AN OPEN REPOSITORY OF IFC DATA MODELS AND ANALYSES TO SUPPORT INTEROPERABILITY DEPLOYMENT

Robert Amor, Associate Professor , trebor@cs.auckland.ac.nz
Johannes Dimyadi, Researcher, jdimyadi@gmail.com
Department of Computer Science, University of Auckland, Auckland, New Zealand

ABSTRACT

In order to promote interoperability through IFC-enabled design tools it is necessary to build confidence in the ability of the available design tools. To date the potential user of such design tools would be reliant upon the promotional material put out by the design tool vendor and the fact that they have been certified against a particular version of the IFC by the IAI. Research over the last five years has shown that it is not sufficient to rely upon the claims of vendors or the fact that a design tool has been certified against a particular standard. In a very large organisation there may be the resources and expertise available to undertake in-house testing of design tools to ensure they work sufficiently for the required purpose. However, this is beyond the means of the majority of organisations in the industry.

There are a number of software utilities that support various aspects of IFC checking and use. These utilities run the gamut of: counting entities within IFC data files; providing summary statistics for IFC data files; providing metrics for information with IFC data files; determining the syntactic correctness of IFC data files; determining redundancies within IFC data files; visualizing aspects of IFC data files; navigating IFC data files; etc. Used in combination, by expert users, they can provide a fairly comprehensive view of how well interoperability is being achieved on a project. However, this expertise also does not exist in the majority of organisations in the industry.

This paper reports on the development of an open repository of IFC data files which have been analysed by many of the existing software utilities and the analysis captured online to provide an evolving record of the ability of various design tools to handle IFC data files with various content.

Keywords: IFC, open repository, data models, analysis

1. INTRODUCTION

There has been a significant focus on approaches to increase interoperability within Architecture, Engineering, Construction and Facility Management (A/E/C-FM) industries. Ensuring interoperability has gained impetus from several national surveys which detail the impacts of poor interoperability. In particular the report from NIST (Gallaher et al 2004) on costs of inadequate interoperability, which estimated that it costs the US Capital Facility Industries $15.8 billion US dollars per annum. Consequently there have been government level interventions to encourage interoperability in these industries, in particular in Scandinavian counties, Singapore, and the USA (through the GSA). More recently the CIB have started a research initiative in this area with a priority theme on ‘Integrated Design and Delivery Solutions’ (Owen et al 2009) promoting the need for research beyond the current commercial focus on BIM (Building Information Modelling) and encompassing process, education as well as the technical challenges.

Research undertaken internationally over the last five years has identified that there are a significant number of technical issues with current approaches to interoperability in the A/E/C-FM industries. These technical issues impact on almost every aspect of the current approaches to interoperability. Pazlar and Turk (2008) as well as

Lipman (2009) identified problems with geometric exchange in interoperability environments. Pazlar and Turk (2007) determined that there is considerable redundancy in the information content of IFC data files. Several projects have shown that it is not possible to maintain the semantics of data exchanged in current interoperability environments (Amor and Ma 2006, Ma et al 2006, Amor et al 2007, Kiviniemi 2007, Amor 2008, Lipman 2009). More recently it has been proposed that standardised metrics be established to enable those working in the interoperability field to measure the ability of systems to achieve interoperability (Amor et al 2007).

In looking to address the interoperability issues above Amor (2008) looked at the practices of other industries who have a similar need for significant interoperability. This identified greater sophistication evident in several areas. For example, in the healthcare industries (AMHL 2008) and structural steel (CIMsteel 2000) it was noted that there is significant ability for vendors to specify a set of conformance classes against which tools can be tested, allowing for greater flexibility and focus on particular parts of the overall data models that are being used for interoperability. It was also clear that greater support was provided in those industries for those looking to test their conformance against the applicable standards. In the healthcare industries there are freely available tools for testing conformance of data files against the standards (e.g., AHML 2008). In engineering fields there are tools to compare the differences in geometric representation from two different data models (e.g., TranscenData 2010). In other engineering domains there are sets of freely available test suites that can be used by those developing software tools (CCHIT 2008, CIMsteel 2000). There is also significant resource provided for developers in other engineering domains in regards to common practice on how standards are to be implemented (CAx 2008).

