

Indian Building Code Compliance for n-BIM Model

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Abstract

BIM softwares export the building data in the IFC formats such as .IFC, IFCXML, IFCZIP. These formats are the shareable ones i.e. every engineer shares their building data on the podium i.e. Building Information Modeling (BIM). IfcXml format is similar to the .xml format which is used to describe the data. The information related to building entities is stored in the various tags and further there are subtags to store additional information. The tags are named by the name of building entity preceded by IFC. This paper describes how the data is being fetched from the .IfcXml file.

Parsing is a technique used for fetching data from the tags of .IfcXml file through various parsing techniques. After parsing the .IfcXml file, the building checks are being performed on the data fetched from the .IfcXml file. The hierarchy followed in .IfcXml file is known as parent-child hierarchy. This paper explains a generalized method of scrutinizing the .IfcXml file in an effective manner.

Keywords:

BIM, IFC, SCRUTINIZER, JAVA, TECHNOLOGY

1. Introduction

The information of building is provided in the Industry Foundation Classes (IFC) which is a sharable platform for transporting 3-D model data into BIM [1, 2]. To extract the desired values from the product model IFC file is a complex task and to use the automated code in a generalized way is a one step ahead [1, 3, 4, 5]. For extracting the values and to apply the constraints on those, includes these steps:

- Producing building model into 3D CAD model into IFCXML format i.e. the design representation models for BIM [6].
- Extracting the information from the design representation models for applying the building rules by designing a software system which works on executing rules [1, 7, 2, 8, 9, 10].

1.1. Building Information Modeling (BIM)

It is a process involving the generation and management of digital representation of physical and functional characteristics of places [11, 12]. BIM software is used by individuals, businesses and government agencies who plan to design, plans, construct, and manage buildings. It is 3D model. The three dimensions (width, height and depth) with time as the fourth dimension and cost as the fifth dimension. Firstly Autodesk Revit released a white paper entitled "Building Information Modeling" [11]. The first software tools developed for modeling buildings emerged in the late 1970s and early 1980s, and included workstation products such as Chuck Eastman's Building Description System and GLIDE, RUCAPS, Sonata and Reflex. ArchiCAD Radar CH released in 1984 was the first software made available on a personal computer.

BIM is associated with Industry Foundation Classes (IFCs) [1, 7, 10, 9] and aecXML data structures for representing information. IFC have been developed by buildingSMART (the former International Alliance for Interoperability) for sharing BIM data among different software applications [2, 8, 13, 14, 15, 16]. BIM is a relatively new technology in an industry typically slow to

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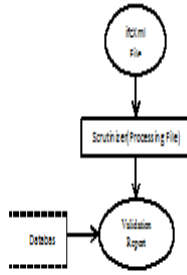


Figure 1: Describing work flow of .IFCXML file.




| | | |
|--------|---|---|
| ifc | IFC data file using the STEP physical file structure according to ISO10303-21. The *.ifc file shall validate according to the IFC EXPRESS specification. Default IFC exchange format. |  |
| ifcXML | IFC data file using the XML document structure. It can be generated directly by the sending application, or from an IFC data file using the conversion following ISO10303-28, the XML representation of EXPRESS schemas and data. |  |
| ifcZIP | IFC data file using the PKzip 2.04g compression algorithm (compatible with eg. Windows compressed folders, winzip, zip, info-zip, etc.). It requires to have a single ifc or *.ifcXML data file in the main directory of the zip archive. |  |

Figure 2: Formats of IFC.

adopt change. Proponents claim that BIM offers:

- Improved visualization.
- Improved productivity due to easy retrieval of information.
- Increased coordination of construction documents.
- Embedding and linking of vital information such as vendors for specific materials, location of details and quantities required for estimation and tendering.
- Increased speed of delivery.
- Reduced costs.

The building properties in BIM can be used to automatically create the input file for building energy simulation and save a significant amount of time and effort[1,ref3].

