Finite Element and Building Information Modeling Interoperability

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Abstract

Construction of Nuclear Power Plants (NPPs) is a complex and time-consuming process, with many teams working on various aspects of the project. Construction of new plants frequently suffers from schedule delays and increased costs. A major source of these issues arises from inefficient engineering modeling practices during the design and construction phases of NPPs. Finite Element Modeling (FEM) and Building Information Modeling (BIM) software are used in the design and construction of NPPs. FEM software, such as ANSYS or SAP2000, is used in the design process to analyze the stresses and strains in a structure. In contrast, BIM software, such as AVEVA E3D or Revit, manages and coordinates the different aspects of on-site construction. Establishing an interoperable framework between heterogeneous software aims to improve the overall design and construction management approaches through advancements in digital engineering and Artificial Intelligence / Machine Learning. Specifically, this research works towards creating a bidirectional program that allows for seamless interoperability of structural models between FEM and BIM. The development of such a program will also facilitate the development of risk-informed construction management to enable the acceptance of construction deviations when stringent quality requirements, like tolerances, are not met.

There are currently no programs available that offer complete bidirectional interoperability between FEM and BIM. However, successful forward conversion attempts from BIM-to-FEM have been made. BIM-to-FEM conversion is achieved through leveraging Industry Foundation Classes (IFC) as a vehicle for data exchange. An IFC file is a standardized data model for exchanging building information between different software applications and systems. The IFC schema offers a neutral format representing building or equipment models independent of the software used to create them. Therefore, it may be possible to utilize IFC in the backward conversion process as a tool for data translation across software platforms.

Research on the backward conversion for FEM-to-BIM efforts is limited due to the high complexity of the process. This can be attributed to several reasons including the lack of standardization in the way data is exchanged between BIM and FEM systems, intricate information complexities in BIM that complicate data exchange, and the incompatibility of software between BIM and FEM.

FEM-to-BIM interoperability research aims to create a digital data conversion model that will track changes made in the FEM, subsequently exporting data to the original BIM to reflect the changes. The most important objective of this research is to automate the detection of changes in the FE model and to highlight these changes in BIM for the construction crew. Developing a complete bidirectional program will greatly assist in facilitating high-precision and low-cost construction of nuclear facilities. Furthermore, establishing an interoperable framework will enable the refinement and implementation of a risk-informed construction management framework. This will be achieved through simulation-based assessments of risks associated with construction deviations, particularly in the context of modular construction. Additionally, these advancements will support regulatory acceptance of deviations that do not increase overall risks.