This project starts to build similar infrastructure for A/E/C-FM as is found in these other industries, working with the range of existing utilities and tests that have been produced in a wide range of prior projects. In Section 2 a short survey of analysis and visualization tools available for the IFC standard is undertaken and the Section 3 looks at the availability of standard data files that could be utilized for testing purposes. Section 4 describes the development of an open repository of IFC-based data files and analyses performed on these data files. Section 5 concludes with further work required to reach the wider goals of a support environment for interoperability.

2. IFC ANALYSIS AND VISUALISATION TOOLS

In order to evaluate the correctness of an IFC data file it has been necessary to develop utilities to analyse these files from various points of view. Many of these utilities have been developed alongside major research projects where it was necessary to look in great detail at the data that was being handled. The majority of these utilities have been made freely available to the community to work with. For example, the IAI have recently made an analysis tool available (GTDS 2010) for their user community to perform simple checks on data files. While there is significant overlap between abilities of these utilities, they each have a particular strength in terms of the type of analysis they perform.

One category of utility that is available generates summary statistics from an IFC data file in regards to the number of objects of each particular type that was found within a data file. Typically it will also enable navigation through the resultant objects in each category and often provides some analysis of how compliant each object is to the type specification. Examples of these utilities include the IFC Object Counter (FZK 2007) and IFC File Analyzer (NIST 2010) as shown in Figure 1.

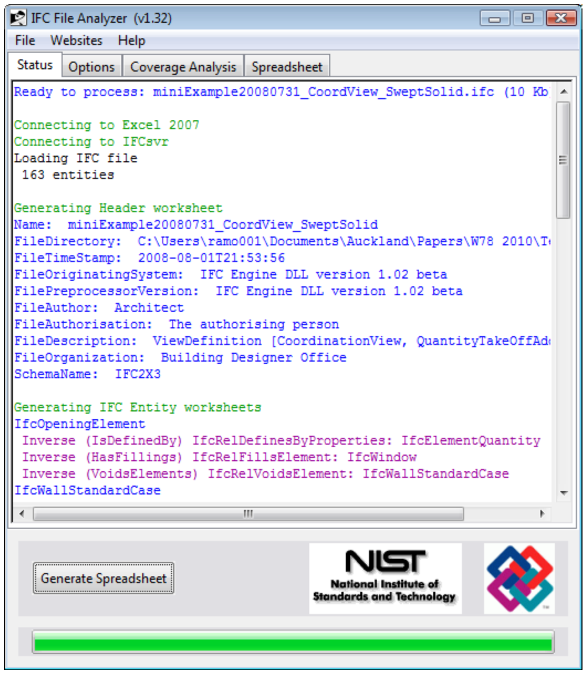

Figure 1: IFC File Analyzer

Another category of utility that is available optimizes an IFC data file to remove what is claimed to be redundant information. This can greatly reduce the file size and processing time required for working with an IFC data file. Examples of these utilities include the work of Pazlar and Turk (2007) and the Solibri IFC Optimizer (Solibri 2010b) as shown in Figure 2. For example, the Solibri tool claims resultant files at 5-10% of the original size through the removal of duplicated objects (as well as compression) and hence a faster loading time with fewer objects to process.

Figure 2: Solibri IFC Optimizer

A third category of utility visualizes an IFC data file and allows the user to check and navigate the model via entities which have a geometric representation as well as through the hierarchy of objects which exist inside the IFC data file. In some cases these utilities incorporate checking and validation functions for the data model, and the commercially available Solibri Model Checker (Solibri 2010c) incorporates a huge range of validation and checking functionality over and above what can be found in the two categories of tools described above. Examples of freely available viewers are DDS CAD Viewer (DDS 2009), FZK Viewer (FZK 2010a), IFC Quick Browser (GEM 2003), Nemetschek IFC Viewer (Nemetschek 2010), Solibri Model Viewer (2010a) as shown in Figure 3 and the IFC Engine Viewer (TNO 2010).

