



From Theory to Reality: How We Actually Delivered the First Contractual IFC Bridge Project in the US

Michael Baker
INTERNATIONAL

Joe Brenner, P.E - Director of Bridge Technologies

Hanjin Hu, Ph.D., P.E. - Technical Manager

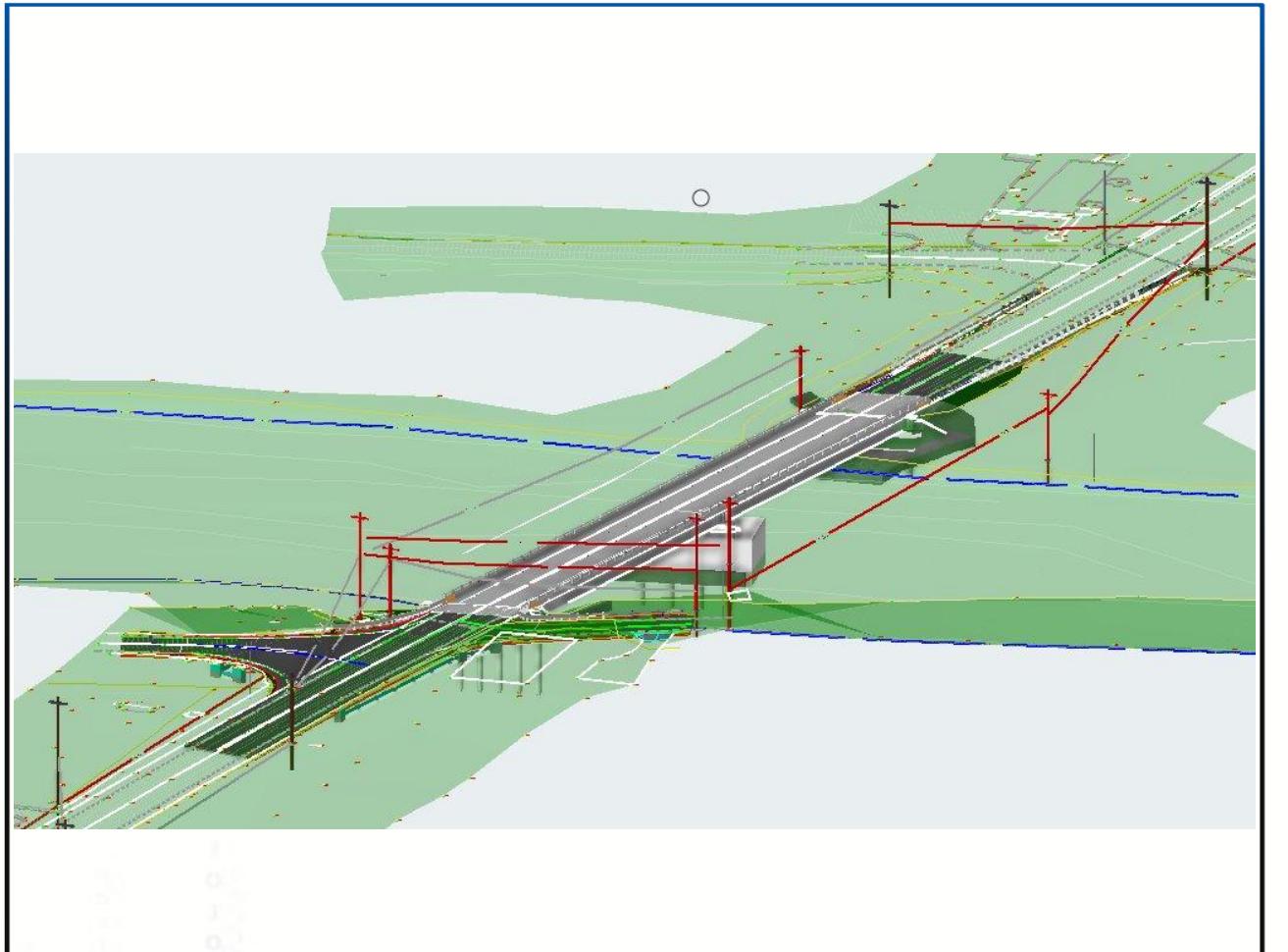
Cagin Yakar - Chief Executive Officer



PennDOT ADCMs Pilot Projects

US Route 6 French Creek Parkway

- 2-Span Steel Plate Girders
- Integral Abutments
- Lead Designer: Michael Baker Intl.



US R6 Over French Creek

Location Map – US Route 6 Bridge Over French Creek in Crawford County, PA



Existing Bridge – Steel Truss Structure Scheduled for Replacement

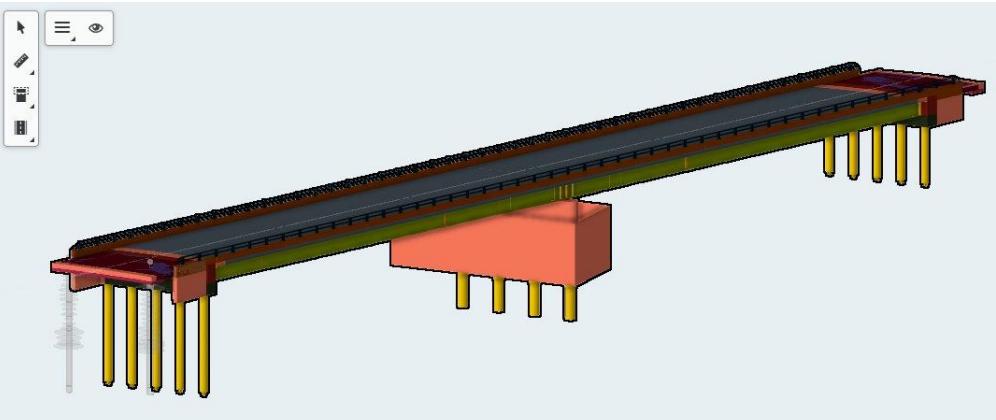


Design Strategy: Deliverables and Tools

Our deliverables include a federated model and supporting 2D plans.