1.2. Industry Foundation Classes(IFC)

IFC is a norms format in which the result of BIM softwares. It tells that how the knowledge of the Infrastructure should be provided at all levels of the building process[1, 2]. It stores every entity of the building in the form of Object. It tells how the properties of an particular object can be described. Data can be stored by IFC for geometry, calculation, quantities, etc. for different fields likewise Architectural Engineer, Structural Engineer, Plumbic Engineer and Electrical Engineer[17, 12].

The graphical notation used to create IFC schema is known as EXPRESS-G. It makes model creation and rechecking easier. EXPRESS-G is international standard data definition language[17]. Another version of IFC also exists in the form of XML known as ifcxml.IfexML is being used as it follows the parent

child relationship and data can be easily capture through the tags[1, 7, 2].

- IFC-XML is an XML format having the file extension .ifcXML which is suitable for interoperability with XML tools and exchanging partials building models. IFC-XML is represented in ISO-10303-28. It follows the hierarchical representation for data.

1.3. Extensible Markup Language(XML)

It is a markup language like HTML which focuses on carrying and transferring data defined by W3C s (World Wide Web Consortium) XML 1.0 specification unlike HTML which used to focus on how the data is displayed. It stores data in plain text format which makes it independent of any specific software and hardware to carry it. It is also platform independent and can be expanded and upgraded to any new browser, applications and operating softwares. XML is self descriptive language i.e it describes itself[6].

The developer or the user has to write the software to send, receive and store it. The tags of XML are not predefined unlike HTML which worked on predefined tags like <P>, <h1> etc. The developer has to define the tags to be used. XML does not have any information about the presentation of data so the XML documents can be used in different presentation styles. The XML documents start with declaring some of the information about themselves.

```
<?xml version=1.0 encoding =UTF-8?>
```

Here XML version 1.0 is used and encoding UTF-8 is used which is a character encoding capable of encoding all possible characters into unicode as XML documents entirely consists of unicode repertoire(stack of items).UTF

-8 encoding is variable length and uses 8 bit code. The key terminology in the XML documents are:

- Unicode
- Markup and content.
- Tag.
- Attribute.

XML documents are like tree structures where there is a root node/element and then their child elements. The syntax of XML is self descriptive. XML documents are according to some specifications which provide a list of syntax rules which makes them well formed. These documents sometimes may be valid which means they contain a reference to a Document Type Definition(DTD) which is an example of schema or grammar. There are two versions of XML that are XML 1.0 and XML 1.1. The extension of the XML documents is .XML. IFC-XML is an XML format having the file extension .ifcXML which is suitable for interoperability with XML tools and exchanging partial building models.

2. Research Methodology

- The .ifcXml file is being parsed to the DOM parser. In the java technology.
- The java libraries used in parsing the .ifcXml file are :
 - Javax.xml.parsers.DocumentBuilder.
 - Javax.xml.parsers.DocumentBuilderFactory.
 - Org.W3c.dom.Document
 - Org.W3c.dom.Element
 - Org.W3c.dom.Node
 - Org.W3c.dom.NodeList
- DocumentBuilderFactory Class is used for parsing the .ifcXml File.
- DocumentBuilderFactory's instance is used to create the instance of DocumentBuilder Class which is further used to parse the document i.e. .ifcXml file.
- NodeList is used to store the occurrence of a particular tag in the .ifcXml file.

