A WORKFLOW FOR FEM GENERATION FROM BIM MODELS BASED ON GEOMETRIC VERIFICATION

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Abstract

This extended abstract addresses the persistent gap between geometric BIM exchange and analysis-ready structural models. Although IFC supports analytical entities, exchanged models often contain geometry without the grids, axes, and connectivity definitions required for finite element analysis (FEA). A geometry-driven workflow is presented for reconstructing local axes, inferring structural grids, correcting alignment, and generating FEM models directly from IFC-derived geometry. A multistorey case study demonstrates that the reconstructed analytical model can be used for numerical analysis and produces structurally meaningful response fields. The contribution is a practical abstraction workflow that improves BIM–FEA interoperability without requiring manually authored analytical models.

Introduction

BIM and the Industry Foundation Classes (IFC) (International Organization for Standardization, 2018) standard are widely used for information exchange in the AEC sector. In structural engineering, however, exchanged IFC models frequently provide detailed geometry while lacking the analytical abstractions required for finite element analysis, including reference axes, structural grids, and consistent connectivity (Dean, 2010; Fedorik et al., 2016; Gomes et al., 2022). This forces engineers to reconstruct the analytical model manually before numerical assessment can begin.

This problem has been discussed in earlier work on IFC interoperability in the structural domain. While IFC aims to support object-based exchange, the reliable transfer of analytically relevant information remains limited, particularly across heterogeneous software workflows (Dean, 2010; Fedorik et al., 2016). More broadly, BIM models are often shaped by coordination and visualisation requirements rather than analytical needs, which can further reduce their suitability for structural assessment (Holzer, 2011). As a result, geometric completeness should not be confused with analytical readiness. The objective of this work is therefore to present a workflow that reconstructs minimal analytical reference systems directly from geometric information and uses them to generate a finite element model.

Related work

Previous BIM–FEA integration approaches have primarily focused on direct mapping between IFC entities and structural analysis software, or on proprietary workflows within specific software environments. These approaches can transfer geometry and selected metadata but typically depend on either predefined analytical models or substantial manual preprocessing (Fedorik et al., 2016; Gomes et al., 2022). Earlier studies have also shown that missing or inconsistent object mappings, unsupported attributes, and incomplete analytical entities remain recurring issues in IFC-based structural exchange (Dean, 2010; Ciccone et al., 2023).

Although IFC includes concepts for analytical representations, these are inconsistently implemented in practice. Consequently, current workflows do not adequately address the common case in which only geometric information can be assumed to be reliably available. The present work differs from direct conversion approaches by treating analytical abstraction itself as the central problem, rather than assuming it has already been solved upstream.

Method

The proposed workflow consists of four steps (A–D), as illustrated in Figure 1.

Step A: Element identification. Structural elements relevant for analysis (columns, beams, slabs) are extracted from the IFC model. Their geometric representations are used as the primary input, independent of analytical entities.

Step B: Axis estimation and grid point generation. Local axes are estimated from geometry using principal directions and element extents. Based on these axes, candidate grid points representing potential analytical node lo-cations are generated.

Step C: Grid inference and alignment. The generated points are grouped using geometric regularity, dominant directions, and spacing consistency to infer a global structural grid. Structural elements are then projected onto this grid to enforce consistent alignment and connectivity.

Step D: FEM model generation. The corrected analytical representation is converted into an FEM model with aligned axes and consistent connectivity, enabling numerical structural analysis.

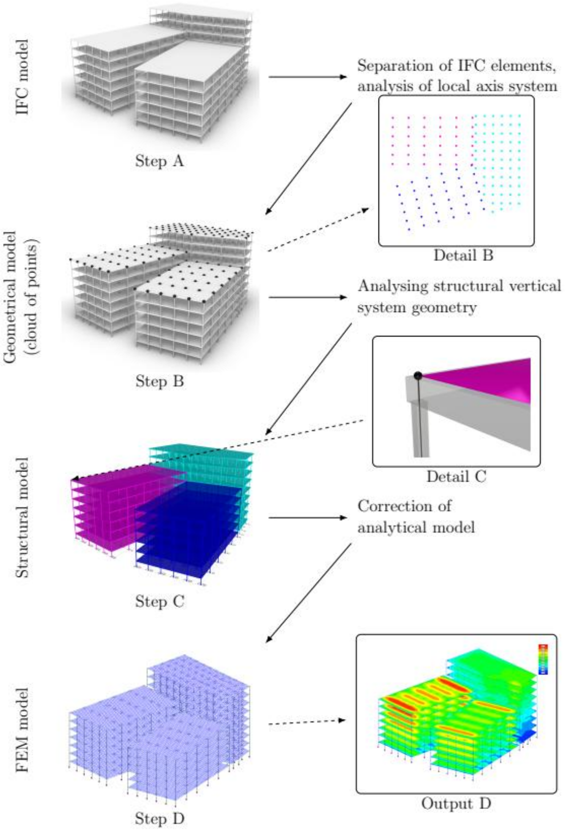

Figure 1: Geometry-driven workflow for FEM generation from IFC data. (A) Extraction of structural elements. (B) Estimation of local axes and generation of grid points. (C) Inference and correction using a global structural grid. (D) Generation of an FEM model and structural response.

Results and discussion

The workflow was applied to a multistorey building model represented in IFC. The input model contained geometrically detailed structural components but did not provide a directly usable analytical grid or consistent axis system. The geometry-based procedure successfully identified the primary structural components, estimated their orientations, and reconstructed a coherent structural grid.

Using this reconstructed grid as a global reference reduced ambiguity in member alignment and improved consistency at intended connections between beams, slabs, and columns. The corrected analytical representation was then used to generate a finite element model that could be analysed without requiring manual redefinition of the global structural layout. Representative analysis output showed stable and physically meaningful structural response.

The main benefit of the workflow is that it does not depend on manually authored analytical entities in the exchanged BIM model. This is important because many practical BIM workflows prioritise coordination and geometric detail rather than structural abstraction. At the same time, the approach has limitations. The current workflow is best suited to structural systems in which geometric regularity is sufficient to infer dominant reference directions. Future development will focus on extending the approach to highly irregular layouts, improving the treatment of sup-port conditions, and incorporating structural walls.

Conclusions

This extended abstract has presented a geometry-driven workflow for reconstructing analytical reference systems and generating FEM models from IFC data. By explicitly recovering local axes, structural grids, and alignment from geometry, the method supports structural model generation even when exchanged BIM models are not analysis-ready. The results indicate that analytical abstraction can be treated as a recoverable step in the workflow, improving BIM–FEA interoperability while remaining compatible with existing modelling practice.

References

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