Federated IFC Model

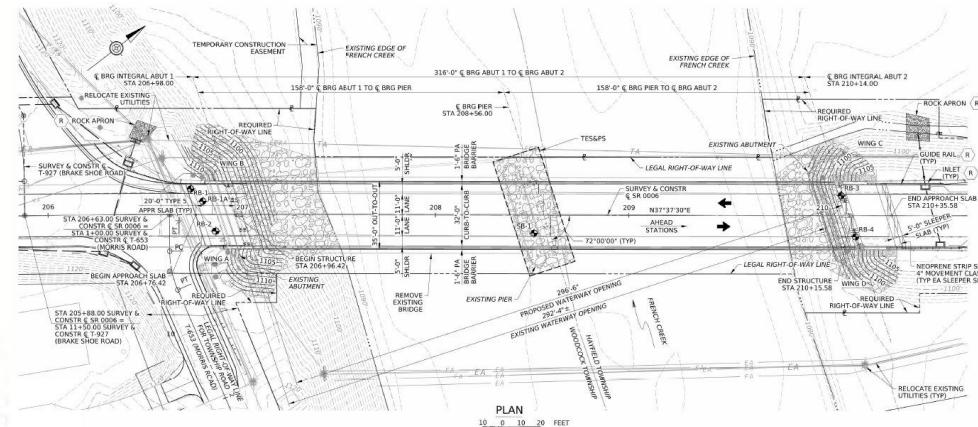
- OpenBrIM: Bridge geometry, materials, and detailed components
- Bentley OBM/Prostructures: Reinforcements



IFC Model

2D Plans

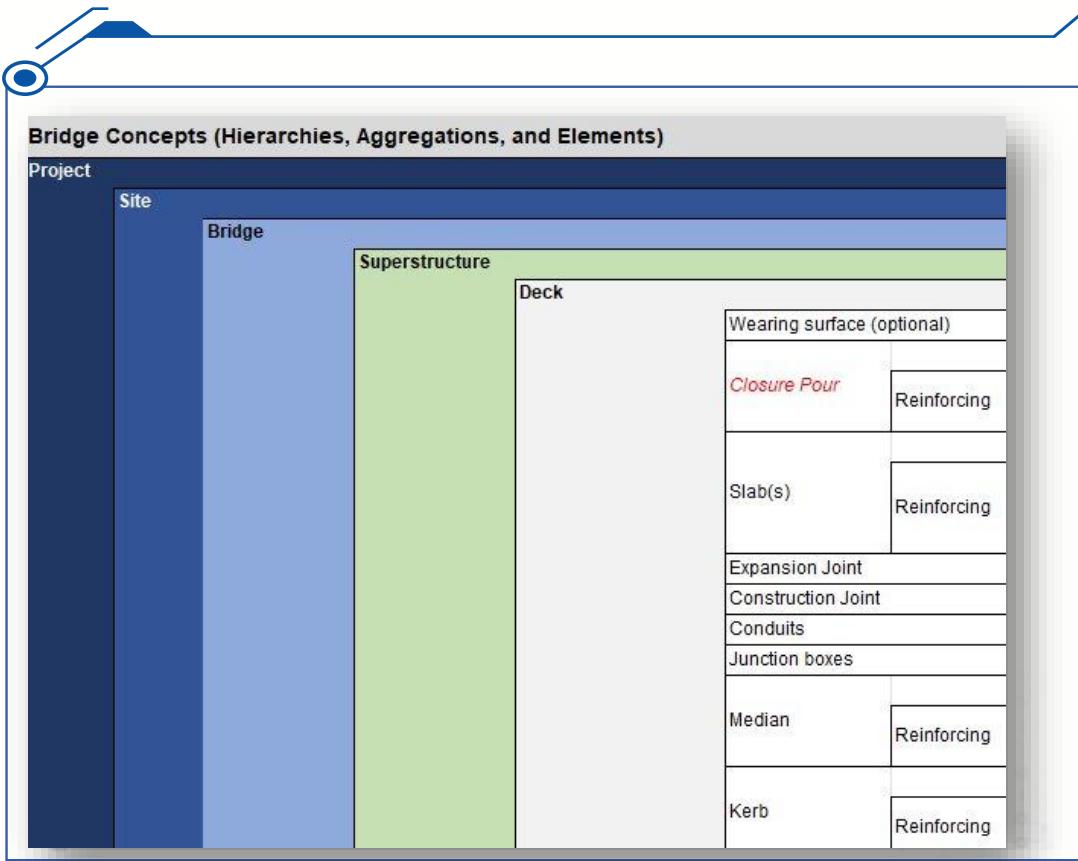
- Bentley OpenBridge Modeler and MicroStation: General notes, camber tables, detailed views, etc.



