Implementation of Precast NBIMS – Phase 2

Participating Companies:

- Tekla
- Structureworks
- Vectorworks
- Nemetschek – Scia - Allplan
- Bentley Architecture
- Revit Structure

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Outline

• Introduction
• Phase-2 Objectives
• Primary Building Elements
• Issues in Reinforcement Modeling
• Discussion
Introduction

- Initial set of implementations demonstrated at the PCI Annual Convention in October, 2011. ([AECBytes article](#))
- The complete definition is available in the precast NBIMS project website ([Documents](#))
Introduction

- Precast NBIMS test repository (overview of website) ([http://dcom.arch.gatech.edu/pcibim/testing.asp](http://dcom.arch.gatech.edu/pcibim/testing.asp))
- Semantic Exchange Modules (SEM) definitions
- Sample test files for import testing (Ifc files)
- Guidelines for export testing (Implementation docs, dxf files)
Objectives

• Phase -2
  • building elements and their common attributes - Brep shapes - individuals and types
  • reinforcing - tendons, rebar and mesh - extruded swept disk
  • features addition and subtraction
  • components and discrete accessories
  • detail slabs - hollowcore, DT, toppings, mesh etc.
  • detail walls elements
  • fasteners and connections - logical, feature addition/subtraction, hardware, assemblies
  • finishes & coverings
  • testing on GTDS after manual verification
Primary Building Elements

- **Building Elements**
  - Beam
  - Column
  - Slab
  - Pile
  - Ramp
  - Wall
  - Stair
  - Member

- **Building Element Types**
  - Beam Type
  - Column Type
  - Slab Type
  - Pile Type*
  - Ramp Type *
  - Wall Type
  - Stair Type *
  - Member Type

* - IFC Release 4

Refer SEMs: [Primary Building Element](#) [Primary Building Element Type](#)
## Basic Concepts

<table>
<thead>
<tr>
<th>Element Description</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Contained in Project</td>
<td>PCI-042</td>
</tr>
<tr>
<td>Building Contained in Site</td>
<td>PCI-043</td>
</tr>
<tr>
<td>Building Storey Contained in Building</td>
<td>PCI-044</td>
</tr>
<tr>
<td>Space Contained in Building</td>
<td>PCI-045</td>
</tr>
<tr>
<td>Space Contained in Building Storey</td>
<td>PCI-046</td>
</tr>
<tr>
<td>Grid Name</td>
<td>PCI-047</td>
</tr>
<tr>
<td>Grid Representation</td>
<td>PCI-048</td>
</tr>
<tr>
<td>Grid Spatial Structure Containment</td>
<td>PCI-049</td>
</tr>
<tr>
<td>Grid Axis Assignment</td>
<td>PCI-050</td>
</tr>
<tr>
<td>Placement Relative to Grid</td>
<td>PCI-052</td>
</tr>
<tr>
<td>Element Attributes</td>
<td>PCI-053</td>
</tr>
<tr>
<td>Element Type Assignment</td>
<td>PCI-054</td>
</tr>
<tr>
<td>Precast Property Set Assignment</td>
<td>PCI-055</td>
</tr>
<tr>
<td>Precast General Attributes</td>
<td>PCI-056</td>
</tr>
</tbody>
</table>
Primary Building Elements

- **Requirements**
  - Ifc Entity and Attributes
  - Brep Geometry
  - Material Association
  - Common Property Sets
  - Type Definition

