the EXPRESS language and EXPRESS-G graph [3]. IFC is an open data expression standard, which can make all the participants share and exchange the data information of different phases during the application process of BIM. The latest version is IFC4 at present, which was published by the Building SMART in March, 2013.

The spatial structure of IFC standard data files can be classified into four layers according to the logic relations [4]. They are respectively domain layer, interoperability layer, core layer and resource layer from high to low, which shows as the following figure 2. The domain layer is the highest layer of the spatial structure of IFC standard data files. Any definitions that is quoted or utilized in the domain layer is independent. The main function of the domain layer is to penetrate deeply into internal data of all application domains so as to form various professional information. The interoperability layer is the secondary high layer of the spatial structure of IFC standard data files. The main function of interoperability layer is to serve for the domain layer, which solves the problem of the model information exchanges of the domain layer. The main function of the core layer is to provide the basic IFC data files model structures and concepts, effectively organize the data information of the resource layer and become an organic entirety in order to objectively reflect the real structure of the model files [5]. The resource layer is the lowest layer of the spatial structure of IFC standard data files, which serves for the other three layers. The function of resource layer is to describe the basic information related with the IFC standard. It isn't in connection with any specific profession.

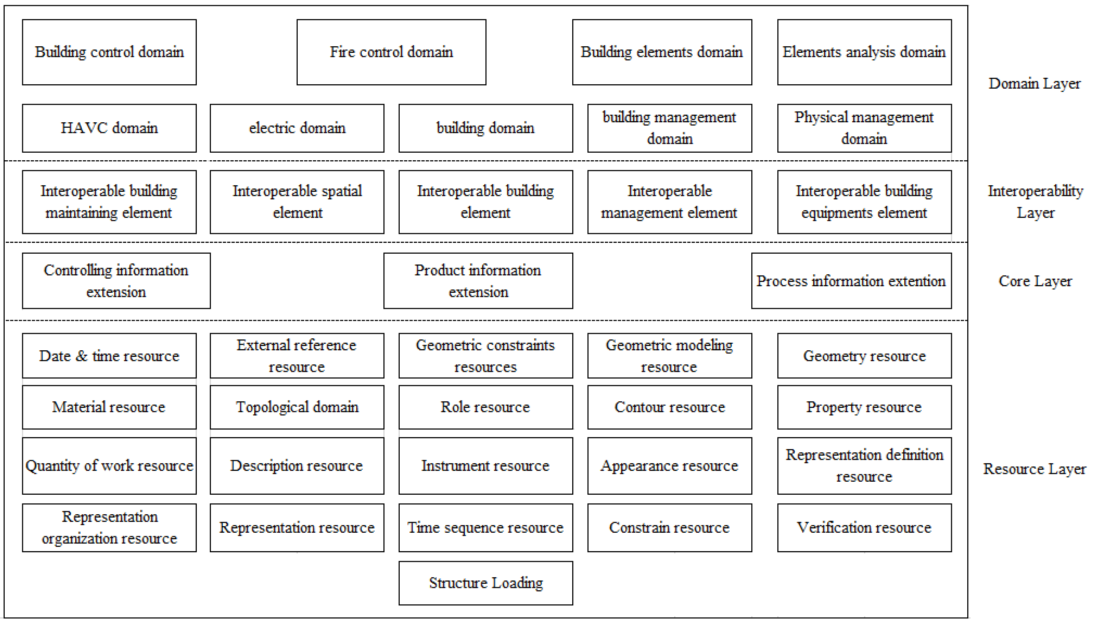

Fig 2 The Schematic Diagram of IFC Standard Data File of Spatial Structure

The model of IFC data format is consist of entities, definition types, selection types, rules, functions and attributes sets. IFC standard includes plenty of entities, in which the IFCROOT is the most important root of the IFC entity definitions. The others are all derived from the IFCROOT, which can be divided into two categories: one is the entities that can be used independently for the data exchanges, distributed in the frame layer, interoperability layer and domain layer and it possesses the GLOBALID attributes. The other can't be used independently for the data exchanges. It always exists in the form of the derived entity of the IFCROOT and it doesn't have the identification attribute of the overall situation. This type of entities are all distributed in the resource layer.