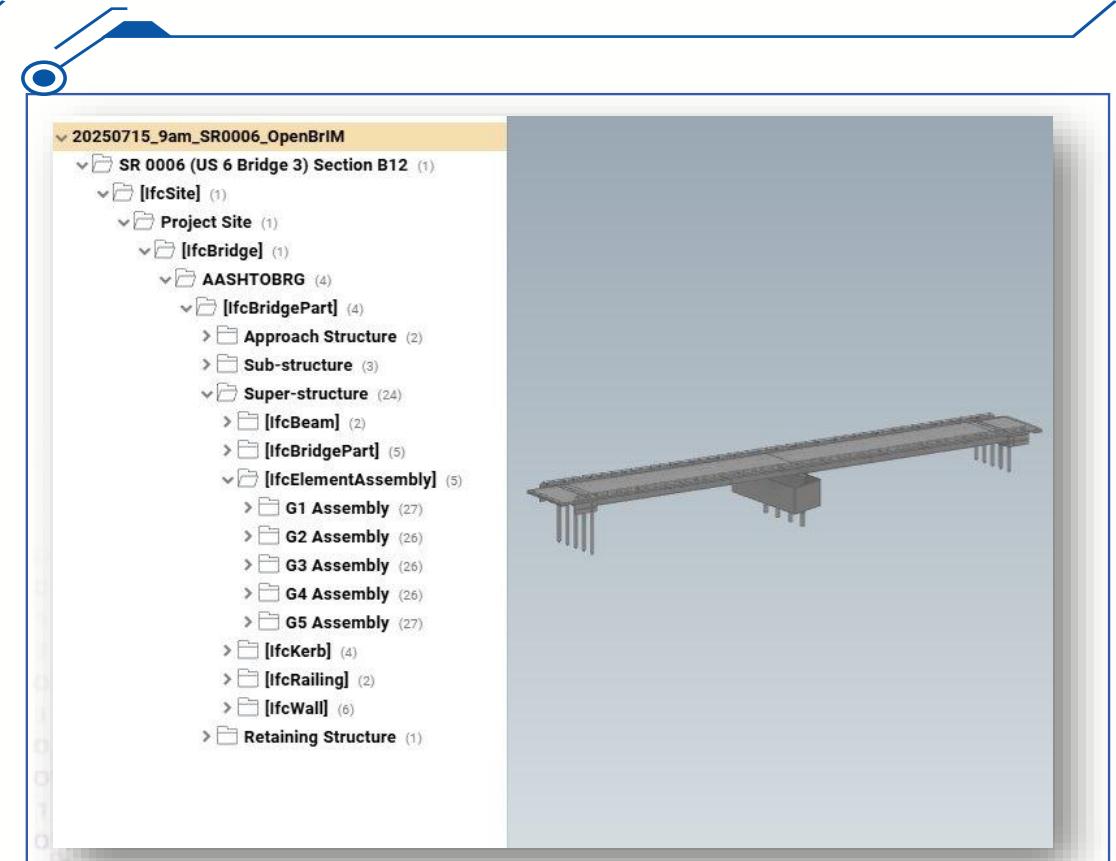
Supplemental 2D Plans

IFC Export: Entity Hierarchy

TPF-5(372), BIM for Bridges

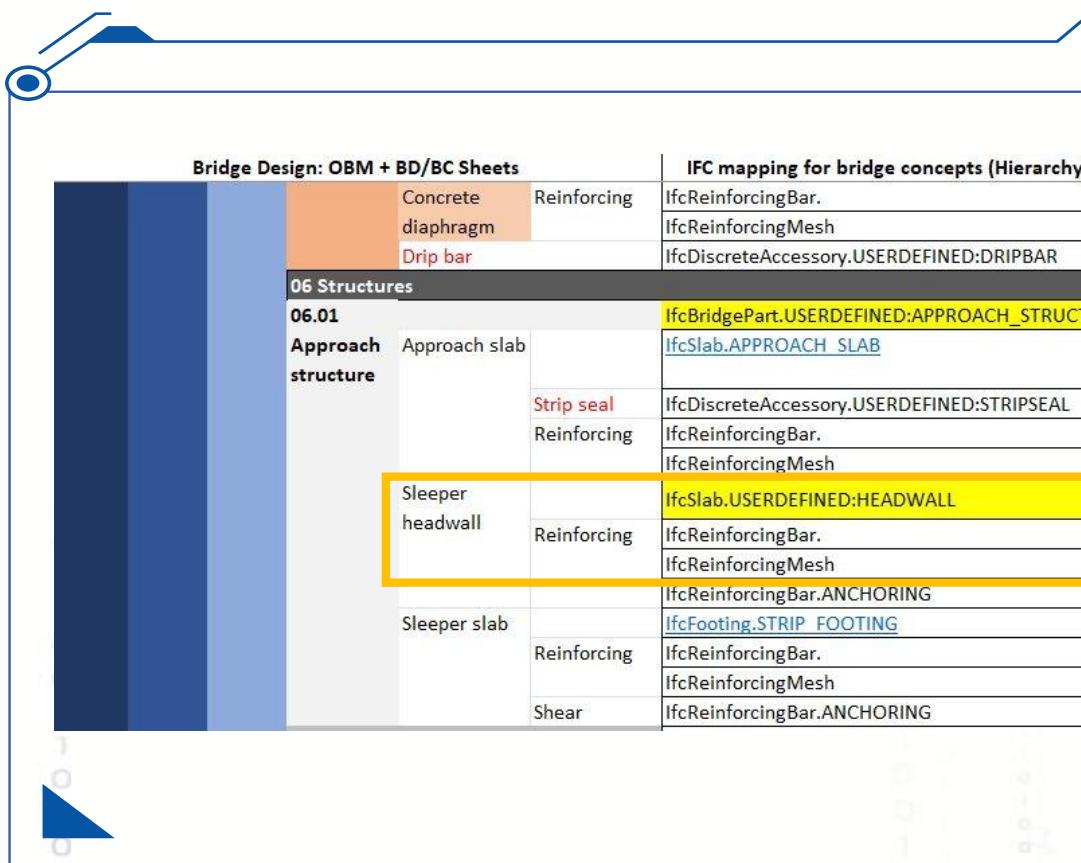


IFC Entity Hierarchy in Viewer



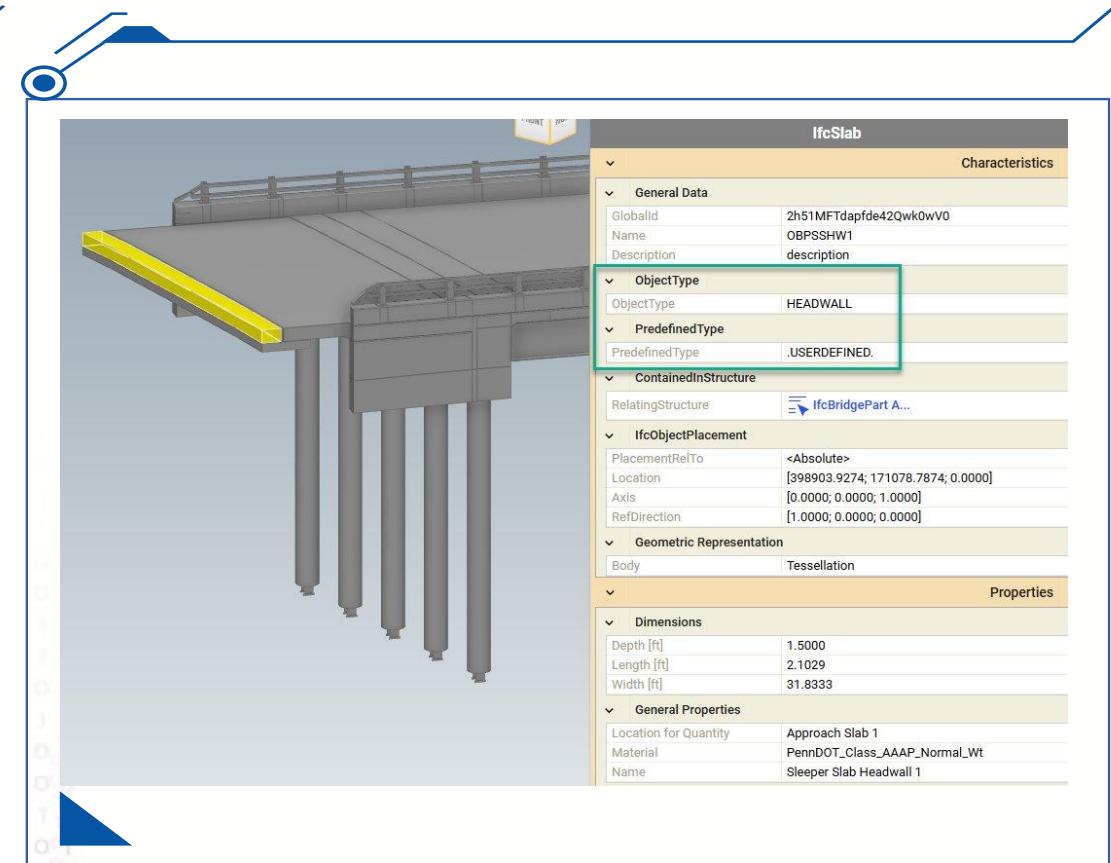
IFC Export: Entity Mapping

IFC Entity Mapping



Bridge Design: OBM + BD/BC Sheets		IFC mapping for bridge concepts (Hierarchy)	
Concrete diaphragm	Reinforcing	IfcReinforcingBar.	
Drip bar		IfcReinforcingMesh	
		IfcDiscreteAccessory.USERDEFINED:DRIPTBAR	
06 Structures			
06.01			IfcBridgePart.USERDEFINED:APPROACH_STRUCT
Approach structure	Approach slab		IfcSlab.APPROACH_SLAB
	Strip seal		IfcDiscreteAccessory.USERDEFINED:STRIPSEAL
	Reinforcing		IfcReinforcingBar.
Sleeper slab	Sleeper headwall		IfcReinforcingMesh
	Reinforcing		IfcSlab.USERDEFINED:HEADWALL
Sleeper slab	Reinforcing		IfcReinforcingBar.
			IfcReinforcingMesh
	Shear		IfcReinforcingBar.ANCHORING

IFC Entity for Sleeper Headwall



IfcSlab

Characteristics

General Data

- GlobalId: 2h51MFTdapfde42Qwk0wV0
- Name: OBPSHW1
- Description: description

Object Type

- Object Type: HEADWALL

Predefined Type

- Predefined Type: .USERDEFINED.

Contained in Structure

- Relating Structure: IfcBridgePart A...

Ifc Object Placement

- Placement Rel To: <Absolute> [398903.9274; 171078.7874; 0.0000]
- Location: [0.0000; 0.0000; 1.0000]
- Axis: [1.0000; 0.0000; 0.0000]
- Ref Direction: [0.0000; 0.0000; 0.0000]

Geometric Representation

- Body: Tessellation

Dimensions

- Depth [ft]: 1.5000
- Length [ft]: 2.1029
- Width [ft]: 31.8333

General Properties

- Location for Quantity: Approach Slab 1
- Material: PennDOT_Class_AAAP_Normal_Wt
- Name: Sleeper Slab Headwall 1

