

## Modeling Structural Steel: CIS/2 – IFC Gap Analysis (10 Jan 2011)

### Overview

This analysis was developed as a result of discussions at the AISC CIS/2 workshop in Chicago on 18 December 2009. It was developed by Robert Lipman ([robert.lipman@nist.gov](mailto:robert.lipman@nist.gov)) with contributions from Chuck Eastman, Barry Butler, and Frank Wang.

The following table lists many issues, how the issues related to IFC2x3, possible workarounds or alternatives for IFC2x3, deficiencies in the implementations, what is different in the upcoming version of IFC2x4, and how the issue is handled in CIS/2.

The deficiencies in the implementations were tested by importing sample IFC files into a wide variety of CAD applications and IFC viewers. Some of the workarounds have been implemented in SteelVis.

The analysis was presented and discussed at the CIS/2 Workshop at NASCC, 11 May 2010, in Orlando, FL.

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Issue	IFC2x3	Workaround or alternative for IFC2x3	Deficiencies in implementations	IFC2x4	CIS/2
Section profile cardinal point	IfcParameterizedProfileDef has no cardinal point	Simulate with IfcParameterizedProfileDef.Position or IfcExtrudedAreaSolid.Position and a property set	Some IFC apps do not import IfcParameterizedProfileDef.Position correctly for all profiles. IfcExtrudedAreaSolid.Position is correctly implemented.	New type IfcCardinalPointReference referenced from IfcMaterialProfileSetUsage. Cardinal point offset XYZ values on IfcExtrudedAreaSolid.Position (occurrence) rather than profile position (type).	Cardinal point on section_profile (type)
Mirroring profiles for non-symmetric profiles such as angles and channels	IfcDerivedProfileDef can be used to mirror profiles, however, this is a general transformation and difficult to implement	Use IfcArbitraryClosedProfileDef or reverse the longitudinal axis	Only a few IFC apps import IfcDerivedProfileDef and probably none export it	New entity IfcMirroredProfileDef is much simpler than IfcDerivedProfileDef	Mirroring specified by a boolean flag on section_profile
Compound sections such as double angles	IfcCompositeProfileDef	IfcElementAssembly and IfcRelAggregates could also be used	Only a few IFC apps import IfcCompositeProfileDef and probably none export it		Some CIS/2 apps use section_profile_compound In others, double sections are specified as 2L10x5x1/2 which leads to ambiguities in the section orientation
Bent plates, corrugated decking, cold-formed sections	IfcCenterLineProfileDef	B-rep	Only a few IFC apps import IfcCenterLineProfileDef and probably none export it		section_profile_centreline, few implementations
Curved parts as extrusions	IfcRevolvedAreaSolid (circular arc) or IfcSurfaceCurveSweptAreaSolid (general curve)	B-rep	Only a few IFC apps import IfcRevolvedAreaSolid or IfcSurfaceCurveSweptAreaSolid and some export it, need some good examples of curved part		Some CIS/2 apps model curved parts. Curve is usually defined by a polyline, b-spline, or composite curves
Copes and cutouts	No parametric definition of copes and cutouts. Web penetrations modeled with IfcOpeningElement and IfcRelVoidsElement	B-rep or use boolean operations with IfcHalfSpaceSolid and IfcBooleanClippingResult for miter cuts and chamfers, IfcBooleanResult for more general cutouts. Use IfcFeatureElementSubtraction similar to how precast is modeled. Use property set to capture parameters of cutout.	Not sure about the implementations of boolean operations and IfcFeatureElementSubtraction in general. Not sure that if implemented, they are used for copes and cutouts.	Need parametric definitions and property sets for copes and cutouts	feature_volume parametrically defines common copes and cutouts. Need to define other features that could be parametrically defined such as web penetrations, weld access holes, etc.