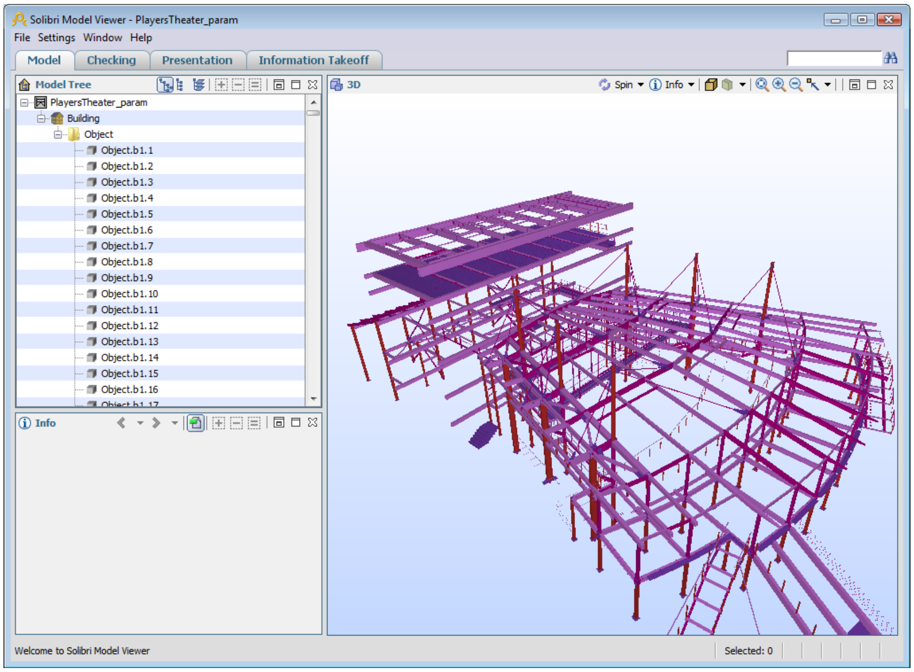

Figure 3: Solibri Model Viewer

A final category of utility allows the user to compare two IFC data files to ascertain the changes that exist between the two files. For example, when an IFC data file has been processed by a CAD system. These utilities are helpful in understanding how well a particular design tool maintains the integrity of the data that it processes and where there may be problems in its ability to handle IFC data. Examples of these utilities include EvaSys (Amor et al 2007) and Compare 21 (Yonsei 2009) as shown in Figure 4.

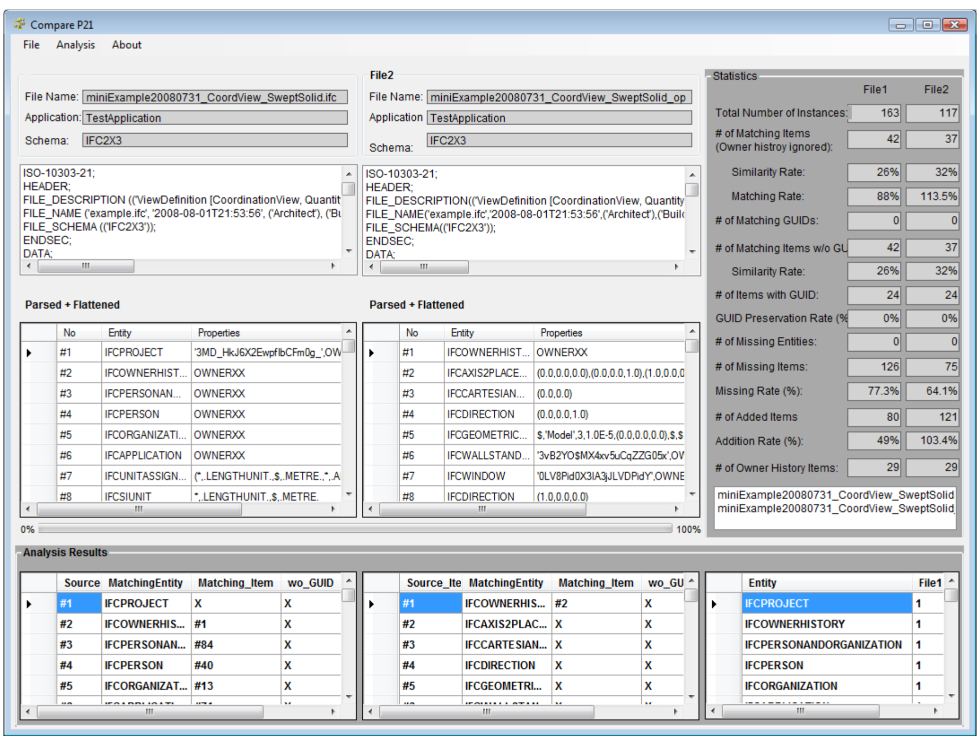

Figure 4: Compare P21

3. STANDARD IFC DATA FILES

It is difficult to identify IFC data files which have been analysed in a way that they can be used as reference files for those starting to look at the use of IFC for interoperability. While it is possible to generate IFC data files from a model developed within most major CAD systems, there are likely to be several issues in using that model.