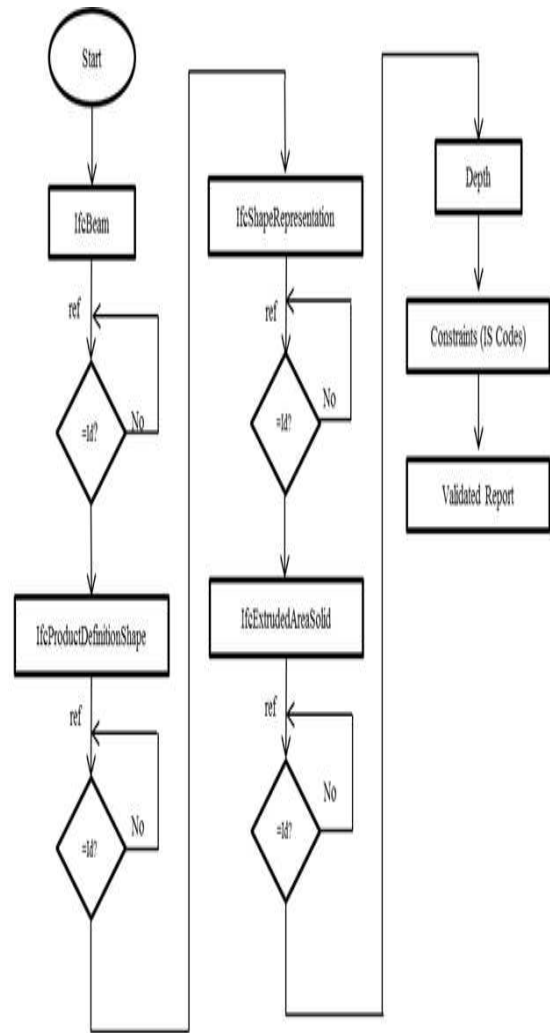


Figure 3: Flow chart of generalized code compliance.

```

DocumentBuilderFactory dbf =
DocumentBuilderFactory.newInstance();

DocumentBuilder db = dbf.newDocumentBuilder();

Document document = db.parse(new
File("MainTank.ifcxml"));

```

Figure 4: Parsing of the .ifcxml file.

```

NodeList nodeList =
document.getElementsByTagName("IfcBeam");

Node firstNode = nodeList.item(0);

Element firstElement = (Element) firstNode;

gid = firstElement.getAttribute("id");

```

Figure 5: Checking for the attribute id.

```

if (IfcDefinition.hasAttribute("ref"))
{
nodeList.item(0).getAttributes().getNamedItem("id").getNodeValue();

String
IfcDefinition.ref = IfcDefinition.getAttribute("ref");
}

```

Figure 6: Getting value from the attribute id

- Node is used to fetch a particular occurrence of a tag from a index of the NodeList.
- hasAttribute() is applied on the element to check whether the tag is having the particular attribute or not.
- Then ,a particular subtag is searched between the an tag and its attribute that is referenced in a variable .For example the sub tag is IfcProductDefinitionShape.
- Again similarly ifcXml file is parsed to find the tag IfcProductDefinitionShape having the attribute id similar to reference which we got earlier.
- When tag matches with IfcProductDefinitionShape and id matches to ref then sub tag that is IfcShapeRepresentation is searched and its attribute ref is stored in a variable.
- Again ,the ifcXml is being parsed to search the tag IfcShapeRepresentation having the attribute id similar to the ref which we got from the subtag of the IfcProductDefinitionShape.
- When the tag matches with IfcShapeRepresentation and Id matches with the ref then the subtag IfcExtrudedAreaSolid is being searched and its attribute is stored in a variable.
- Similarly,the IfcExtrudedAreaSolid tag is being searched in the .ifcXml file and its attribute is matched with the ref which we got from earlier tag.
- If tag matches with IfcExtrudedAreaSolid and id matches with the ref then the subtag depth is searched.

| IFC Building entity | Units | Checks | Maximum value | Minimum value | Obtained value | Status |
|-----------------------|-------|-----------|---------------|---------------|----------------|--------|
| IfcColumn | Mm | Depth | 7000 | 5000 | 5300 | Valid |
| IfcBeam | Mm | Depth | 7000 | 5000 | 5300 | Valid |
| IfcWallStandaloneCase | Mm | Height | 13000 | 10000 | 12000 | Valid |
| IfcSlab | Mm | Thickness | 300 | 200 | 200 | Valid |

Table 1: Status Table Of Building Rules On Product Model

- The subtag contains the depth of the structural element which we initially searched.
- Hence we can find every data related to any structural element of the building following this hierarchy of the .IfcXml file.
- This is the generalized code for each and every model developed by 3D BIM Software .
- We just provides .IfcXml File to the code to perform checks.
- Finally ,we get all the information in the text file through the file handling concept of the java technology.

