Comparative Study between ETABS and Bentley ProStructures for Building Design: Analysis-to-Detailing workflow

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Abstract
The seamless integration of structural analysis and detailed fabrication documentation is pivotal for modern building design and delivery. This research paper presents an in-depth comparative analysis of ETABS and Bentley ProStructures, two leading software solutions in structural engineering and Building Information Modeling (BIM). ETABS specializes in the analysis and code-based design of multi-storey buildings, while ProStructures excels in parametric 3D detailing and the generation of shop drawings and fabrication data. The study systematically reviews the core capabilities of each platform, evaluates their interoperability—particularly via Industry Foundation Classes (IFC)—and dissects a typical ETABS-to-ProStructures workflow. The findings demonstrate that while each tool offers unique strengths and limitations, their combined deployment through a robust IFC-mediated pipeline enables a BIM-oriented, efficient, and quality-assured workflow from analysis to detailing. The research further provides best-practice recommendations for engineers and detailers seeking to maximize the advantages of both platforms in contemporary construction projects.

Keywords: ETABS, ProStructures, BIM, IFC,structuralanalysis,detailing,interoperability

1. Introduction

The evolution of the construction industry is inextricably linked with advances in digital technologies, especially in the realm of Building Information Modeling (BIM). A critical requirement in any building project is the accurate and coordinated transition from structural analysis to the generation of fabrication-readydocumentation.

Traditionally, these two domains—structural analysis and detailing—existed in silos, leading to inefficiencies, duplication of efforts, and potential errors that compromise project delivery. The emergence of integrated digital workflows seeks to bridge this divide, fostering collaboration, efficiency, and quality assurance.

ETABS, developed by Computers and Structures, Inc. (CSI), and Bentley ProStructures, from Bentley Systems, represent state-of-the-art solutions for structural analysis/design and 3D detailing/fabrication, respectively. ETABS is renowned for its robust analytical capabilities, especially in multi-storey and high-rise building applications, while ProStructures is optimized for producing highly detailed, parametric models and

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automated shop drawings for steel and concrete structures. The ability of these tools to interoperate—predominantly through the neutral IFC format—forms the backbone of a modern, BIM-centric design-to-fabrication pipeline.

This paper addresses the following research questions:

- What are the core capabilities and intended uses of ETABS and ProStructures?
- How do these platforms interoperate through IFC, and what are the practical considerations in such workflows?
- What are the comparative strengths and limitations of each, and what recommendations can be formulated for their combined use in practice?

2. Objectives

The objectives of this research are threefold:

1. To systematically summarize the key features and intended applications of ETABS and Bentley ProStructures within the context of building design and delivery.
2. To evaluate the interoperability mechanisms between the two platforms, focusing on the IFC schema and practical ETABS-to-ProStructures workflows.
3. To critically analyze the strengths, limitations, and challenges inherent in each platform and their integration, culminatinginbest-practice recommendationsforindustry practitioners.

3. Software Overviews

3.1 ETABS (CSI)

ETABS stands as a purpose-built environment for the analytical modeling, analysis, and design of buildings, particularly multi-storey and high-rise structures. Its integrated workflow encompasses:

- **Modeling:** Grid-based and story-oriented modeling, facilitating rapid creation and management of complex building geometries. ETABS supports both analytical and physical models, allowing for a close alignment between engineering intent and design representation.
- **Analysis:** Comprehensive analysis capabilities include linear, non-linear, static, modal, response spectrum, and time history procedures. The software is equipped for advanced seismic analysis, wind load generation, and automated load combinations according to international and regional codes.
- **Design:** Automated code-based design and checking for reinforced concrete, steel, and composite structures, compliant with ACI, AISC, Eurocode, and various local codes via templates.
- **User Interface and Automation:** ETABS offers a graphical user interface (GUI) tailored for building design, with scripting and API options for customization and automation [ETABS — Building Analysis and Design].

These features position ETABS as the de facto analytical tool in the structural engineering domain, particularly for high-rise and complex multi-storey buildings [ETABS — Building Analysis and Design].

3.2 Bentley ProStructures

Bentley ProStructures is a specialized CAD/BIM solution tailored for the detailing, modeling, and fabrication documentation of steel and reinforced concrete structures. The platform comprises two main modules: ProSteel (for steel) and ProConcrete (for concrete), both integrated within Bentley's broader ecosystem for infrastructure and plant engineering.

Key capabilities include:

- **Parametric 3D Modeling:** Enables the creation of highly detailed, fabrication-

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level models, encompassing connections, plates, bolts, welds, stairs, handrails, and reinforcement cages.

- **Automated Documentation:** Generates 2D shop drawings, bar bending schedules (BBS), bills of materials (BOM), and NC (Numerical Control) data for fabrication machinery.
- **Integration:** Seamlessly connects with Bentley's ProjectWise and other infrastructure solutions, supporting large-scale, multidisciplinary projects.
- **Interoperability:** Supports various exchange formats, notably IFC, DGN, and DWG, fostering collaboration across platforms [ProStructures — Steel & Concrete Design Software].

