Indian Building Code Compliance On BIM Model

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Abstract

Building Information modeling (BIM), has emerged as an effective alternative for building modeling that has transformed the building industry into a digital form, and enhanced its productivity as BIM software supports parameterized object that stores complete attribute information and their relation to other existing structural components.Still Code Compliance is performed separately to assure the structure constancy, behavior and immunity when concerned about atmospheric conditions. Nowadays the Code Compliance Checking is accomplished manually, which is a problematic task and gives the error prone results. Our Work presents an approach for scrutinizing the automated code compliance according to various architectural and structural codes as per Indian standard (IS) specifications and user defined rules. This includes an effective way of checking the Industry Foundation Classes(IFC) of any BIM Model resulting in a framework designed in Java technology checking constraints like depth of beam, slenderness ratio, center-to-center spacing between reinforcing bars on a water tank model.

Keywords: BIM, Industry, Foundation Classes(IFC), IFCXML, JAVA.

1. Introduction

Basically automated code compliance is the validation of the values fetched from the 3-D Modeling softwares like ArchiCAD, Revit etc. with the digitized standard values to give a result whether all the entities of the infrastructure are valid or not[1, 2, 3]. It is more efficient than the Manual code compliance, saves lot of time and the manual work and is error free[1].

Industry Foundation Classes commonly known as IFC is used to carry the information about an infrastructure and is compatible with every BIM software[4, 5]. There is another format which is being derived from this basic format i.e. IFCXML. This format is same in structure with an XML file consists of the tags representing the entities of an infrastructure[1, 6]. It follows Parent-Child Hierarchy.Java Technology is used for the Automated Code Compliance[2, 7].The data from the IFCXML format is being fetched by the Java desktop application and various checks according to Indian Standard Codes are being applied to generate the Report [2, 8, 9, 7].

1.1. Building Information Modeling(BIM)

Traditional Building design was largely reliant upon the 2- D Drawings resulting in poor coordination and loss of information. But with the introduction of BIM, this problem has been solved up to maximum extent as BIM uses 3- D Models instead of 2 D Drawings. BIM has changed the way of planning, building and management of an Infrastructure. It is basically a platform on which all engineers can work together on the information of the infrastructure[10, 11].

It was very difficult to work simultaneously by engineers before the introduction of the BIM. Earlier different engineers used to develop different models using different softwares that results into Compatibility issues and were not able to communicate with each other.Then BIM softwares came into existence and proved to be a remedy to these compatibility problems. All the BIM softwares store the information of an infrastructure in the standard format known as IFC [1, 5, 2, 12, 3, 4, 13, 14, 15, 16].

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1.2. Industry Foundation Classes(IFC)

IFC is a standard format in which the output of BIM softwares[2]. It tells that how the information of the Infrastructure should be provided at all levels of the building life cycle. It stores every entity of the infrastructure in the form of Object[1, 2]. It tells how the properties of an individual object can be described. Data can be held by IFC for geometry, calculation, quantities, etc. for different professions such as Architectural Engineer, Structural Engineer, Plumbic Engineer and Electrical Engineer[2].

The graphical notation used to create IFC schema is known as EXPRESS-G[3, 11, 17]. It makes model development and reviewing easier. EXPRESS-G is international standard data definition language. Another version of IFC also exists in the form of XML known as IFCXML. IFCXML is being used as it follows the parent child relationship and data can be easily fetched through the tags[1].

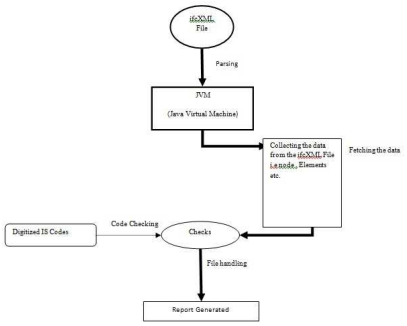

Figure 1: Data Flow Diagram explaining the Automated Code Compliance.