3. Result and Discussion

The generalized code/method to read the .ifcXml is being developed so that it could work for all the architectural models which are being developed in the 3-D BIM softwares. It is the optimized way of decoding the .ifcXml file to perform the various building checks according to Indian Standard (IS) codes. the XML file is the best format to carry the data from one software to other. So it is being used to bring the building data from the 3-D BIM softwares to the generalized code to get the report of the various checks performed .The Automated Code Compliance performed by the generalized code reduces the manual efforts and the time which is being needed in manual code compliance. It is the optimized technique that gives the error prone results. The java technology is being used to decode the .ifcxml file as it is a fully object oriented language and there exists many java APIs to perform the tasks such as Parsing. The generalized code would be useful as there is great increase in the adoption of BIM and IFC and it is the efficient code but further enhancements could be done to make it more effective.

4. Conclusion and Future Aspects

In Conclusion, this research digitalizes the Indian Standard Codes. The approach followed here is the automated code compliance and the check performed here is on the depth of the column according to the IS codes.It reduces the time required and manual work. It provides error free results.

As, the automated code compliance approach is under development so more checks according to IS codes can be applied and there can be improvement in graphical representation.

5. References

- [1] P. Nawari. O. Nawari, Ph.D., A framework for automating codes conformance in structural domain, Journal of Computer and Information Technology 1 (1).
- [2] Q.Z. Yang*.Xingjian Xu, Design knowledge modeling and software implementation for building code compliance checking, Building and Environment 39 (6) (June,2004) 689698.
- [3] Sharpe R, Oakes S., Advanced it processing of australian standards and regulations, The International Journal of Construction Information Technology 3 (1) (1995) 7389.
- [4] Zarli A, Debras P., Integration of corba and web technologies in the vega dis., Proceedings of the European Conference on Integration in Manufacturing, Gothenburg, Sweden 3 (1) (1998) 184 97.
- [5] S. M. Inc., J2ee overviewthe java 2 platform enterprise edition. URL <http://java.sun.com/j2ee/>
- [6] Parsing of xml file. URL [http://blog.sanau11a.info/2013/05/23/parsing-xml-using-dom-sax-and-stax-parser-in-java.](http://blog.sanau11a.info/2013/05/23/parsing-xml-using-dom-sax-and-stax-parser-in-java)
- [7] zgn Balaban, Elif Sezen Yagmur Kilimci, Glen agdas3, Automated code compliance checking model for fire egress codes, Digital Applications in Construction 2 (2012) 117–125.
- [8] David greenwood,Stephen Lockley,Sagar malsane,Jane methews, Automated compliance checking using building information models, The Construction, Building and Real Estate Research Conference of the Royal Institution of Chartered Surveyors.
- [9] C. fu*, Ifc model viewer to support nd model application, Automation in Construction 15 (2) (2006) 178–185.
- [10] Susmita Sinha,Anil sawhney, Extracting information from building information models for energy code compliance of building envelope.
- [11] M.Fischer, Linking cadand expert systems for constructability reasoning, Proceedings of the Fifth International Conference on Computing in Civil and Building Engineering 322 (10) (1993) 156370.
- [12] Building, C. A. of Singapore (BCA), e-plancheck system in corenet. URL <http://www.bca.gov.sg/>

- [13] C. D., Development and implementation of automated code compliance checking in the u.s., International Code Council, 2007.
- [14] Ding, L., Drogemuller, R., Rosenman, M., Marchant, Gero, D. J., Automating code checking for building designs: in: K. brown, k. hampson, p. brandon (eds.), clients driving construction innovation, Cooperative Research Centre (CRC) for Construction Innovation (2006) 113–126.
- [15] Delis E.A., Delis A., Automatic firecode checking using expert-system technology, journal of computing in civil engineering, ASCE 2 (1995) 141–156.
- [16] Eastman, C. M., Jae-min Lee, Yeon-suk Jeong, Jinkook Lee, Review automatic rule-based checking of building designs, Automation in Construction 18 (2009) 10111033.
- [17] E. Technology, Express data manager.
URL <http://www.epmtech.jotne.com>