An automation tool for exporting structure models from Revit to Tekla Structure

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Abstract. BIM modeling process currently faces a significant exchange issues since there is a need for conversion of intelligent building models between various design applications. Right now, Autodesk Revit and Tekla Structures, as the most popular BIM applications, in which compatibility issues were noted since many projects are facing the difficulties when a building model was converted from Revit to Tekla. Although Industrial Foundation Class (IFC), as a promise open file format which enables the possibility of exchange of models between different design applications, an exchange of models with IFC may cause compatibility issues where parts of building information can be lost or relocated. This study aims to develop a plug-in application for converting building models from Revit to Tekla by using API interface. To test the plug-in tool, a 34-storey high-rise residential building model is exchanged from Revit and Tekla with IFC and the plug-in application. The results showed the plug-in application performed better than IFC method in terms of accuracy and efficiency.

Keywords: BIM, Revit, Tekla, API, IFC.

1. Introduction

“Building Information Modeling (BIM) is an intelligent 3D model-based process that gives architecture, engineering, and construction (AEC) professional the insight and tools to more efficiently plan, design, construct, and manage buildings and infrastructure” [1]. In recent years, BIM has gained much attraction since digital construction technology that will fundamentally transform the AEC industry in the delivery of an excellent built environment. The concept of BIM was first appeared in the 1974 by Professor Eastman who described a novel working prototype named Building Description System (BDS) which described the use of computers to store and manipulate design information through the buildings’ entire life cycle (design, construction and operation stages) [2]. After years of research and development, the academic community integrated the research results of building product models and product information models, and put forward the concept of Building Information Model [3].

To date, the intensive scientific and technological development in Computing and Communication science has boosted and advanced the substantial development of BIM technology. Autodesk released a series product of Autodesk Revit in 2002, since then, commercialized BIM products have been spread and promoted over the AEC industry. Design with Revit software can automatically generate all the required design information from the 3D building model such as plan drawings and elevation drawings. In addition, the information within Revit is automatically associated and interrelated from one another,
which means that when there is one element being changed, its related information will change automatically without any manual work; this greatly enhances the effectiveness of design modifications.

2. The compatibility issues between Revit and Tekla

Autodesk Revit, as one of the most popular BIM application software, has been introduced in China for more than 10 years and has taken a substantial proportion (more than 50%) of BIM market in China [4]. However, the process of constructing a building from design to construction is very complex, it is impossible to rely on a single software. The implementation of BIM technology in AEC requires coordination of various professional software for different tasks [5]. Although Revit is a very powerful software to integrate the assets’ information from design to construction, it suffers difficulties when it is used to perform the steel reinforcement design [6]. Small-scale projects can basically meet the needs of structural design; but for large-scale projects, the speed of Revit modeling depends on the model processing capabilities of the platform itself. For example: After creating a large-scale project in Revit, there is a serious sluggishness of Revit. If the computer configuration is not good enough, with big-scale project, Revit suffers lock down when performing steel structural design task, therefore further adding steel bars into the model is even impossible. In this project, we performed a reinforcement design by using Revit for a 20-storey residential building. When the floor reinforcement work was carried out, the computer was stuck, and Revit basically stopped running, and the entire modeling work was forced to stop. Therefore, there is a need to use the other software to process the reinforcement design.

Tekla structure, an advanced structural BIM software, which is used to combine, manage, and share multi-material 3D models packed with valuable construction information. Tekla performs detailed steel design easily and quickly whereas steel structural design suffers software collapse in Revit, especially when the building model is complicated. Tekla Structures is the first 3D solid model professional steel structure software developed by a Finnish company which is most commonly used in steel structure with detailed design. Tekla can execute the whole process operation of design, detailed drawing, processing and construction management, and is used to output construction drawings, material reports, etc. Compare with Revit, Tekla has the following advantages: the creation of steel bars is easier, occupies a smaller memory, and not prone to stalling during processing. The superiority of Tekla is exactly the limitation of Revit; hence a combination application of Revit and Tekla structures will optimize BIM workflows with truly constructible design, detailing and information management.

