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Building Renovation with BIM: 4. Model checks for testing the compliance of renovation options

Bulding Renovation with BIM

A Practical Guide

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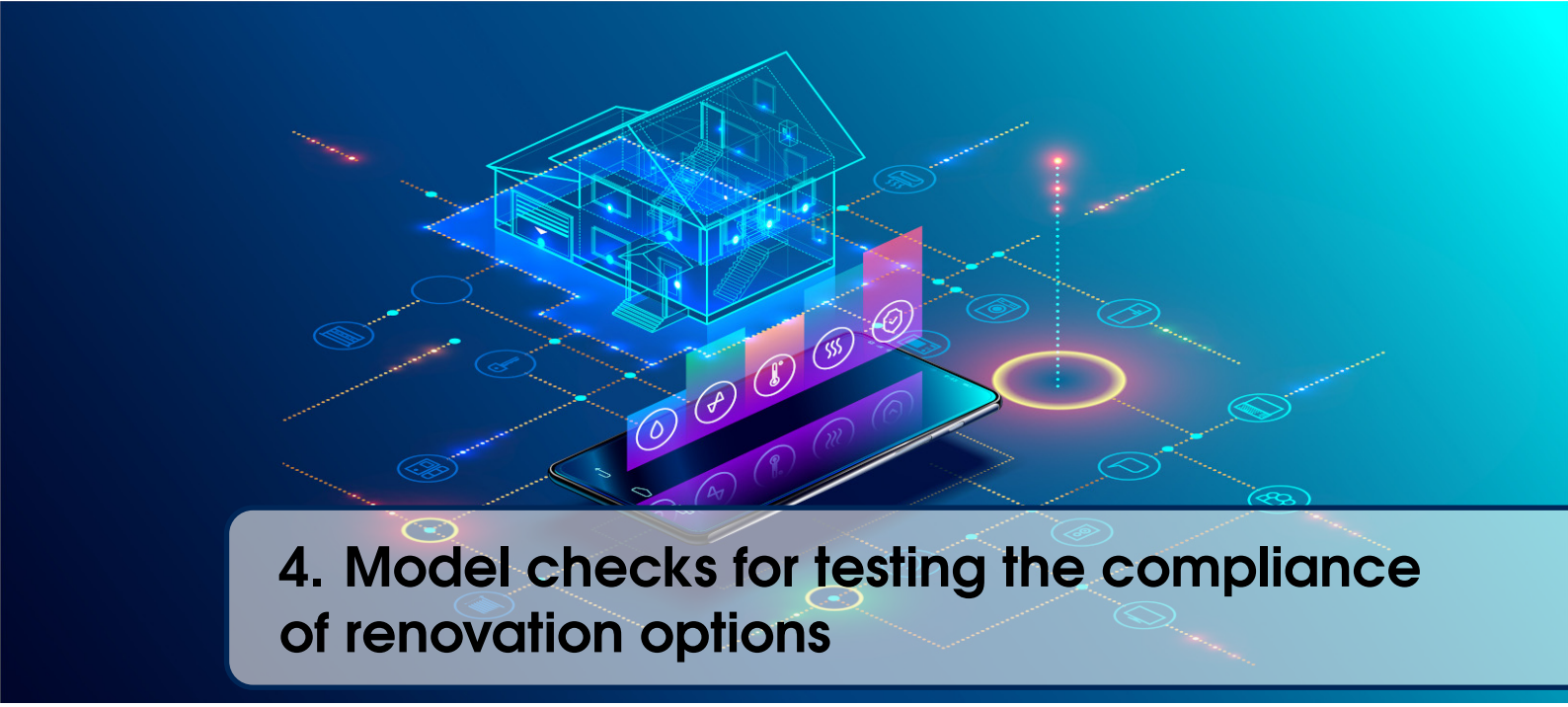


4. Model checks for testing the compliance of renovation options

4.1 Introduction

BIM, in addition to being a three-dimensional visualization of a building, also functions as an all-encompassing model containing several information related to design, execution, maintenance etc. A 3D BIM model is created considering the objectives, in terms of use-cases from the client, but also considering certain pre-requisites that a BIM model must fulfil in order to implement it in a project. Most often, 3D BIM models of renovation projects are developed from existing 2D drawings. In order to enable the smooth implementation of 3D BIM models for the defined BIM use cases, verification of the BIM model in terms of model checks need to be performed.

Essentially, the outcome of a 3D BIM model that underwent model checking is a well-defined model that is interoperable and confirms to certain compliance based as well as geometry-based requirements for coordinated design and other defined BIM use cases within the renovation project. Semantical checks ensure the consistence of elements in terms of naming, definition (levels/layers/properties/attributes) as well as confirming if all the elements are closed and solid. Numerical checks further check the model for numerical information provided within the elements in terms of values within allowed ranges. These checks in turn assess the compliance of the model to national and regional standards. Such a checked 3D model is later handed over for geometrical checks among trades which is further explained in the chapter of Clash detection use case.