IFC Export: Defining Properties

We defined IFC Psets and properties in Excel, including metadata, IFC data mapping, source references, and value specifications.

Entity	Property Set	Property	Source	Value	Unit	IFC Entity	IFC Value Type
Bearing	General Properties	Connected by	IDM				
		Connected Elements	IDM				
		Description	IDM				
		Dimension	IDM				
		Identification	IDM				
		Location for Quantity	IDM, PennD	Abutment 1, 2, Pier 1		IfcBearing	IFCLABEL
		Material	IDM	Neoprene rubber 50 durometer		IfcBearing	IFCLABEL
		Quantity	IDM				
		Type	IDM, PennD	Elastomeric		IfcBearing	IFCLABEL
		Name	IDS	ELBRNG1		IfcBearing	IFCLABEL
Layout		Centerline of Bearing Offset from Horizontal Control Line (HCL) [ft]	IDM	15.5	ft	IfcBearing	IFCREAL
		Distance from Centerline of Bearing to Centerline of Support [ft]	IDM	0	ft	IfcBearing	IFCREAL
PennDOT_Bearing		Details/Notes	PennDOT	See 2D Details and Notes		IfcBearing	IFCLABEL
		NBI#	PennDOT	310		IfcBearing	IFCLABEL
		Applicable BC Standards	PennDOT	BC-755M		IfcBearing	IFCLABEL
		Element Detail Designation (EDD)	PennDOT	D-2		IfcBearing	IFCLABEL
		Element Information Designation (EID)	PennDOT	I-2		IfcBearing	IFCLABEL
		Fixity	PennDOT	Fixed		IfcBearing	IFCLABEL
PennDOT_BearingPayItem		Designation	PennDOT	None		IfcBearing	IFCLABEL
		ECMS Pay Item	PennDOT	(Part of LS 8120-0001)		IfcBearing	IFCLABEL
		Description	PennDOT	Laminated neoprene bearing p		IfcBearing	IFCLABEL
		Unit	PennDOT	Each		IfcBearing	IFCLABEL
		Note1	PennDOT	See approximate quantity tab		IfcBearing	IFCLABEL
		Note2	PennDOT	None		IfcBearing	IFCLABEL

Bridge Modeling: Overview

We used **OpenBrIM** to model and export the bridge to IFC.