2. Research Methodology

Earlier the technique used for the code compliance was not automated. It was being performed manually. In that case the model of the infrastructure was developed and was sent for the Manual Code Compliance to the Code Officers. That method was too much time consuming and error prone. To solve this problem the efficient tools like BIM etc. are being used. In this case the modeling work is performed 3-D modeling softwares such as ArchiCAD, Revit, etc. Then the code compliance is performed automatically by applying checks on the various entities of the infrastructure as Beam, Column, Slab, Wall, etc. For the Automated Code Compliance the Indian standard codes are being used. Indian Standard (IS) Codes for validating the thickness, height, depth etc. of the various Infrastructure entities such as Beam, Column, Slab, Wall, etc.

Java Technology is used for code compliance. As .ifc and .ifcxml file are the output of the 3-D modeling softwares like ArchiCAD, Revit, etc. This .ifcxml file is used as the input to the java desktop application.

2.1. There are basically 3 parsing techniques:

- DOM Parsing.
- SAX Parsing.
- Stax Parsing.

Figure 2: 3D shaded view of Tank .

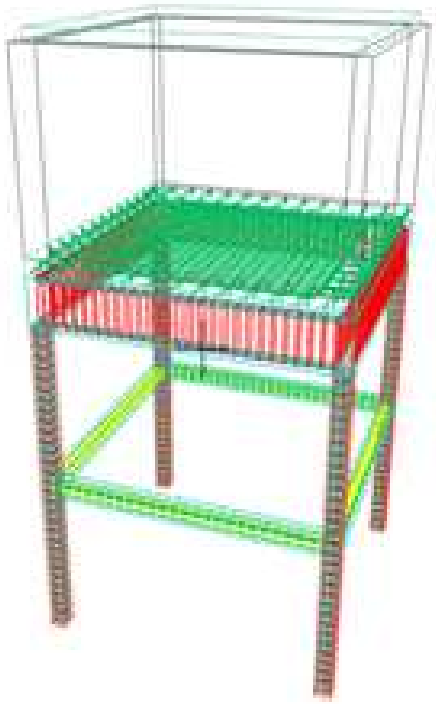

Figure 3: Wireframe tank model in ArchiCAD.

```
<IfcPerson id="i1541">
        <FamilyName>Undefined</FamilyName>
</IfcPerson>
<IfcOrganization id="i1543">
        <Name>Undefined</Name>
</IfcOrganization>
<IfcPersonAndOrganization id="i1547">
        <ThePerson>
                <IfcPerson xsi:nil="true" ref="i1541"/>
        </ThePerson>
        <TheOrganization>
                <IfcOrganization xsi:nil="true" ref="i1543"/>
        </TheOrganization>
                </IfcPersonAndOrganization>
```

Figure 4: . ifcxml file as the output of BIM softwares.

```
<IfcExtrudedAreaSolid id="i1758">          Parent Tag
<SweptArea>
<IfcArbitraryClosedProfileDef xsi:nil="true" ref="i1738"/>
        </SweptArea>
                <Position>
        <IfcAxis2Placement3D xsi:nil="true" ref="i1751"/>
                </Position>
        <ExtrudedDirection>
<IfcDirection xsi:nil="true" ref="i1754"/>
        </ExtrudedDirection>
        <Depth> 300</Depth>
                Child Tag
</IfcExtrudedAreaSolid>
```

Figure 5: Hierarchy of .ifcxml File.

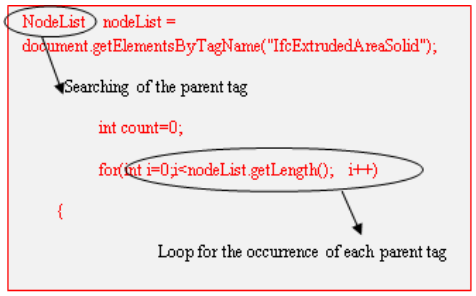

Figure 6: Nodelist and .getlength() function .