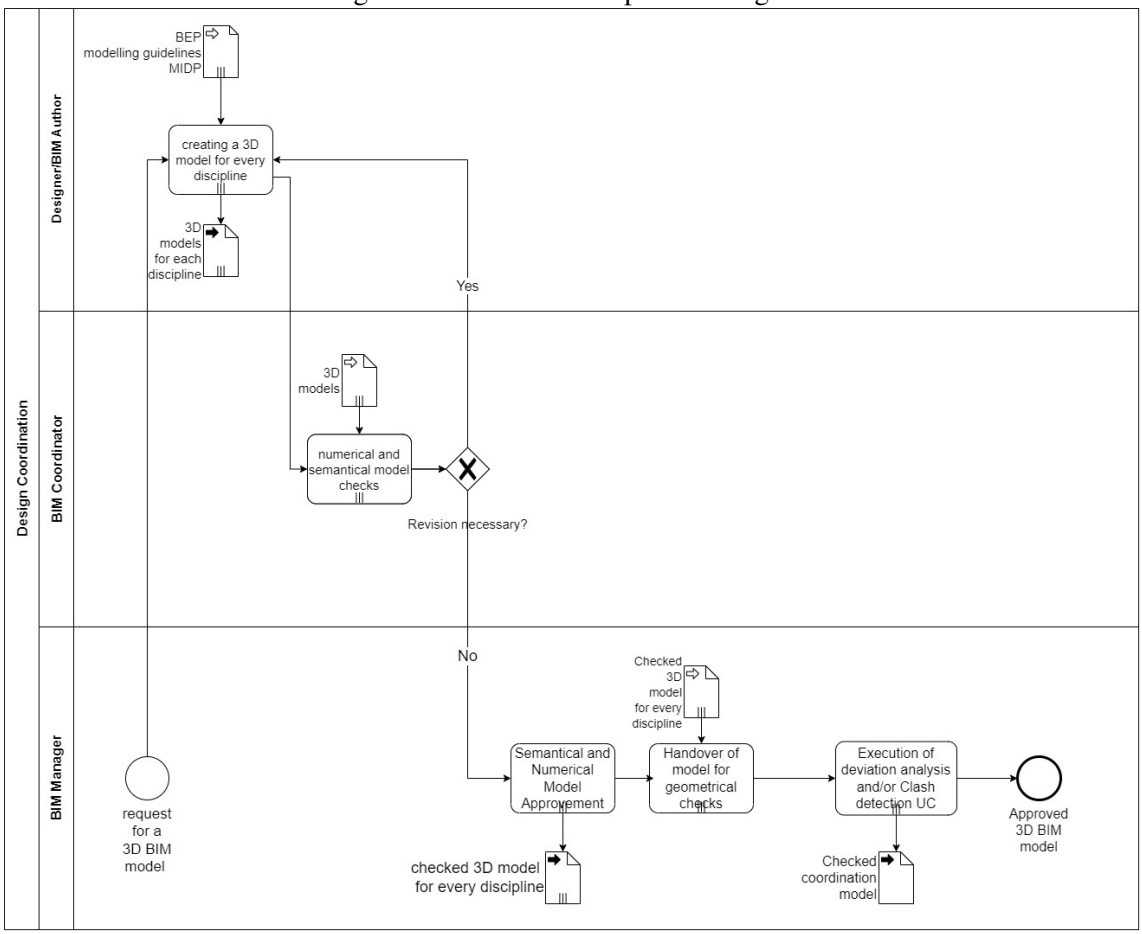
Within the BIMSPEED project this process of model checking was further automated by including rule-based model checking in the form of a script which the model runs and checks itself for conformance to these checks, thereby improving correctness, wholeness of these checks along with time reduction in the execution of the use case which is one of the fundamental objectives of the BIM-SPEED project. Model checking is often considered in the earliest stage of development of a 3D BIM model. However, this process is not confined to early-stage design instead is repeated throughout the design and execution phases as need arises based on over arching trades that the BIM model contains, followed by coordinated design of these trades.

4.2 Information and Process

The model checking BIM use case ensures the validity of the model to perform the use cases required for the project. As input for carrying out model checking BIM use case the following data is required:

- EIR (Exchange Information Requirement)/ BEP (BIM Execution Plan)
- 3D BIM Model

Figure 4.1: Model check process diagram



- Naming converntions
- National / regional standards
- Model Element Matrix

Figure 4.1 provides a process map of the use case.