- **Key Features**
 - Parametric modeling
 - Built-in IFC export based on IDM and IDS
- **Collaboration** with OpenBrIM developer:
 - Feature enhancements
 - Quick turnaround for IFC export improvements

IFC Delivery: OpenBrIM Vision

The software must support four key capabilities:

1. 3D Object Creation

- Rapid generation of 3D objects
- Minimal manual effort required

2. Hierarchy

- Structured representation of bridge components

3. Full Coverage of IFC Entities

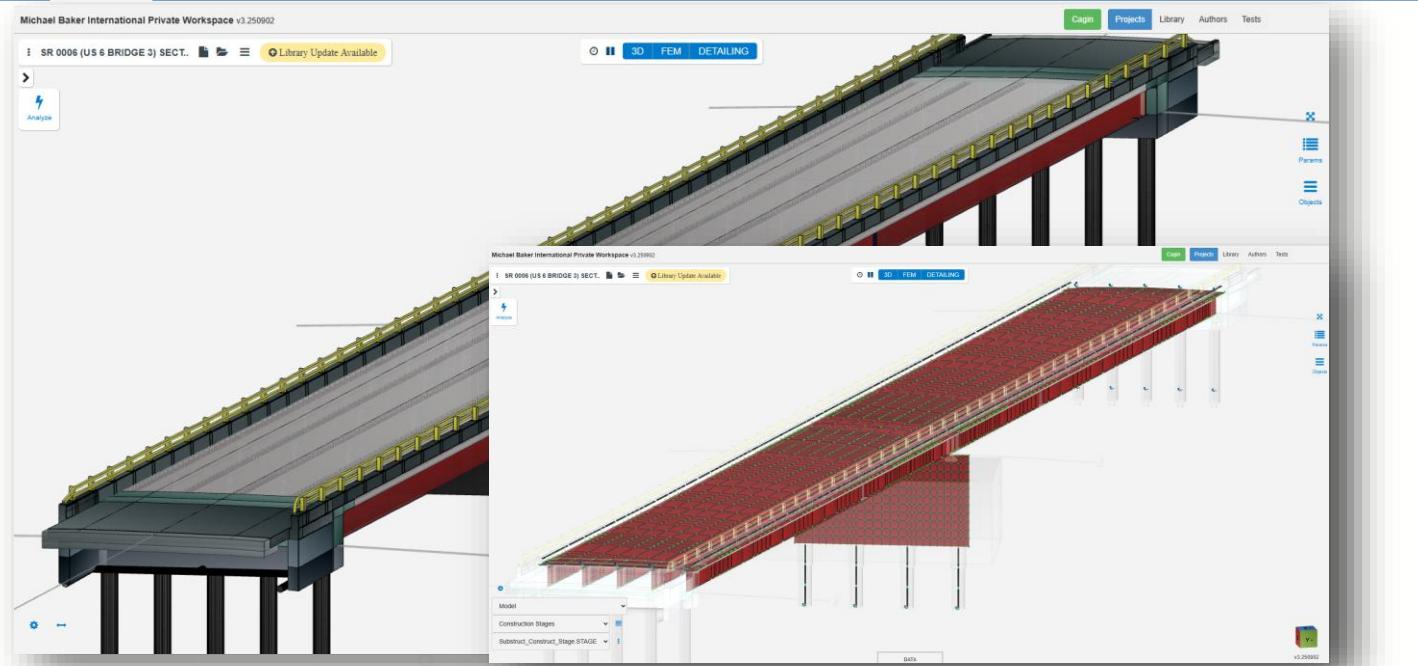
- Support for all entity types defined in IFC