ProStructures is optimized for producing shop-ready documentation and detailed 3D models that serve as the digital twin for constructionandmanufacturing [ProStructures — Steel & Concrete Design Software].

4. Interoperability: IFC and Practical Data Exchange

Central to the integration between ETABS and ProStructures is the Industry Foundation Classes (IFC) schema, an open, neutral file format developed by buildingSMART International for BIM data exchange. Both ETABS and ProStructures support IFC import and export, but their focus and implementations differ [CSI Technical Note: IFC4 Import and Export (ETABS/SAP2000); ProStructures Documentation — Using IFC Files].

- **ETABS:** Prioritizes the export of the structural analysis view, encapsulating analytical nodes, elements, boundary conditions, and loads. Exported models are geared toward preserving the engineering logic required for subsequent detailing.
- **ProStructures:** Consumes IFC files by interpreting geometry and object definitions suitable for detailed modeling and shop drawing production. The software is attuned to parametric object types and expects well-defined entities such as IfcBeam, IfcColumn, and IfcSlab [ProStructures Documentation — Using IFC Files].

ApracticalETABS-to-ProStructures workflow involves the following steps:

1. **Model and Analyze in ETABS:** The engineer creates the building model, defines loads and boundary conditions, and completes analysis and design checks.
2. **Export to IFC:** The model is exported, ensuring that the structural analysis view and relevant entities (IfcBeam, IfcColumn, IfcSlab) are included. Attention must be paid to mapping conventions, section naming, material definitions, and level offsets [CSI Technical Note: IFC4 Import and Export (ETABS/SAP2000)].
3. **Import and Detail in ProStructures:** The IFC model is imported, verified for completeness and accuracy, and converted into native parametric objects for further detailing, connection design, reinforcement, and documentation [ProStructures Documentation — Using IFC Files].

While the process is conceptually straightforward, practical challenges such as semantic mismatches, loss of analytical metadata, and manual rework are not uncommon [CSI Knowledge Base — Import IFC into ETABS].

5. ComparativeAnalysis(Functional Areas)

This section presents a detailed comparative analysis of ETABS and ProStructures across the key domains relevant to the building design-to-fabrication workflow.

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5.1 Modeling & Geometry

- **ETABS:** Provides grid-based story modeling with integrated analytical and physical models. Slab/area meshing and automated load assignment are standard, facilitating rapid iteration during design development [ETABS — Building Analysis and Design].
- **ProStructures:** Excels in parametric, fabrication-level detail, including connections, plates, stairs, handrails, and reinforcement. The 3D model reflects real-world constructability, supporting downstream fabrication and erection [ProStructures — Steel & Concrete Design Software].

5.2 Analysis & Design

- **ETABS:** Offers comprehensive structural analysis capabilities (static, modal, non-linear, time-history), with automated design per international and local codes. It is equipped to handle complex load cases and performance-based design [ETABS — Building Analysis and Design].
- **ProStructures:** Does not provide building-scale structural analysis or code-based design checks. Instead, it relies on upstream results from ETABS, SAP2000, or similar analysis tools [ProStructures — Steel & Concrete Design Software].

5.3 Detailing & Documentation

- **ETABS:** Limited to basic reinforcement sketches and schedules, insufficient for fabrication or construction. Detailing output is mainly schematic or for design intent communication [ETABS — Building Analysis and Design].
- **ProStructures:** Delivers advanced 2D shop drawings, BBS, material lists, NC files, and highly detailed 3D views. Automated generation of fabrication documents ensures accuracy and consistency [ProStructures — Steel & Concrete Design Software].

5.4 Automation & Parametrics

- **ETABS:** Supports automated load and design routines, with scripting and API access for custom workflows. Automation is focused on the design and analysis domain [ETABS — Building Analysis and Design].
- **ProStructures:** Utilizes parametric components and drawing automation to expedite repetitive detailing tasks, significantly reducing manual drafting [ProStructures — Steel & Concrete Design Software].

5.5 Outputs

- **ETABS:** Analytical results, design reports, load and response diagrams, code check reports.
- **ProStructures:** 2D and 3D shop drawings, bills of materials, bar bending schedules, fabrication files, and construction-ready models [ProStructures — Steel & Concrete Design Software].

6. Typical Workflow: ETABS → IFC → ProStructures

The practical integration of ETABS and ProStructures is best illustrated through a typical workflow (see Figure 1 for a conceptual diagram):

1. **Modeling & Analysis in ETABS:** The engineer develops the full analytical model, applies loads and boundary conditions, and conducts the required analyses and code checks [ETABS — Building Analysis and Design].
2. **IFC Export from ETABS:**
   Following analysis and design, the model is exported to IFC, with emphasis on including the correct entity set (IfcBeam, IfcColumn, IfcSlab) and adopting the structural analysis view. Mapping conventions for section names, levels, and materials are established to facilitate accurate translation [CSI Technical Note:

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IFC4 Import and Export (ETABS/SAP2000)].