For renovation projects, the BIM author generates the 3D BIM model from existing 2D drawings as well as requirements defined in BEP, Modelling guidelines and MIDP. The 3D BIM model created is handed over to the BIM coordinator who carries out numerical and semantical checks which is further explained in the next section. Upon carrying out these checks, the discrepancies are shared with the BIM author who must update the model accordingly to meet the requirements of the defined BIM use cases of the renovation project. The automated method of process checking developed within the BIMSPEED project is represented in Figure 4.2.

To meet the objectives of time reduction and increased accuracy, identified design rules are checked for existence from previous implementation of the same rules for model checking, and if this exists it is re-used for the checking process. If not, new rules are developed to run the automated check.

The semantical model checks verifies whether properties assigned to elements correspond to the naming conventions defined within the project. Numerical checks verify the values of these properties are defined within logical bounds or ranges based on standards.

The discrepancies from the resulting numerical and semantical checks are reported in BCF format which allows automated guidance to the discrepancies within the authoring software.

The process is further explained in a test case in Section 4 of the chapter.

Figure 4.2: Semantic and Numeric model check process

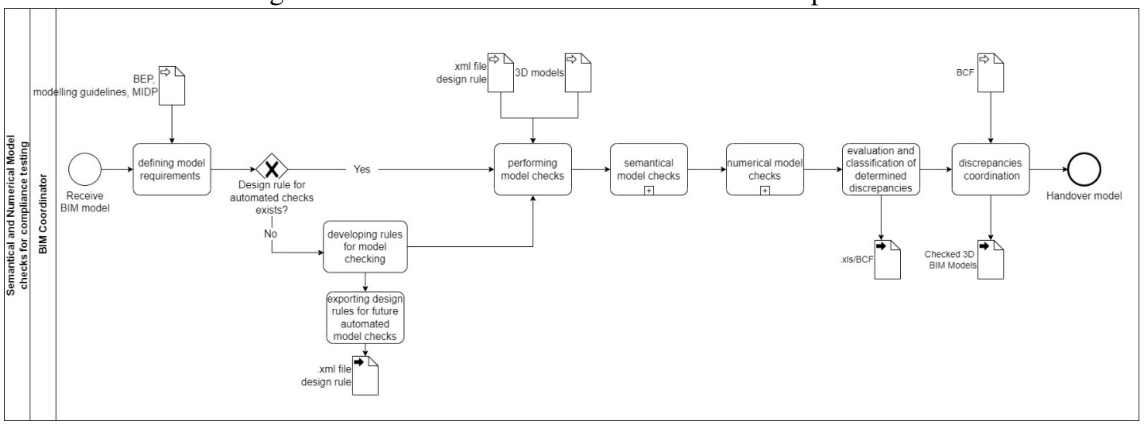


Figure 4.3: A semantic checking rule in XML

```
<?xml version="1.0" encoding="UTF-8"?>
- <filterrules xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  - <preconditions>
    - <frset name="newPreconditionGroup">
        <filter name="BIMSPEED_Building:BIMSPEEDCountry" default="1" pattern="Spain" dtype="xs:string"/>
        <filter name="BIMSPEED_Wall:BIMSPEEDIsExternal" default="1" pattern="true" dtype="xs:boolean"/>
        <filter name="BIMSPEED_Building:ES_BIMSPEEDClimateZone" default="1" pattern=""A" "B" "C" "D" "E" "a"" dtype="xs:string"/>
      </frset>
    </preconditions>
  - <attributerules>
    - <frset name="newRuleGroup">
        <filter name="BIMSPEED_Wall:BIMSPEEDAcousticRating" default="3" pattern=">35" dtype="xs:string"/>
      </frset>
    </attributerules>
</filterrules>
```

4.3 BIM Tools with model checking capability

Numerous BIM model checking tools are currently being used. Some among these are free to use and some are fee-based. The decision of which tool to use, lies largely upon the user and the availability of the software. The software currently available have been assessed for the ability to handle large scale models. These include, Autodesk Navisworks, thinkproject Desite BIM, Nemetscheck Solibri Model Office, Leica, Cyclone 3DR, KUBUS BIMcollab ZOOM.