2.2 The methods of BIM data exchanges

There are three main methods of BIM data exchanges: Firstly, it can exchange data between different soft wares based on the IFC standard; secondly, it must be further developed so as to plug in the Revit in the form of Revit Application Programming Interface (API); thirdly, the other means of exchanges, such as data exchange based on the intermediate file Excel. This thesis chooses the first method to be studied. The BIM based on the IFC standard can store many kinds of geometric model data. Table 1 lists several type of geometric models, in which Curve2D, Geometric Set, Geometric Curve Set can be used to describe the models which are consist of the basic primitive such as points, lines and surfaces. Surface Model is used to describe the surface models. Solid Model is used to describe the solid models which can be further classified into more models such as Swept Solid, Brep, CSG, Clipping, Advanced Swept Solid etc.

Table 1 Predefined Geometric Type of IFC

Type	Remarks
Curve 2D	2 dimensional Curve
Geometric Set	Sets of points, curves and surfaces （2 or 3 dimensional）
Geometric Curve Set	Sets of points, curves （2 or 3 dimensional）
Surface Model	Surface model
Solid Model	Solid model
Swept Solid	Swept solid through Stretching or Rotating
Brep	The solid described by the boundary
CSG	Geometric solid through Boolean operations
Clipping	Geometric solid through Boolean operations（Differential operations）
Advanced Swept Solid	Swept solid along the baseline

3 FDS data format

Among the Fire Dynamics Simulator (FDS) models, the geometric information of the entities within the space has its special storage means [6]. If we use the cuboids to represent the building elements and the interior decoration, each cuboid will have its special definition. The geometric information of the building elements and the interior decoration usually use the OBST order to be represented (except for a few elements, such as doors and windows). One OBST represents one cuboid, which includes its coordinate location information. Each cuboid uses two diagonal points to be described. For example, if one cuboid has two diagonal points A（X1，Y1，Z1）and B（X2，Y2，Z2）, it will be represented in the OBST in the form of XB=X1，X2，Y1，Y2，Z1，Z2 [7].That is to represent the cuboid through the maximum and minimal coordinate points, such as the figure 3.

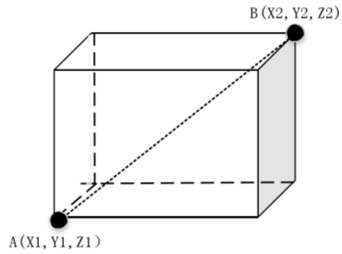

Fig 3 The geometric representation means of the FDS model

4 The plans of data exchanges

The FDS software can only build the models through the text programming previously and various parameters such as the materials, equipment also need the text programming, which make the modeling extremely inconveniently. Therefore, we use the Pyrosim software to simplify the modeling process [8].

Pyrosim is a software that is developed by the Thunderhead Engineering Company of United States on the basis of the FDS. It can accurately predict and analyze the pattern of motion of the fire smoke, the smoke temperature and density of the poison gas. The greatest feature of Pyrosim is that it can provide three dimensional visual graphics operation interface for the FDS modeling and improve the modeling process efficiently.

This research firstly adopts the Autdoesk Company’s Revit as the Computer Aided Design (CAD)platform of the building design to set up the BIM database, and then use the conversion function of the IFC to automatically generate the IFC data exchange file——the Drawing Exchange Format (DXF) file for the Pyrosim to be used in the simulation[9]. The following figure 4 shows the data exchanges plan.