While it may not require significant time to create a small model of a minor residential dwelling, the development of a complete and correct model of a large and complex building is going to require significant effort. When testing IFC interoperability, and the ability of a particular design tool to manage IFC data, most users would like to make their tests with a variety of IFC data files ranging from small through to large. Generating this sufficient set of IFC data files will be beyond the reach of most wishing to undertake this task. Users would also likely wish to have available test files which cover varying aspects of a building so as to focus on their ability to achieve interoperability for particular processes such as structural design, or lighting design, etc. Creating a range of IFC data files which are well populated with data for each of these domains is also going to require significant resource, and likely will require design tools which may not be readily available within one particular organisation. Even if a user creates a suite of IFC data files they will need to undertake significant work to ensure the correctness of these data files, as would be reported by various of the IFC analysis tools discussed in Section 2. It is also unlikely that users will be able to create IFC data files representing past versions of the IFC standard, which may be a problem going into the future when users would like to ensure that design tools have the ability to interoperate across a number of versions of the standard. The ability to access IFC data files which have a known provenance, are well tested and correct as per the analyses which can be made through the analysis tools described above, and have been run through a number of design tools with significant scrutiny of the resultant data files would be a boon to users starting in this field.

There are at least three major processes which have developed IFC data files over the last decade. First, in the IAI there have been road shows with demonstrations of IFC-based interoperability. Second, the IAI have also generated a range of IFC data files for conformance testing against their standards. Finally, in major research projects there has been a need to generate data files for their demonstration scenarios.

The IAI (2010) have run a number of road shows over the last decade to demonstrate in a live environment the ability for design tools to interoperate with IFC data files. In the different countries that this has been run, and over the last decade, they have used different data models which would be relevant to the audience and the time of the road show. These data files were usually well crafted to ensure compliance with all of the design tools being demonstrated within the road show. They were also of a fairly modest size to ensure that they could be processed quickly during the demonstrations. However, these data files have not been made generally available for use outside of the road shows.

For vendors looking to gain certification of their design tools the IAI had two sets of IFC data files that had to be used as part of this process (IAI 2010). First of all there was a set of small IFC data files representing particular aspects of a building which were freely available to anyone looking to prepare for certification. Secondly during the formal certification process there were larger IFC data files which had to be processed by the design tool to the satisfaction of the IAI. This second set of large IFC data files is not available to the general public for their use in testing interoperability.

Also over the last decade there have been many major research projects focusing on achieving various aspects of interoperability based on the IFC standard. In order to demonstrate their progress these research projects had to develop IFC data files relevant for the particular type of interoperability they were charged with achieving. For example, structural steel data files for NIST's work on the translation of CIMsteel data standards to IFC (Lipman 2009). Many of these IFC data files are still in existence on the websites of the projects (see for example: DDS 2009, NIST 2010, FZK 2010b, Statsbygg 2010, Tekla 2005). However, it is also clear that when projects complete and there is no further follow-on activity that these sites become defunct and often disappear. For example, the BIM House Project which used to be found at DTU (2007).

4. AN OPEN REPOSITORY OF ANALYSED IFC DATA FILES

The first step in developing the type of interoperability support suite as discussed in Section 1 has been to focus on supporting the provision of standard IFC-based data files for those working on software tools for interoperability. The aim of this repository is for it to be a location from which a wide variety of well analysed IFC-based data files can be sourced. It is planned that over time the number of data files will expand to provide significant coverage of the major aspects that would need to be tested for interoperability. In particular this would need to encompass data files for:

- All the major IFC versions that have been published and for which certified design tools exist
- All of the Model View Definitions (MVD) that have been published by IAI
- A wide range of sizes of building from small structures through to very large and complex structures
- A wide range of file sizes representing typical and small constructions through to very large models
- Coverage of particular elements from the IFC standard so that design tools developed for a particular construction process can ensure they can cope with typical objects for that process
- Construction data which has been analysed and proven correct as well as for files where known and well documented inconsistencies exist
- The certifying bodies published and analysed test files

To make this repository useful in an enduring fashion it is necessary to ensure that it exists not just as a dumping ground for data files, but that there is significant information available about the provenance and previous analysis of each data file. This allows the nature of the data file being examined to be identified and for testing with that data file to be compared to past analyses performed on the data file. To achieve this a fairly significant amount of meta-data is collected as part of the process of depositing an IFC-based data file into the repository.