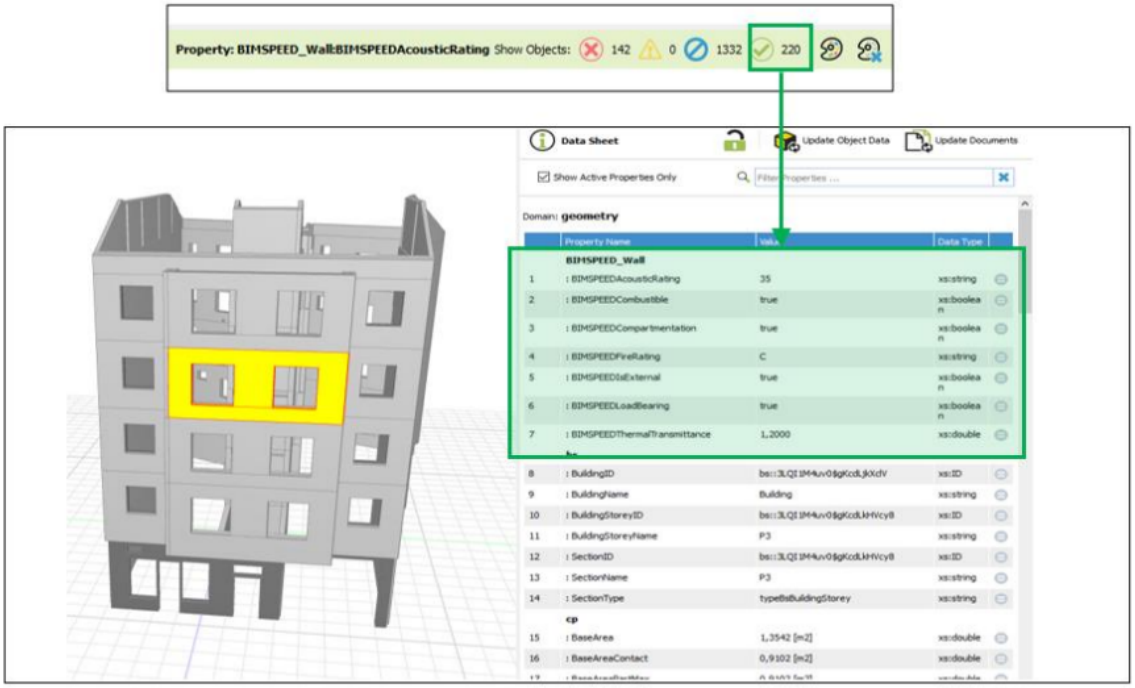
Vendor	Product (Free Version)	Product (Fee based version)	Features	Geometry Check	Semantic Check
Autodesk	Autodesk Naviswork - Freedom	Autodesk Navisworks Manage	clash detection, import of different data formats, BCF-Workflow support	Yes	No
thinkproject	none available	Desite BIM	rule-based configuration, possibility to add new attributes	Yes	yes
Nemetschek	Solibri Anywhere	Solibri Office	predefined checking rules, no 4D capability, only IFC and DWG format supported	No	Yes
Leica	Cyclone 3DR Viewer	Cyclone 3DR	point cloud analysis, supports common BIM formats	Yes	No
KUBUS	BIMcollab Zoom Free	BIMCollab Zoom	point cloud analysis, clash detection, rule based checking	Yes	Yes

4.4 Project Demonstration

BIM model checking use case developed within the project was demonstrated as a BIM case study on one of demonstration sites within the BIM-SPEED project - 'Vitoria demonstration site' in Spain. Design rules based on country and region-specific standards have been developed along with a list of mandatory properties has been collected into single xml files in order to be imported in order to carry out the automated check. An example of one such design check which was translated to a machine-readable design rule is (Figure 4.3): "In Spain in climate zone A-E, each external wall needs to have an acoustic rating of more than 35dB".

Upon importing this machine-readable model check, the model checking platform carried out the checks defined. The semantical and numerical checks carried out, that the 3D BIM model does not comply with the guidelines. The checks have identified 142 model elements, that are in fact

Figure 4.4: A checking rule for a BIM component



walls, but they do not provide the required parameter BIMSpeedAcousticRating, which each model element should contain to enable the usage in the aimed BIM use cases. Completing interpreting the identified results, there luckily have been 220 model elements identified, that are in compliance with these requirements. (Other and Methods, 2021)

4.5 Benefits of testing compliance with BIM

BIM model checking ensures uniformity, compliance to design rules and wholeness of the model to be worked on as a central source of information as well as to incorporate various trades of design across different lifecycle stages of the project. While the implementation of BIM in itself offers the possibility of an integrated source of information, the checking of this model is of prime importance to ensure the implementation of further BIM use cases within the renovation project. Furthermore, the automated process of model checking developed as a part of this project is illustrated in the figure below to demonstrate the potential in achieving the objectives of time reduction and increased efficiency of the model checking process.

- Manual process of checking the model based on the rules defined is transformed into an automated process, which carries out three separate processes of checking into a single automated check
- The evaluation and classification of discrepancies is enhanced by allowing the BIM author to visualize and quickly locate the discrepancy arising by exporting a BCF file which allows an easy import into a different BIM viewing tool.
- The time reduction by implementing this use case estimated based on experience accounts to up to 50% reduction in time and qualitatively an improved efficiency in the checks due to reduction in human error in carrying out the checks manually and based on experience.

Figure 4.5: Comparision of conventional BIM model checking with automated model checking