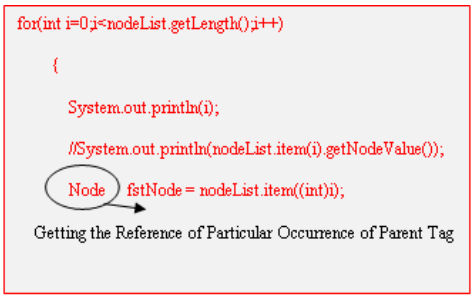

Figure 7: Node is used to get a leaf of the tree.

2.1.1. DOM Parsing

DOM stands for Document Object Module. It comes with the Java Development Kit (JDK). The DOM parser loads the complete file into the memory in the form of tree structure. Nodelist and Node are used to fetch the data from the .ifcxml file. Figure 4 shows the DOM parsing of an .ifcxml file.

3. Steps to Access the Building Data from the .ifcxml file

3.1. Loading

- Here the technique used for the parsing is DOM Parsing.
- The Parsing of .ifcxml File is done by Object of Document Class.
- The input file is completely loaded in the memory in the form of tree structure.

3.2. Reading

- Then the nodelist interface is used to search a tag in the .ifcxml file as known the Figure 6.
- Basically nodelist is the collection of DOM elements.
- In the Figure 7, the node is used to get the particular leaf of the tree created by the Nodelist.

3.3. Processing

- Then the value contained in the nodelist is converted to the Element form as shown the Figure 8.
- It is being converted to Element form as some Functions Like getAttribute (), etc are to be applied on it.
- Then Figure 9 shows that the hasAttribute () function, is used to check whether the tag is having a particular attribute or not.
- Then the function getChildnodes() is used to check whether the parent tag is having a child tag or not.
- Then After getting the value of child tag, it is being trimmed as the last character is . , which is done so that a simple string could get because . restricts a string to get converted into integer and a integer values is needed for searching.
- Trimming is being performed as the value is in string type and we want to convert it into the Numeric Value.

3.4. Checks Performed

- The Code Compliance is done according to the IS (Indian Standard) Codes.
- IS Codes are the Standard Codes which are accurate according to Indian conditions for construction.
- By these Codes we can validate the depth, height, diameter, etc of the entities used for construction.
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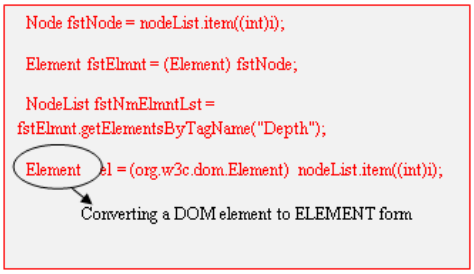

Figure 8: DOM element or the leaf node of the tree converted. Implementation of the hasAttribute() function into Element form.

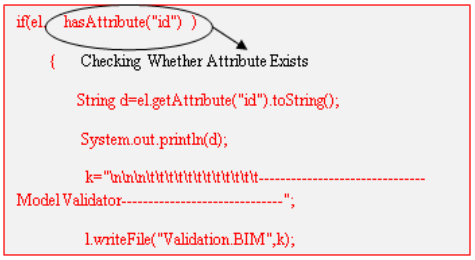

Figure 9: Implementation of the hasAttribute() function into Element form.

- Checks Performed :
  - Height of the Column.
  - Thickness of Slab.
  - Diameter of Reinforcement Bar.
  - Depth of Beam.
  - Number of Reinforcing bars.

- At the end, limit is applied according to IS Codes for Automated Code Compliance.
- If the value fetched from the .ifcxml file lies within the range then the entity of the infrastructure is valid that means it could be constructed else the model needs some modification at a particular entity of infrastructure.

4. Result and Discussion

- If the child tag exists the .getnodevalue() function is used to get the value of the child tag.

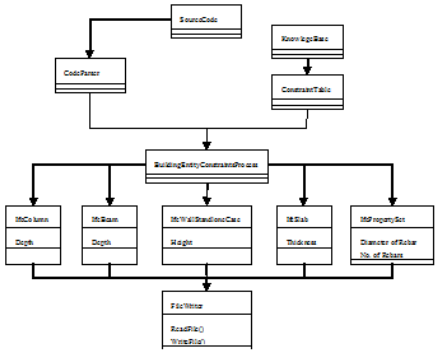

Figure 10: Knowledge Diagram of Building Code.

