Modeling using Open Standards: Examples from bSA and FHWA

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Overview

• Highlight several recent initiatives in USA for standardizing building information

• What’s in it for...
  – owners
  – contractors
  – designers
  – software vendors
Industry Foundation Classes (IFC) has been used in building industry for 15 years to exchange data. Major vendors support, ~160 applications. Historically used for design coordination. While possible to capture everything within plans for bidding and building, has not really happened at scale... yet.
What are we trying to solve?

• Capture everything in digital form to automate bidding, procurement, fabrication, construction
• Near-term: provide IFC alongside plans “for informational purposes”
• Long-term: if/when parties trust digital files, eventually contractually binding
Long-term possibilities?

- Purchasing an airline ticket today, as a user moves a slider around to adjust times, gets instant feedback of available flights with contractually binding prices.
- Can we get to an equivalent experience with BIM such as by moving walls, etc., a designer gets instant feedback on cost and schedule? – automated bidding?
Reality

• A lot of detail still needs to be defined for hundreds of building domains
• Even elements as commonplace as interior walls do not yet have sufficient detail standardized or machine usable
• Some domains further along, e.g. steel
• Fragmentation of construction industry doesn’t support all business cases
Strategies to get there

• Organizations having economies of scale can justify upfront heavy lifting
• Specialized domains having fewer players but larger scale are better positioned
• Leverage existing investments
• Avoid adding anything new unless critical
Projects attempting to get there

• Wall Information Exchange
  – Component Assembly Systems – largest U.S. framing subcontractor
  – Detail for interior walls is manageable

• Bridge Information Exchange
  – Federal Highway Administration, State DOTs
  – Detail for bridges is relatively contained
Wall Information Exchange has two parts:

• Specific representation in IFC
  – IfcWallElementedCase specific usage
  – Incorporated into IFC4 Design Transfer view

• Library of standard wall types for U.S.
  – Performance (fire, sound, height, etc.)
  – Components (studs, track, sheets, insulation)
  – Identifiers (similar to AISC shape designation)
Wall IE: Scope

+ Wall assemblies
+ Framing
+ Studs
+ Track
+ Insulation
+ Surfacing
+ Sheets
+ Screws

Build in the visual cues that allow for isolated review and clear intent

Visual Indicators within 3D → +Δ BIM

Show continuity of Life Safety rated enclosures
Wall IE: Specification

6.1.3.46 IfcWallElementedCase

- Natural language names
- Change log

6.1.3.46.1 Semantic definitions at the entity

- Entity definition

The IfcWallElementedCase defines a wall with certain constraints for the provision of its components.

- The wall has a type (IfcWallType) that indicates material layers and corresponding elements to be placed parametrically.
- The wall is decomposed into elements for part occurrences, each corresponding to parts defined at the wall type.
- The relationship IfcRelConnectsWithElementsByTag adds information on how parts are connected.

```
IfcWallElementedCase
Name: "Wall Element"
PredefinedType: 'ELEMENTEDFACE'
ObjectPlacement: "Placement representation (49,34,1,0)"
Representation: "Representation (49,34,1,0)"

/* The overall wall is defined by a top, a bottom, and two side boundaries which are defined by the type definition using the TopDefinedBy attribute. */
```

```
IfcWallType
Name: "Wall Type"
PredefinedType: 'WALL'
ObjectPlacement: "Placement representation (49,34,1,0)"
Representation: "Representation (49,34,1,0)"

/* The overall wall is defined by a top, a bottom, and two side boundaries which are defined by the type definition using the TopDefinedBy attribute. */
```
Wall IE: Wall Type Library