4. Properties

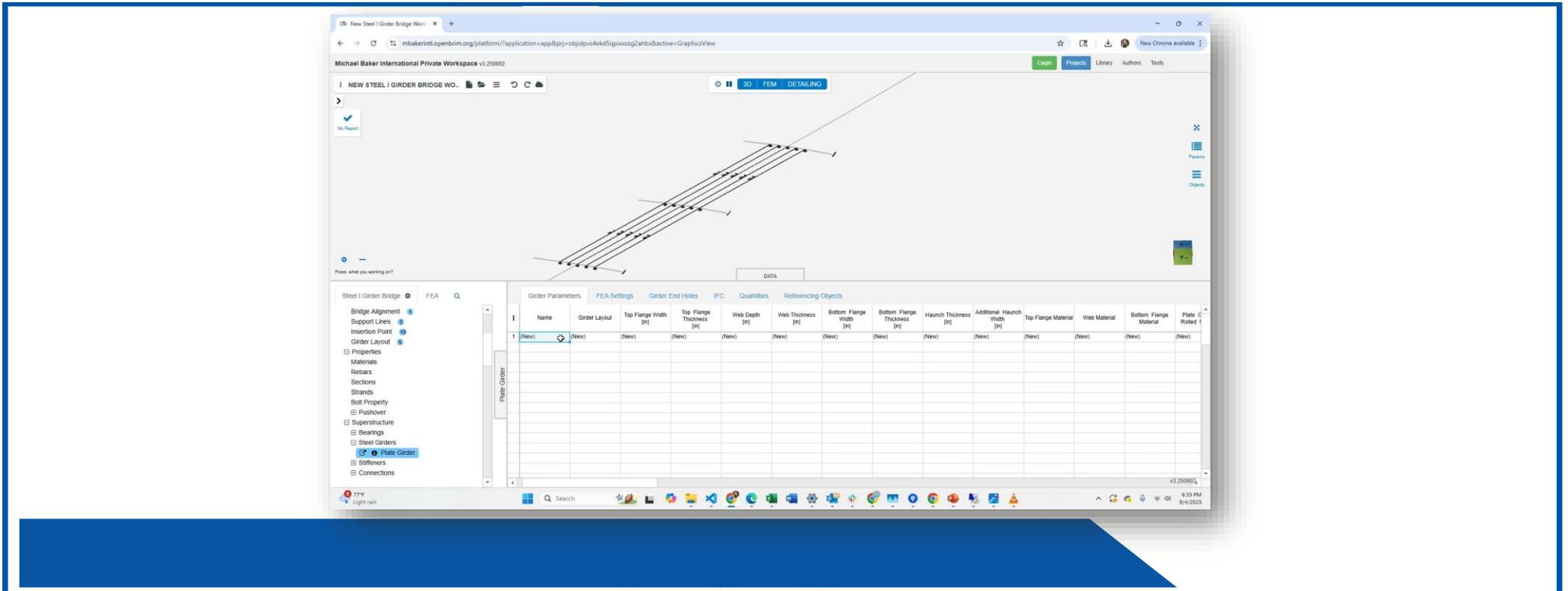
- Easy entry and management of property sets

OpenBrIM Platform

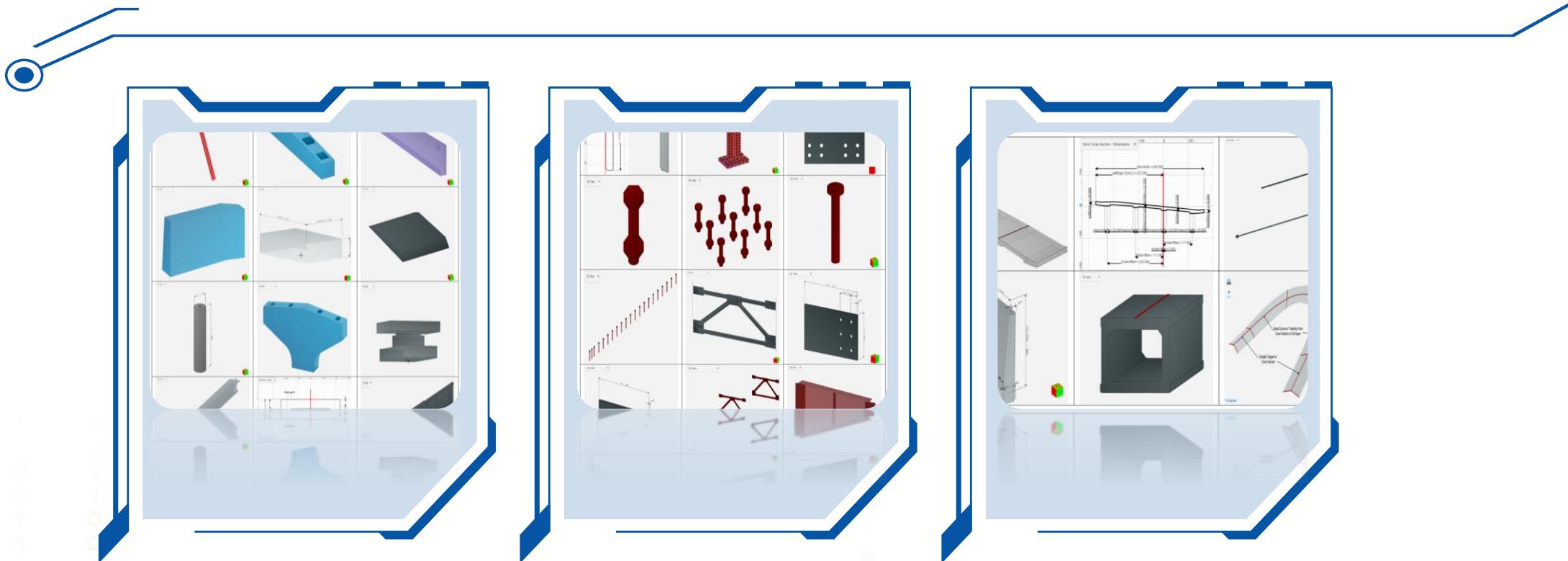
- Cloud-based, browser-accessible
- Integrated capabilities:
 - 3D modeling
 - Finite Element Analysis
 - Soil-structure interaction
 - AASHTO spec checks
 - Load rating
 - Quantities