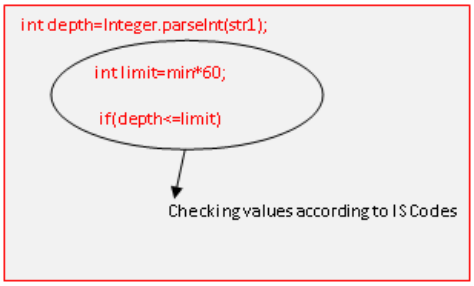

Figure 11: Check Applied according to Indian standard (IS) Codes.

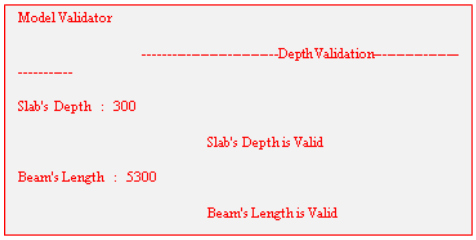

Figure 12: Graphical view of the Report generated

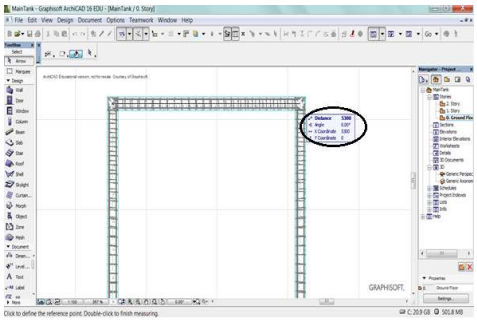

Figure 13: Measurement through the BIM Software (Length/Depth of Beam=5300)

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
Diameter Of Reinforcing bar	Mm	Diameter	30	20	25	Valid
No Of Reinforcing bar	No.	Number	6(Circular)	4(Square)	4	Valid

Table 1: Checks Performed

- The Checks are being performed on the values fetched from the IFCXML file , then if the data is according to the Indian Standard Codes then its status is written in the text file by file handling as shown in Figure 12.
- Status here refers to the Valid/Invalid according to the IS codes or user defined.
- A backend database is used for the storing the limits in the form of maximum and minimum according to the element type as shown in table 1.

Report generation of the MainTank.ifcXML file is the validation file which is generated as per checks performed on the file.As discuss earlier the checks applied on the file are depth of beam,height of wall,thickness of slab,length of column,diameter of reinforcing bar and no. of reinforcing bar.There is set of maximum and minimum limits which is fixed as IS codes and user defined such as the maximum limit of beam depth would be 7000 and minimum depth would be 5000 (for ref. see Figs. 13 and 14). As shown in Table.1 the value is valid as it is 5300 which lies in between the limits.Hence for all the performed checks specific limit is maintained.

5. Conclusion and Future Aspects

Approach followed follow is Automated Code Compliance. In this the check is being performed on the depth of Column according to IS (Indian Standard)

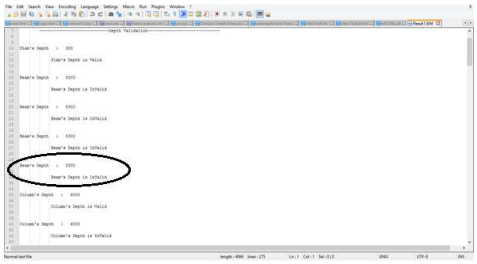

Figure 14: Measurement in the Report Generated

Codes. Indian Standard Codes are being digitalized. Automated code Compliance helps in saving time and manual efforts. The biggest advantage is that it gives error free results.

As this Automated Code Compliance is in the Developing stage so more checks could be applied according to the Indian Standard Codes. The Reporting graphics could be improved for graphical representation of the Results.

6. References

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