- **Example: Slab**

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Implementation agreements</th>
</tr>
</thead>
<tbody>
<tr>
<td>GlobalId</td>
<td>Must be provided (<a href="#">IfcGloballyUniqueId</a>)</td>
</tr>
<tr>
<td>OwnerHistory</td>
<td>Must be provided, but may contain dummy data (<a href="#">IfcOwnerHistory</a>)</td>
</tr>
<tr>
<td>Name</td>
<td>The Name attribute has to be provided for the slab (<a href="#">IfcLabel</a>).</td>
</tr>
<tr>
<td>Description</td>
<td>Optional description may be provided (<a href="#">IfcText</a>).</td>
</tr>
<tr>
<td>ObjectType</td>
<td>Optional (<a href="#">IfcLabel</a>).</td>
</tr>
<tr>
<td>ObjectPlacement</td>
<td>Optional. Should be a subtype of <a href="#">IfcObjectPlacement</a>.</td>
</tr>
<tr>
<td>Representation</td>
<td>Optional. Should be a subtype of <a href="#">IfcProductRepresentation</a>.</td>
</tr>
<tr>
<td>Tag</td>
<td>Optional. (Provide piecemark if available)</td>
</tr>
<tr>
<td>PredefinedType</td>
<td>Should be an enumeration of type <a href="#">IfcSlabTypeEnum</a>.</td>
</tr>
</tbody>
</table>

*If IfcSlabType is associated with IfcSlab, then predefinedType is not used*
Primary Building Elements

- **Brep Geometry**

1. Assign a Representation Item to Shape Representation
2. Check the proper use of Items according to RepresentationType
3. No topological representation item shall be directly used for shape representation
• Material Association

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</tr>
<tr>
<td>OwnerHistory</td>
<td>Must be provided, but may contain dummy data (IfcOwnerHistory)</td>
</tr>
<tr>
<td>Name</td>
<td>The Name attribute is optional for the objectified relationship (IfcLabel).</td>
</tr>
<tr>
<td>Description</td>
<td>Optional description may be provided (IfcText)</td>
</tr>
<tr>
<td>RelatedObjects</td>
<td>Should point to set [1:?] of IfcObject. Should be a subtype of IfcBuildingElement.</td>
</tr>
<tr>
<td>RelatingMaterial</td>
<td>Should point to IfcMaterial</td>
</tr>
</tbody>
</table>

There should be at least one subtype of IfcObject associated to the RelatedObjects.
## Common Property Sets

<table>
<thead>
<tr>
<th>Building Elements</th>
<th>IFC Entities</th>
<th>Applicable Property Sets</th>
</tr>
</thead>
</table>
• Pset_PrecastConcreteElementGeneral  
• Pset_ConcreteElementQuantityGeneral  
• Common property sets for all occurrences of different building elements like Pset_WallCommon  
• Pset_ConcreteElementSurfaceFinishQuantityGeneral  
• Property set for pitch length information of reinforcement bar in elements including beam, column, slab, wall, and footing; like Pset_ReinforcementBarPitchOfColumn |
| Building Elements | IfcBeamType, IfcSlabType, IfcColumnType, IfcRoofType, IfcCurtainWallType, and IfcWallType, IfcStairType, and IfcRampType. | • Common property sets for all occurrences of different building elements like Pset_WallCommon |

### Products

- IfcBeam
- IfcSlab
- IfcColumn
- IfcRoof
- IfcCurtainWall
- IfcWall
- IfcStair
- IfcRamp
- IfcPile
- IFCBeamStandardCase (IFC2X4)
- IFCSlabStandardCase (IFC2X4)
- IFCColumnStandardCase (IFC2X4)

### IFC Entities

- IfcSlab
  - + GlobalId
  - + OwnerHistory
    - Name
    - Description
  - ObjectPlacement
    - Representation
    - Tag
    - PredefinedType
  - (INV) IsDefinedBy
    - IfcPropertySingleValue
      + Name
      + Description
      + Nominal Value
      + Unit
[1:?]