<table>
<thead>
<tr>
<th>Identifier</th>
<th>Classification</th>
<th>Fire</th>
<th>Fire Validation</th>
<th>Sound</th>
<th>STC Validation</th>
<th>Height Limit (5 psf L/240)</th>
<th>Panel Left</th>
<th>Panel Right</th>
<th>Frame</th>
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<tr>
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<td>21-41 71 11</td>
<td>U 493</td>
<td>2Hf 66</td>
<td>USG-0508</td>
<td>9'-9'' (5 psf)</td>
<td>5'-8'' X (2)</td>
<td>5'-8'' X</td>
<td>362S125-18 Chase</td>
<td></td>
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<td>U 493</td>
<td>1HF 64</td>
<td>USG-0508</td>
<td>9'-9'' (5 psf)</td>
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<td>5'-8'' X</td>
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<td></td>
</tr>
<tr>
<td>NBC362SH2B-2TX-2X</td>
<td>21-41 71 11</td>
<td>U 493</td>
<td>1HF 60</td>
<td>USG-0508</td>
<td>17'-5'' (5 psf)</td>
<td>5'-8'' X</td>
<td>5'-8'' X</td>
<td>362S125-33 Chase</td>
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</tr>
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<td>n/a</td>
<td>14'-5'' (5 psf)</td>
<td>1''</td>
<td>Line 5'/8''</td>
<td>400C125-18 @24</td>
<td></td>
</tr>
<tr>
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<td>21-41 71 11</td>
<td>U469</td>
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<td>n/a</td>
<td>24'-3'' (5 psf)</td>
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<td>Line 5'/8''</td>
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<td>n/a</td>
<td>17'-5'' (5 psf)</td>
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<td>Line 5'/8''</td>
<td>400C125-30 @24</td>
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<td>n/a</td>
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<td>350S125-30 @24 M</td>
<td></td>
</tr>
</tbody>
</table>
Wall IE: Technical Details

- IfcWallElementedCase (IFC4) usage
- Material layers mapped to components
- Spacing of components (e.g. studs)
- Properties captured for fire, sound, etc.
- Nested assemblies for framing, drywall

- Does not mean every stud is modeled, just default layout of components
Bridge Information Exchange

- U.S. Federal Highway Administration
- Plan-level detail for bidding and building
- IFC Specification (model view definition)
- Report walks through processes, rationale
- Examples files for fully developed bridges
- Tested with Revit, Microstation, Tekla
Bridge IE: Exchanges

• Requirements – provided by owning agency
• Surveying – provided by land surveyor
• Utility – provided by utility authorities
• Structural – finite element models, loads, results
• Template – re-usable components, bridge types

Plans – specific project with plan details for bid
• Bid – bid with quantities, rates, alternates
• Fabrication – shop drawings by fabricator
• Construction – change orders, as-buils
• Inspection – inventory, inspection reports
• Maintenance – rehabilitation
Bridge IE: Specification

- Subset of IFC4.1 adapted for bridges
Bridge IE: Scope

- Decks, girders, framing
- Piers, abutments, bearings
- Rebar, tendons, anchors
- Joints, expansion devices
- Guardrails, railings
- Terrain, soil conditions
- Electrical conduit, lighting
- Pipes, drains, vents
Bridge IE: Examples

- Steel bridge, concrete box girder bridge
- Available as IFC2x3, ~IFC4x2; (.ifc, .xml)
Bridge IE: Testing

- Baseline testing with:
  - Autodesk Revit
  - Bentley Microstation
  - Tekla Structures

- Loads, but more work needed...

- FHWA workshops

- DOT case studies
Bridge IE: Technical Details

- 95% there with IFC Coordination View
- IfcAlignment (IFC 4.1)
  - Reference curve and stationing
- IfcRelPositions (extension; ~IFC4.2)
  - Position, transform elements on alignment
- Other entities not in coordination view
  - IfcSectionedSpine (e.g. decks, girders)
  - IfcSweptDiskSolidPolygonal (e.g. rebar)
  - IfcSweptAreaSolidTapered (e.g. abutments)
Summary

• What’s in it for owners?
  – Leverage data downstream, reduce errors

• What’s in it for contractors?
  – Automate quantity takeoff and bidding
  – Automate fabrication & construction

• What’s in it for designers?
  – Ideally no impact; existing software outputs

• What’s in it for software vendors?
  – Leverage existing technology in new markets
More Information

- **www.nibs.org**
  - Specifications, test case files for bridges

- **www.buildingsmart-tech.org**
  - Supporting tools for software providers

- **timc@constructivity.com**
  - questions or feedback