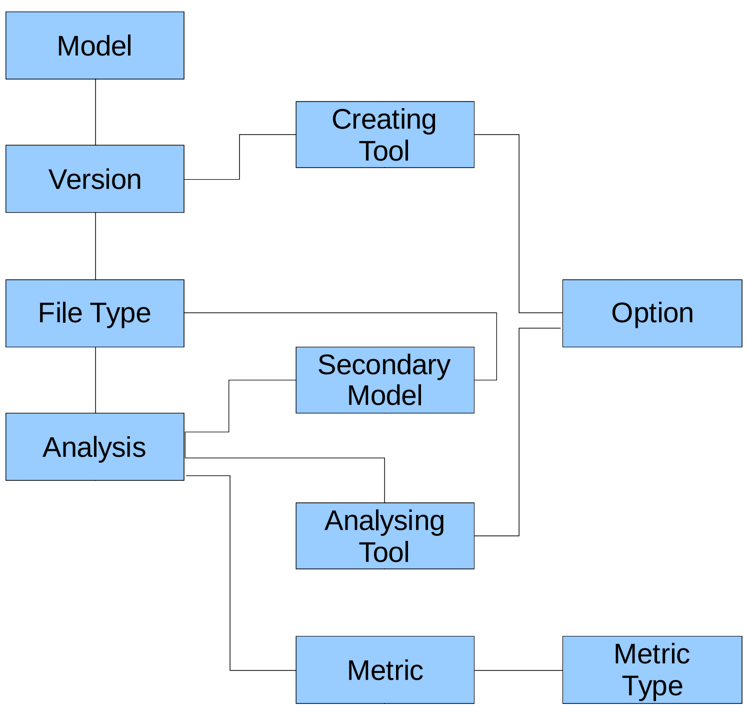

Figure 5: Top-level meta-data structure for the open IFC data file repository

Figure 5 shows the top level structure of the meta-data which is collected for any IFC-based data file which is placed into the repository. The repository is based around capturing a number of models of buildings where any model could have several versions representing the evolution of the building over time (see Figure 6) and where every version could be represented in several output file types (e.g., SPF and ifcXML). Information is captured about the design tool (and its translator) that created a particular version of the model and the options that were selected when creating the data file. For every data file that is deposited a number of analyses could be run and significant data is collected from each of those analyses. Currently, this will be the main point through which researchers can record their results from analyses of particular data models, or comparisons between data models. The version of the tool which performed the analysis is determined along with all of the options in place to create that particular analysis. The output of an analysis can be a set of files with the resultant analysis data, or it can be loaded into the system in a more precise form as metrics with associated values (which can then be searched for through the website, see Figure 7). Where an analysis compares two data files (e.g., identifying the changes which have taken place) then there is also a connection through to the file for the version of the model for which the analysis took place. As the modes of searching through this repository are currently not well understood it relies upon textual descriptions and searching through those textual descriptions to capture the intent of a data model and the points of interest in the model beyond what can be ascertained from the data model itself.

To inaugurate the open repository, IFC-based data files collected from a range of past projects have been downloaded, analysed with standard tools, as described in Section 2, and entered into the repository. Data files in the repository currently exist from the projects of BLIS (2010), DDS (2010), FZK (2010b), IAI (2010), NIST (2010) and Statsbygg (2010). However this is just a small starting set to inaugurate the service and it will need further data from the research community to make this a useful and successful resource. It is also clear that for the data models to be usable to the community as a whole they need to be released for general and open use. In the repository this is managed by requesting the donator to assign a free license to the model, such as utilized in services such as Wikimedia Commons. The service is available through a web-based interface at http://www.cs.auckland.ac.nz/~trebor/openifcmodels/.