However, these two software are from different companies which means that the data format is proprietary for both of them due to the commercial nature. This project is aiming for exporting BIM model from Revit, and then importing into Tekla structures for detailed steel bars design. At present, the model conversion methods based on Revit platform are mainly carried out by developing interface, and there are three major ways: (1) public conversion standard (Industry Foundation Class standard); (2) Direct conversion; (3) intermediate file conversion. Industry Foundation class (IFC) is used to develop and analyze the standard data format and carry it out by establishing a model conversion algorithm. The direct conversion method is to extract the geometric information of the model in Revit and express it in Tekla to achieve the model conversion between these two platforms. Intermediate file conversion refers to the transformation of model files through a third-party software platform.

3. The building model exchange methodologies from Revit to Tekla

3.1. IFC standard based methodology

To address on compatibility issues of different BIM software, Building Smart institute developed a standard data model, named Industry Foundation Class, which supports a full range of data exchanges among heterogeneous applications [4]. The IFC standard has the characteristics of openness, standardization, and support for scalability. These characteristics enable the IFC standard to execute the exchange and sharing of information between various stages in the life cycle of a construction project without relying on a specific operating system. As the most popular BIM software, Autodesk Revit and Tekla Structure support the export and import of IFC format.
Although IFC provides a solution of the compatibility between Revit and Tekla, in an exchange of a building model, it has been noted that specific technical issues in IFC based data exchange, such as loss of object information, geometric misrepresentation and etc. For example, when expressing components such as columns in the structural model, the IFC model file is output as IFC. Column, but when expressing components such as columns in the structural analysis model, the IFC model file is output as IFC Structural Curve Member. Moreover, the information of the IFC files is enormous redundant, which leads to insufficient precision and excessive redundancy in the expression of certain words, leading to deviations in the understanding of it by various software manufacturers, and the degree of support for the IFC standard is also uneven. Therefore, the use of IFC standards often fails to achieve an expected result in practice. The below picture 1 shows the issues of conversion between Revit and Tekla based on IFC format.

![Figure 1. Comparison of beam section sizes of Revit and Tekla](image)

Figure 1 shows that when the model was imported in Tekla software based on IFC format, the type of attributes of the element was wrong in Tekla. For example, the cross-sectional dimension width and height of the beam member are reversed. And this problem occurs randomly without following any possible patterns.

![Figure 2. The missing of element material information](image)

As Figure 2 shown, when the model was imported into Tekla, the material information of the elements was lost. For example, the material information of the concrete wall of C30 cannot be seen in the right column. Moreover, there is a notice that the elements’ positions were offset and rotated after the conversion.

Based on the analysis of the above phenomenon, the following conclusions are drawn: 1) The IFC exchange interface is not perfect enough. When importing through the IFC standard format, it is easy to lose the model components; 2) The richness of the IFC standard content makes it express in certain languages the above is not precise enough and redundant, which leads to differences in understanding; 3) Different software has different definitions of IFC standards. IFC manages and classifies components through ifc GUID (unique identification code). For example, Revit uses the form of the family classifies and defines the components, while the structural design software classifies the components by the cross-
section type. It can be seen that different software defines the attributes of the components. This situation leads to the model passing the IFC Format conversion will cause loss of components.

3.2. Based on secondary development (Direct conversion) Methodology

Both Revit and Tekla provide API (Application Programming Interface) for second developers; this extends their potential towards the entire lifecycle phases of buildings or facilities. The problem of model mutual conduction can be solved through the secondary development of Revit. The secondary development method conducts the model conversion by retrieving the Revit function to obtain the geometric information of the model and then accurately express it in Tekla, making it possible to achieve "point-to-point" precise expression in the two software. Compared with the way of converting into IFC format, the way of secondary development through Revit is more flexible, avoiding a series of problems caused by different software definitions of IFC standards.