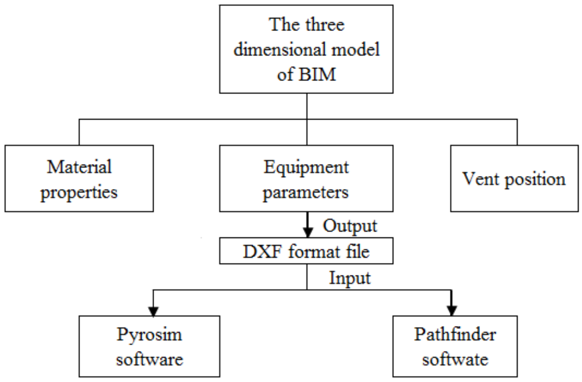

Fig 4 The schematic diagram of the data exchanges plan

DXF is developed by the Autodesk Company in order to exchange data of CAD format between AutoCAD and other soft wares. DXF is an open vector data format which can be divided into two types: ASCII format and binary format. Readability is the advantage of ASCII, but it occupies too large space; binary format occupies small space and the reading speed is fast. The DWG file can't be exchanged between different types of computers [10]. AutoCAD provides the DXF file in order to overcome the shortcomings. Different types of computers can exchange the DXF file so as to exchange the graphs. The DXF file is easy to be read and the clients can revise and program it conveniently [11]. Therefore, it can be edited and revised from the external graphs. The DXF of the ASCII format can be viewed with the text editor.

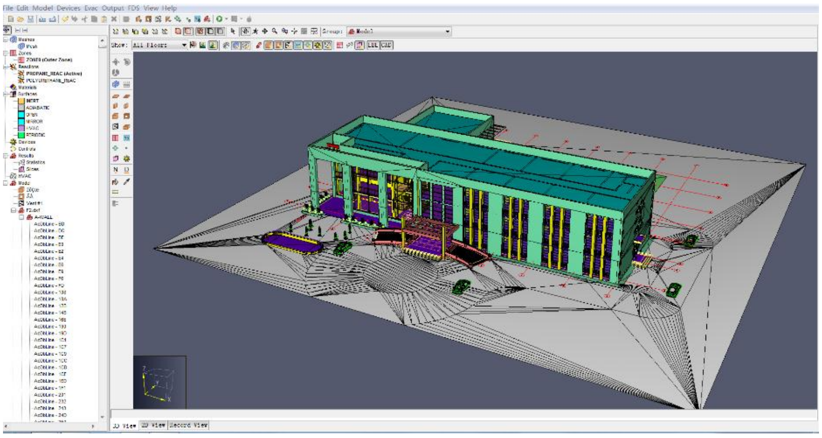

Fig 5 The schematic office building model after input of the Pyrosim

5 The Key issues of the data exchanges

Through large amount of tests we find that the input format of different fire simulation software is not alike, the input model has the special requirement for the interface and format. After repeated tests, the author finds that using the DXF format during the conversion process is the most direct and not easy to cause errors. The models shows normal in the Pyrosim and three-dimensional browsing is more fluently, however, we should also pay attention to the following issues:

1. If the BIM model is too large, it will influence the fluency of the three-dimensional browsing in the Pyrosim or will not be input into it.

2. When transforming the BIM model into the DXF format, we should remove the unnecessary entities of the FDS model, such as greenings and aprons in order to avoid the errors in fire simulation in the later stage.

3. After input the models into the Pyrosim, it will automatically locate the coordinate of the models in the three-dimensional space. When building the fire models, the Pyrosim will automatically give the measurement and quantity of the grid reference according to the input the building model, but the quantities of the grid reference always includes the whole model, therefore, we need revise the grid so as to be closer to the models, which make the simulation results more truthful.

4. Because the BIM model is built in different zones, it will be isolated by different zones after input into the Pyrosim. Therefore, we need to install passable doors in the zone connections in order to let the smoke and personnel to pass.

6 Conclusions

This research analyzes the IFC data standard and the geometric information of FDS model. It can correctly recognize the BIM model in the Pyrosim software through the DXF format. However, this thesis still has some insufficiencies, there is a lot of work need to done in the subsequent development. The main work that needs to be done includes the following:

1. The data exchanges still needs to be improved, such as the extraction and identification of information of the thermodynamic properties of related building materials and the thermal properties;
2. The data exchanges and recognition of the irregular building elements also still needs to be further studied.

Acknowledgment

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