Parametric Modeling in Action



OPENBRIM LIBRARY: BRIDGE ENGINEER'S FUNCTION CONTAINER

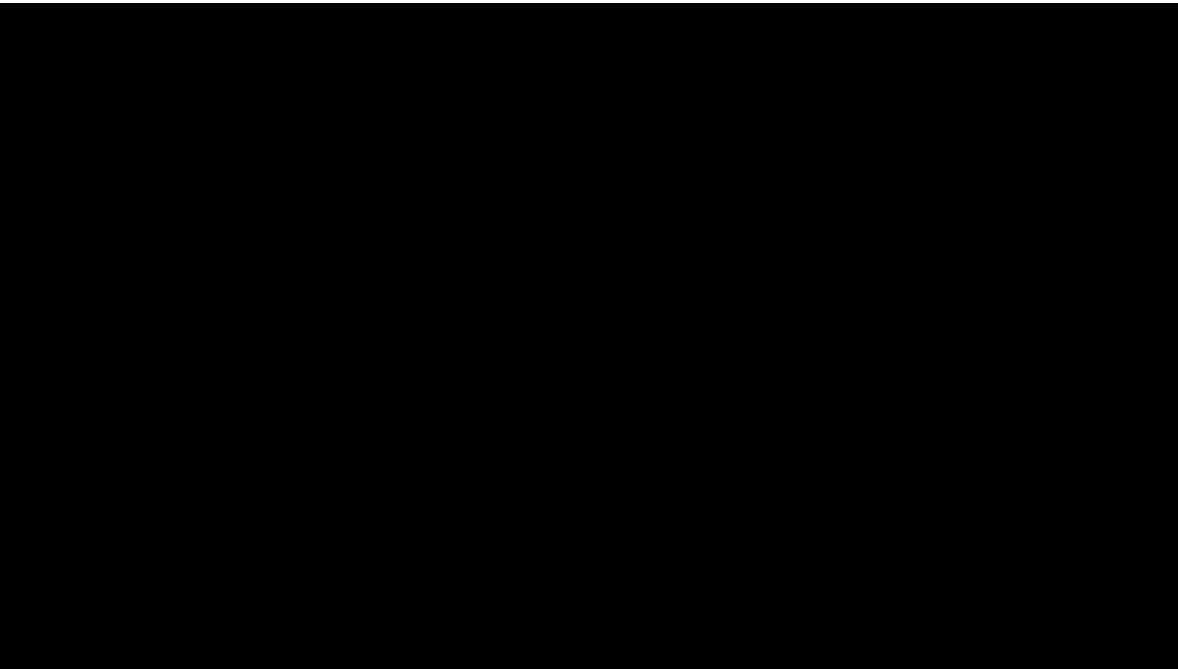


Transparent parametric dependencies

Customizable dependencies according to different project and company requirements

Reusable and modular way to define parametric relationships

OPENBRIM LIBRARY: BRIDGE ENGINEER'S FUNCTION CONTAINER

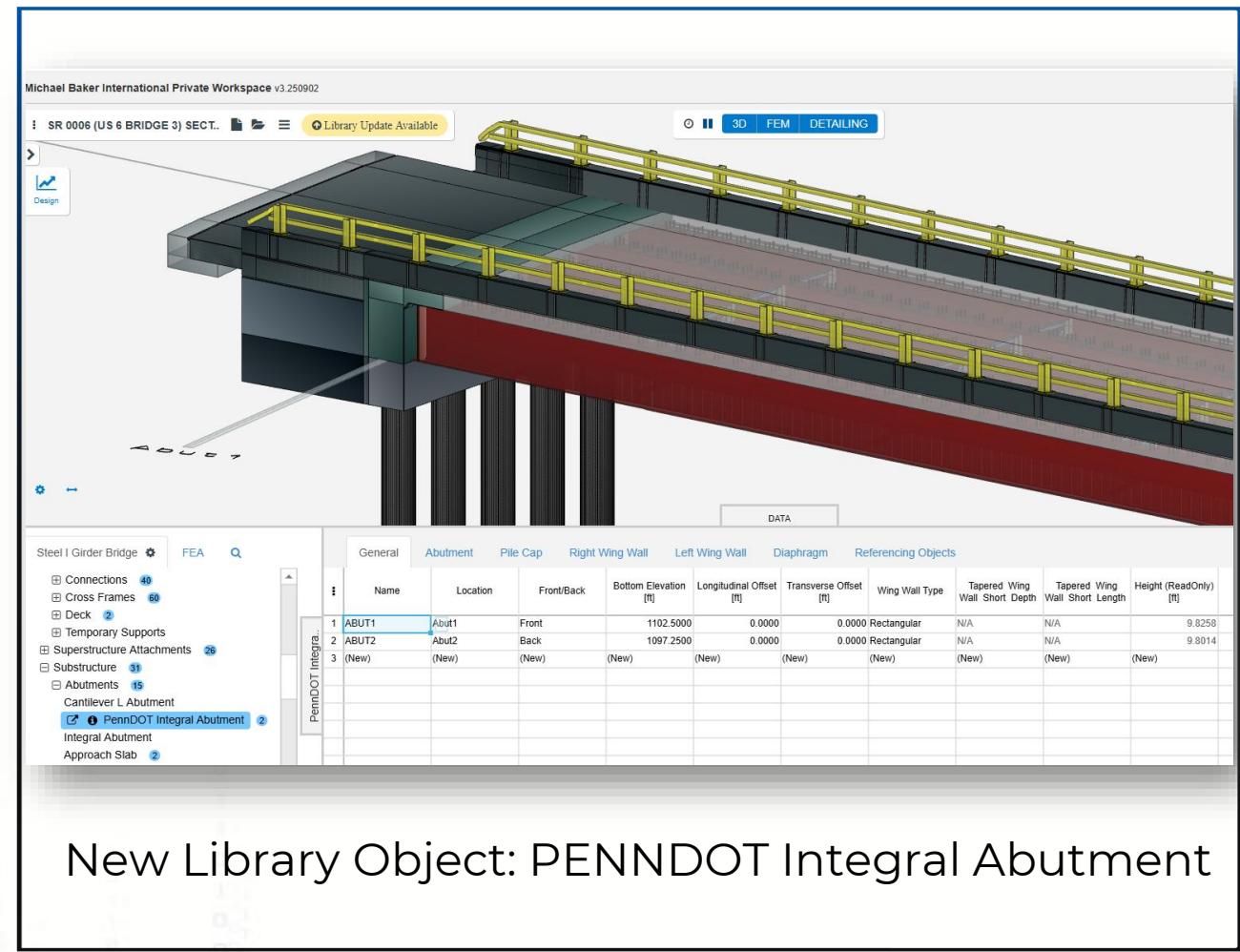


Parametric Bridge Library



Expanding the Open-Source Library

- Gaps in existing parametric library discovered during project
- New components created for SR6-B12
- Contribution back to open source for future projects