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Profile name	There is an implementer's agreement to use IfcProfileDef.ProfileName for the section designator, however, not sure if it is followed.	Can also use a property set which is necessary for b-rep geometry when there is no IfcProfileDef. The profile name can also go on IfcBuildingElement.Description Need naming standards such as with AISC sections.	Some IFC apps do not use ProfileName	IfcBeamStandardCase and others are new in IFC2x4. Not sure if there is a different place for the profile name	Profile name on section_profile. Non-standard names are still an issue.
Bolts, holes, welds	IfcMechanicalFastener, IfcFastener for bolts and welds. Geometry of holes can be modeled with boolean operations or IfcFeatureElementSubtraction.	Bolts can be grouped in a building element proxy to simulate layouts.	Only a few IFC apps import IfcMechanicalFastener or IfcFastener and probably none export it	Need layout of bolts and holes, should be similar for rebar. Need better modeling of welds and holes. Better semantic definition for all.	Bolts, holes, and welds are well defined. Several implementations.
Assemblies	IfcElementAssembly and IfcRelAggregates		Not sure about the implementations		Assemblies are typically a main members and associated clip angles, gusset plates etc. Trusses are not modeled as assemblies.
Joists	None. No mechanism to specify a manufactured component like this.	Individual joist parts can be aggregated into an assembly	Not sure about the implementations		Joist designator can be specified on section_profile. Need to lookup actual dimensions from catalog information.
Associating connections with parts	IfcRelConnectsWithRealizingElements can associate bolts and welds with parts		Not implemented, although also necessary for precast		located_part_joint associates parts (not assemblies) with bolts and welds. Only implemented in Tekla.
Design vs. Detailed model	No differentiation				Separate design and detailed models, mapping between the two
Analysis model	Structural analysis model is similar to CIS/2. Can use IfcRelConnectsStructuralMember to associate analysis element with physical member		Only a few implementations in European software.	Some changes to the structural analysis model. Use IfcRelAssignsToProduct to associate analysis element with physical member	Analysis model is similar to IFC, not sure about loading and other details. Mapping between analysis and design and detailed models. Many implementations.
Member function	Limited in ability to specify a member as a brace, stiffener, etc.				Member function can be specified
Globally Unique ID (GUID)	Required				Optional on managed_data, useful for roundtripping

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### Other Comments, Questions, and Issues

- Issues from the new ISG-Structural subgroup (<http://www.buildingsmart-tech.org/developers/community/structural/>): cardinal points, nested assemblies, design status and phase, use of IfcArbitraryClosedProfileDef regarding section orientation and mirroring
- Precast sections in 2x4 (double tees, hollow core slabs) will not use parametric profiles, rather IfcArbitraryClosedProfileDef and Psets. How can this be applied to steel sections?
- More use of property sets as a workaround for IFC2x3 deficiencies
- Interoperability issues related to vendor specific use of attributes such as IfcBuildingElement.Name, Description, Tag, and property sets
- Is the new structural coordination view sufficient?
- Determine which issues are important based on workflows and MVDs
  
- Given the amount of time it takes to add to or modify the IFC schema, to implement a new schema in software, test and certify implementations; it could be many years before some of the major changes necessary for doing structural modeling and analysis better are available to end-users. What can be done to accelerate the process to get usable solutions to end-users?
- Need advocates for these issues such as the new ISG-Structural subgroup and national industry associations such as AISC, PCI
  
- IFC has a very large organization behind it from which CIS/2 could learn from by how the standard is maintained, improved, and promoted. The IFC schema is continually updated and improved. There is a database of issues. Model view definitions are being developed for many domains. There is a certification process. There are frequent IFC workshops and teleconferences on a variety of topics. There are IFC websites with many resources available:
  - <http://www.buildingsmart-tech.org/>
  - <http://www.blis-project.org/IAI-MVD/>
  - <http://www.buildingsmart.com/bim>
  - [http://www.ifcwiki.org/index.php/Main\\_Page](http://www.ifcwiki.org/index.php/Main_Page)
  - <http://dcom.arch.gatech.edu/pcibim/index.asp>
  
- Information about mapping from CIS/2 to IFC can be found in the following:
  - [http://www.nist.gov/manuscript-publication-search.cfm?pub\\_id=100936](http://www.nist.gov/manuscript-publication-search.cfm?pub_id=100936)
  - [http://www.nist.gov/manuscript-publication-search.cfm?pub\\_id=861673](http://www.nist.gov/manuscript-publication-search.cfm?pub_id=861673)
  - <http://tempest.arch.gatech.edu/~aisc/cisifc/>
  - <http://cic.nist.gov/vrml/cis2.html>
  
- In general, the analysis shows that there are areas of improvement for the IFC schema and software implementations. They include: improvements for detailed or fabrication models; incorporating some of the semantic information that is found in CIS/2; and improving the geometric modeling of structural steel.