3.3. Comparison of the two exchange methodologies

Through the comparative analysis of the above three conversion methods, the following conclusions can be drawn: Due to the richness of the content of the IFC standard, its expression is not precise enough, and it is easy to cause differences in understanding. In addition, different software defines the IFC standard differently, resulting in the use of IFC standard import methods often fail to achieve the expected effect. The secondary development of Revit API will be more flexible and does not rely on third-party software. The geometric information of the model can be obtained by calling the Revit function and then accurately expressed in Tekla, making it possible to achieve "point-to-point" accurate expression in the two software.

Therefore, this project is aiming to develop an add-in application for executing the conversation of BIM models from Revit to Tekla. This development is based on the Visual Studio 2012 platform in the .Net development environment. In the project, AddinManager is used to stall the application into Revit, and RevitLookup is for checking and reading the parameter information of objects in Revit.

3.4. Self-development of Plug-in application for model conversion between Tekla and Revit

To achieve access to the interfaces in Revit API, Tekla API and Windows Forms programs, there is a need to add references Tekla.Structures.dll, Tekla.Structures.Model.dll, Tekla. Structures. Geometry3d. Compatibility.dll, RevitAPI.dll, RevitAPIUI.dll, and System.Windows.Forms.dll into the software, and change its Copy Local property to ‘False’. After adding the reference, introduce the namespace through the ‘using’ directive. In this programming process, there are three categories of namespaces, namely (1) related classes and commands of system applications; (2) related classes and commands related to Revit graphics elements, documents, etc.; (3) Related classes and commands for documents, etc. The specific reference is written as Figure 3 shown:

```csharp
using System;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.Collections.Generic;
using System.Linq;
using System.Text;
using System.Threading.Tasks;
using System.Windows.Forms;
using Autodesk.Revit.DB;
using Autodesk.Revit.UI;
using Autodesk.Revit.Attributes;
using Autodesk.Revit.UI.Selection;

using TSM = Tekla.Structures.Model;
using TSG = Tekla.Structures.Geometry3d;
using Tekla.Structures;
```

**Figure 3.** ‘using’ directive with C# programming language
The following are the outlines of the ‘using’ instructions in Figure 3: (1) the instructions related to ‘System’ are used to recall system relevant classes and commands; (2) the instructions related to ‘Autodesk. Revit’ are used to provide access to Revit primitives and documents, and recall their related classes and commands; (3) the instructions related to ‘Tekla. Structures’ are used to access Tekla primitives and documents, and recall their relevant classes and commands.

For a building model, there are four major elements related to reinforcement steel bars which are column, beam, wall and floor. In this project, we are going to investigate how to retrieve these four elements information from Revit first, and then import them into Tekla.

In this project, we have developed a methodology which successfully makes the conversion of the model (column, beam, and wall) from Revit to Tekla. The test model is a 34-storey high-rise residential building. The followings are the conversion process:

1. The first step is loading the add-ins into Revit;
2. The second step is selecting the components which will be converted into Tekla Structures;
3. After loading the conversion process, the model of the building was successfully loading into Tekla from Revit.
Figure 4. Three steps of conversion of a building model from Revit to Tekla

For this plug-in application development, it is required to operate the Revit and Tekla software during the conversion process. Comparing with IFC conversion method, there are no missing components, and all information of the elements in Tekla are represented correctly.

4. Conclusion
In this project, a direct conversion plug-in is developed for converting models from Revit to Tekla. This plug-in application was used to convert a building model which includes the elements of columns, beams and walls and regular floors from Revit to Tekla. Comparing with IFC conversion method, the direct conversion method is achieving ‘point to point’ accurate expression between these two software. And for a 34-storey building, it only took less than 40 seconds for the process. This plug-in makes the conversion accurate and efficient.

Although, the plug-in has a better performance than IFC method, it is still suffering difficulties when there are irregular-shaped floors in the building. In the future, an intermediate file conversion method will be applied where the model information is transferring into Excel software first, and then imported into Tekla to solve the irregular-shaped floor problem.

Acknowledgments
This work was financially supported by BIM Research Center of Shenyang Jianzhu University fund.

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