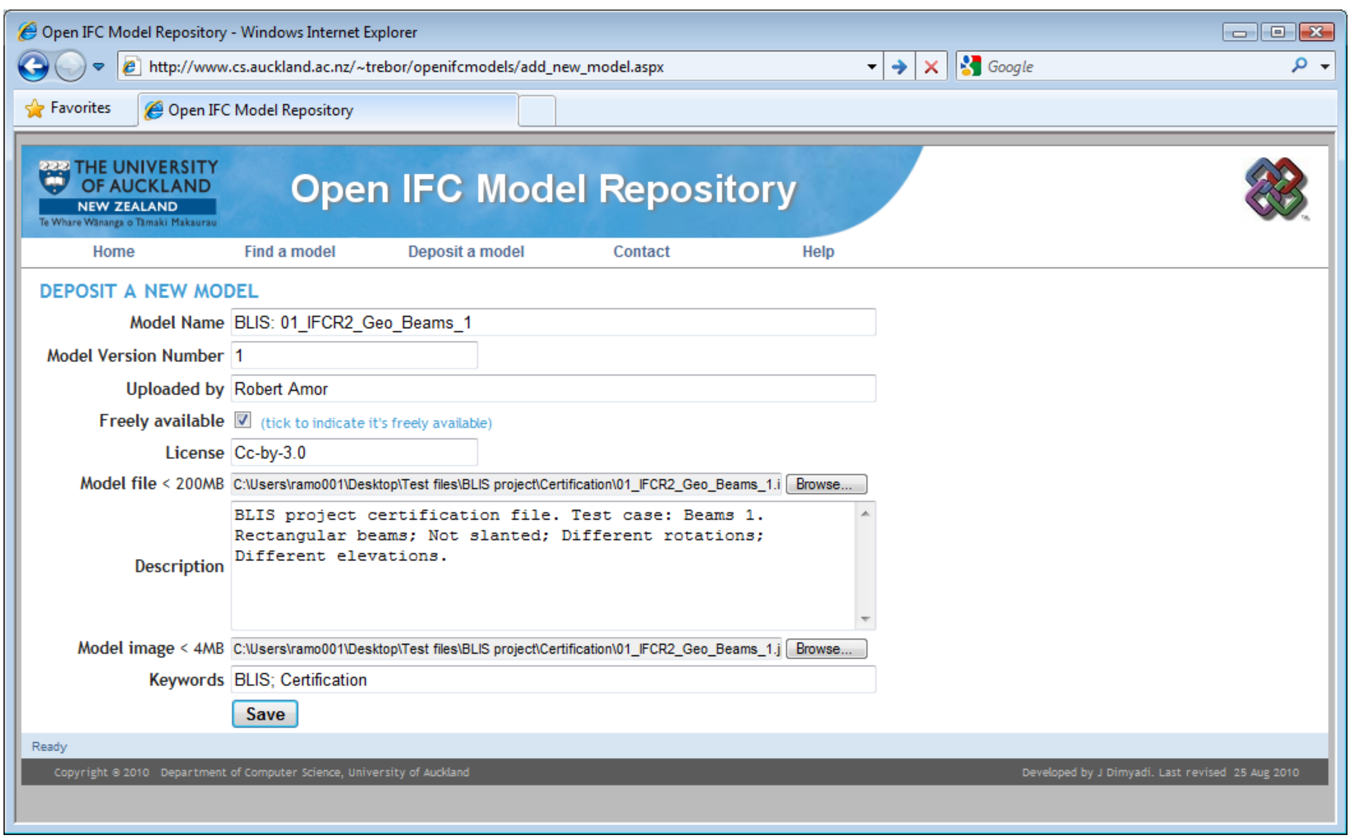

Figure 6: Uploading an IFC model

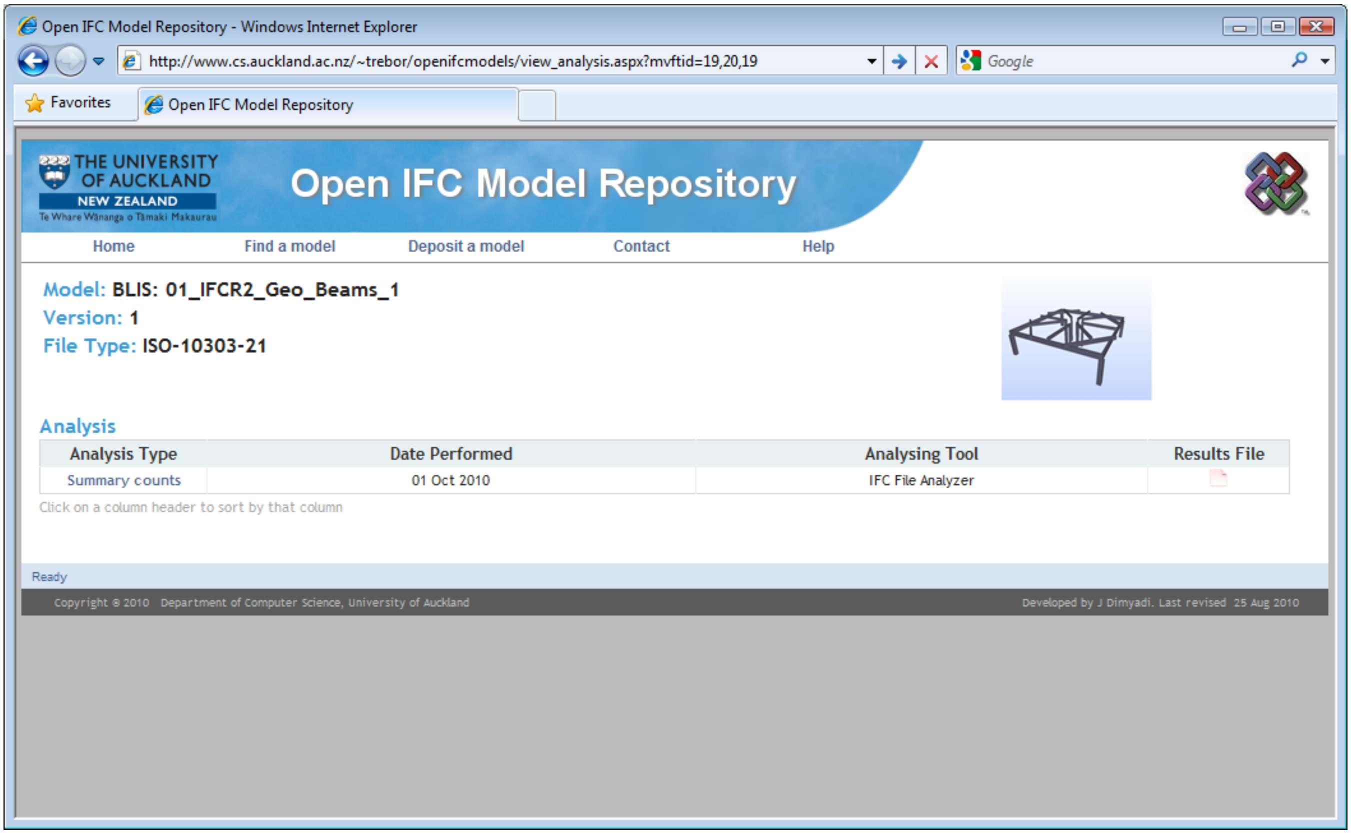

Figure 7: Navigating to analyses for an IFC model

5. CONCLUSIONS AND FUTURE WORK

To strengthen approaches to achieving interoperability for A/E/C-FM it is necessary to provide a support suite for developers of design tools as well as for those users who wish to explore the ability of design tools to interoperate within the environment that they work. One of the major aspects of this support suite is the ability to work with a standard set of IFC-based data files which represent the data requirements of particular processes in A/E/C-FM. In this project such a repository has been created allowing for the collation of publically available data files along with analyses which have been made against those data files. This repository has been inaugurated with data from a small number of projects and analysed by a small set of publically available test utilities.

While this demonstrates the ability of the website to manage such data files, and analyses, it does not at this time establish a sufficient resource to address all of the aspects which were detailed for the repository. It is clear that it will require significant input from the research community to get this repository up to the level at which it can provide significant coverage of the domains that will be needed by all those trying to achieve interoperability for A/E/C-FM industries.

In its current form the analyses that have been performed against data files reside in the repository mostly as output files from the individual analysis tools. While this ensures that past analyses are stored for posterity, and able to be accessed by users of the website, it does not allow for identification or searching of results from within the website. This could be addressed by adding parsers for the output files of particular analysis utilities to extract data required in the website's search functions, though this would require a major piece of software development to achieve this outcome.

Alongside undertaking to continue populating the current website with freely available data files there is work being undertaken to further build the system to support those exploring interoperability. In particular there is work to develop interfaces to existing utilities (whether they are web-based on stand-alone) to allow a wider range of functionality to be directly accessible from this website without replicating the work that has been put into these utilities. In time it is planned that similar support for interoperability is provided to those working in the A/E/C-FM domains as there is for those in the healthcare industries and other engineering domains.

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