3. **Import and Refinement inProStructures:**
   ProStructures imports the IFC file, converts entities into parametric members, and verifies geometry, connectivity, and data integrity. Additional detailing is performed, including the addition of connections, bolts, welds, and reinforcement. Shop drawings, BBS, and NC data are generated for fabrication and construction [ProStructures Documentation — Using IFC Files].
4. **Quality Assurance and Validation:** The transferred model is subjected to verification, ensuring that cross-sections, materials, and reinforcement details are consistent with the original design outputs from ETABS.

PracticalNotes:

- The IFC export must be curated to include only relevant entities, avoiding extraneous data that may complicate import. - Some manual rework is often necessary, especially regarding naming conventions, level offsets, and material mapping. - It is prudent to test the workflow with a small pilot project to identify and rectify mapping issues before full-scale conversion [CSI Knowledge Base — Import IFC into ETABS].

7. Case Study (Conceptual): 10-Storey RC Frame Workflow

Consider a conceptual case of a 10-storey reinforced concrete (RC) frame building:

1. **DesigninETABS:**
   The engineer models the entire frame, assigns loads, and performs analysis and code-based design of beams and columns.
2. **IFCExport:**
   After design, the engineer exports the model, ensuring that beams and columns are mapped to appropriate IFC entities and that section and material assignments are preserved.
3. **ImportinProStructures:**
   The imported geometry becomes the basis for assigning parametric concrete elements, placing reinforcement cages, and applying detailing standards.
4. **DetailingandDocumentation:**
   ProStructures generates bar bending schedules, shop drawings, and 3D construction views. The process reduces duplication of modeling effort and shortens the design-to-fabrication cycle.

Validation:

- Cross-checks are performed to ensure that the ETABS-designed sections correspond to those detailed in ProStructures. - Any discrepancies (e.g., reinforcement detailing, section offsets) are resolved collaboratively between engineering and detailing teams.

This combined workflow exemplifies the practical benefits and challenges of integrated BIM-oriented delivery, highlighting the need for careful mapping, verification, and team coordination [ProStructures Documentation — Using IFC Files].

8. Discussion: Strengths, Limitations & Recommendations

Strengths

- **ETABS:**
  – Unparalleled analytical rigor for multi-storey and high-rise buildings.
  – Advanced features for seismic and dynamic analysis.
  – Integrated code checking and automated design routines [ETABS — Building Analysis and Design].

- **ProStructures:**
  – Industry-grade detailing for steel and concrete,includingautomated
  – documentation.

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– Parametric modeling enhances efficiency and reduces errors.
– Robust output for fabrication and construction [ProStructures — Steel & Concrete Design Software].

Limitations

• IFC Mapping:

– The translation between analysis- and detail-oriented models is not lossless; semantic differences may require manual intervention and validation [CSI Technical Note: IFC4 Import and Export (ETABS/SAP2000)].
– Not all analytical metadata (e.g., loads, boundary conditions) are relevant or translatable to the detailing domain.
– Inconsistent naming, level offsets, or section definitions can lead to errors or omissions [CSI Knowledge Base — Import IFC into ETABS].

• **ProStructures Analytical Limitations:**

– ProStructures is not a substitute for full-scale structural analysis and code checks; it relies on upstream engineering validation.

Recommendations

1. **AdoptaStandardized ETABS→IFC→ProStructures Pipeline:**

– Establish naming conventions, mapping tables, and protocols for section, material, and level translation.
– Use pilot projects to identify and rectify mapping issues before large-scale deployment.

2. **Verification and Quality Control:**

– Systematically cross-check section properties, reinforcement, and member assignments between ETABS outputs and ProStructures detailing.
– Implement a verification step post-import to ensure consistency and compliance.

3. **Team Training and Collaboration:**

– Invest in training for both engineering and detailing teams on the nuances of both platforms and the interoperability process.

4. **Continuous Improvement:**

– Solicit feedback from project teams, document lessons learned, and refine the workflow to reduce manual rework and improve efficiency.

5. **Leverage BIM-Oriented Best Practices:**

– Adopt broader BIM standards and best practices, such as those recommended by buildingSMART and industry bodies, to ensure long-term scalability and interoperability [A Generalized LLM-Augmented BIM Framework: Application to a Speech-to-BIM system; BIM-GPT: a Prompt-Based Virtual Assistant Framework for BIM Information Retrieval].

9. Conclusion

The comparative study of ETABS and Bentley ProStructures underscores their complementary roles in the modern building delivery process. ETABS offers a robust environment for structural analysis and code-based design, while ProStructures is unrivaled in its capacity for detailed, parametric modeling and automated documentation for fabrication. The integration of these tools via the IFC standard is both practical and effective, provided that mapping conventions, validation procedures, and team training are rigorously implemented.

Despite the inherent challenges of semantic translation between analysis and

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detail models, the combined workflow reduces duplication, enhances accuracy, and streamlines the design-to-fabrication cycle. As the construction industry continues its digital transformation, the adoption of integrated, BIM-oriented workflows—anchored by the strengths of ETABS and ProStructures—will be essential for delivering complex, high-quality projects on time and within budget.

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