### Applicable Property Sets

- Pset_ConcreteElementGeneral
- Pset_PrecastConcreteElementGeneral
- Pset_ConcreteElementQuantityGeneral
- Common property sets for all occurrences of different building elements like Pset_WallCommon
- Pset_ConcreteElementSurfaceFinishQuantityGeneral
- Property set for pitch length information of reinforcement bar in elements including beam, column, slab, wall, and footing; like Pset_ReinforcementBarPitchOfColumn

### Property Set

- IfcRelDefinesByProperties
  + GlobalId
  + OwnerHistory
    + Name
    + Description
  + RelatedObjects
    + RelatingPropertyDefinition

- IfcPropertySet
  + GlobalId
  + OwnerHistory
    + Name
    + Description
  + HasProperties
  + [INV] PropertyDefinitionOf

- IfcPropertySingleValue
  + Name
  + Description
  + Nominal Value
  + Unit
• Common Property Sets

Implementation of Pset_SlabCommon
Primary Building Elements

- **Type Definition**
  - Common geometry and property sets

### Attributes

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<tr>
<td>GlobalId</td>
<td>Must be provided (<a href="#">IfcGloballyUniqueId</a>)</td>
</tr>
<tr>
<td>OwnerHistory</td>
<td>Must be provided, but may contain dummy data (<a href="#">IfcOwnerHistory</a>)</td>
</tr>
<tr>
<td>Name</td>
<td>The <em>Name</em> attribute can be optionally provided for the slabtype (<a href="#">IfcLabel</a>).</td>
</tr>
<tr>
<td>Description</td>
<td>Optional description may be provided (<a href="#">IfcText</a>)</td>
</tr>
<tr>
<td>ApplicableOccurrence</td>
<td>Optional (<a href="#">IfcLabel</a>).</td>
</tr>
<tr>
<td>HasPropertySets</td>
<td>If <code>PredefinedType = .USERDEFINED., then ObjectType is mandatory</code></td>
</tr>
<tr>
<td>RepresentationMaps</td>
<td>Optional. Should point to LIST [1:?] OF UNIQUE <a href="#">IfcRepresentationMap</a></td>
</tr>
<tr>
<td>Tag</td>
<td>Optional. (Provide piecemark if available)</td>
</tr>
<tr>
<td>ElementType</td>
<td>Optional (<a href="#">IfcLabel</a>).</td>
</tr>
<tr>
<td>PredefinedType</td>
<td>Should be an enumeration of type <a href="#">IfcSlabTypeEnum</a>.</td>
</tr>
</tbody>
</table>

### List of Occurrences of BuildingElement

- ([INV](#)) IsDefinedBy

### Type Assignment

- ([INV](#)) ObjectTypeOf
• What do we provide?
  • Guidelines for implementation
  • Sample test files for import testing
  • Setup files for export testing
  • Manual verification
• Testing on GTDS server

Example guidelines: **Stair**

<table>
<thead>
<tr>
<th>Element</th>
<th>Import Test</th>
<th>Export</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple Beam</td>
<td>IFC File</td>
<td>Zip File</td>
</tr>
<tr>
<td>Simple Column</td>
<td>IFC File</td>
<td>Zip File</td>
</tr>
<tr>
<td>Simple Wall</td>
<td>IFC File</td>
<td>Zip File</td>
</tr>
<tr>
<td>Simple Slab</td>
<td>IFC File</td>
<td>Zip File</td>
</tr>
<tr>
<td>Stair</td>
<td>IFC File</td>
<td>Zip File</td>
</tr>
<tr>
<td>Ramp</td>
<td>IFC File</td>
<td>Zip File</td>
</tr>
<tr>
<td>Pile</td>
<td>IFC File</td>
<td>Zip File</td>
</tr>
</tbody>
</table>
Implementation Support

• Next: Issues in reinforcement modeling
  
  • REBAR
    a. B-rep geometry vs. extrusions – as SweptDiskSolid
    b. multiple instances of same rebar shape – use of BuildingElementProxyType, or refer to the same RepresentationItem
    b. aggregations to support arrays and also stirrups
    c. a rebar cage is an aggregations of aggregations
    d. carrying a distinct LocalPlacement and GUID for each rebar
  
  • MESH
    a. represented as a sheet with properties in ReinforcingMesh, or as set of individual wires, or other
    b. bends in mesh?
  
  • TENDONS
    a. tendon placement and longitudinal shape
Thank you