IFC Delivery: OpenBrIM Vision

Based on U.S. standards (currently TPF-5(372) BIM for Bridges)

- Predefined **Entities** for each bridge object
- Predefined **Hierarchy** for each bridge object

The image shows a screenshot of the OpenBrIM software interface. On the left, there is a navigation tree for a 'Steel I Girder Bridge' project. The tree includes categories like Girder Layout, Properties, Superstructure, Superstructure Attachments, Substructure, Abutments, End/Interior Bent, Pier, Foundation, and various footing options. 'Rectangular Footing' is currently selected. On the right, there is a table titled 'Rectangular Foo...' with columns for Footing, FEM, Flexural Reinforcements, Shear Reinforcements, Side Reinforcements, and IFC. The table lists seven rows of data for rectangular footings, each with a 'Name' (RF1 to RF6, plus a new entry), 'Type' (fcFooting), 'Predefined Type' (FOOTING), and 'Parent' (BRIDGE). The 'Properties' column contains a 'New' button for each row.

	Footing	FEM	Flexural Reinforcements	Shear Reinforcements	Side Reinforcements	IFC
1	RF1	fcFooting	FOOTING	BRIDGE		
2	RF2	fcFooting	FOOTING	BRIDGE		
3	RF3	fcFooting	FOOTING	BRIDGE		
4	RF4	fcFooting	FOOTING	BRIDGE		
5	RF5	fcFooting	FOOTING	BRIDGE		
6	RF6	fcFooting	FOOTING	BRIDGE		
7	(New)	(New)	(New)	(New)		

IFC Delivery: OpenBrIM Vision

Property Standards

Baseline Standard – AASHTO IDM

- Core property definitions for U.S. transportation projects
- Defines common parameters across agencies

State-Specific Parameters

- Each DOT may extend or adjust IDM
- Local standards/specifications drive these properties

BuildingSMART / IFC Global Parameters

- Ensures compatibility across software platforms

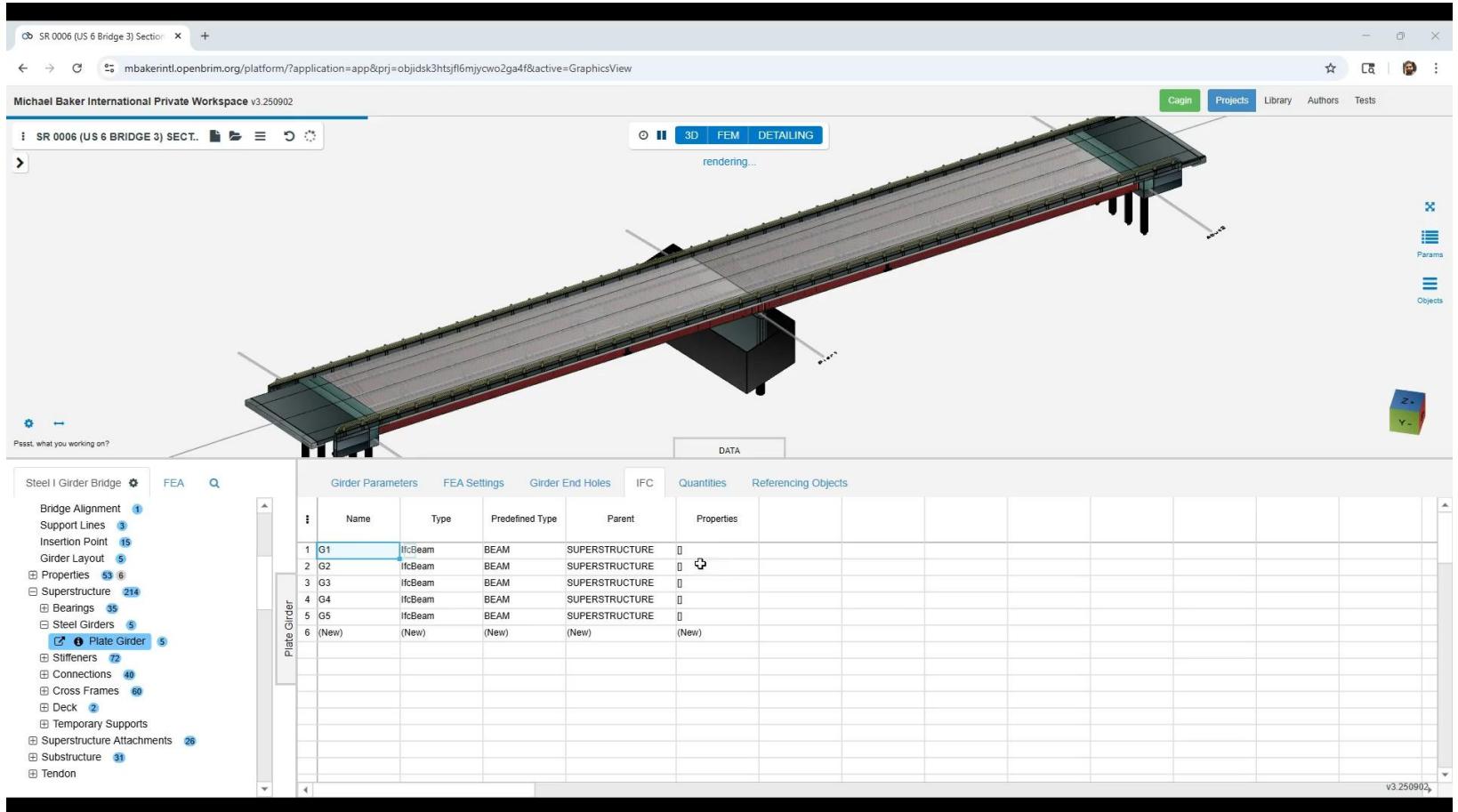
Project-Specific Requirements

- Unique parameters requested by owners, contractors, or fabricators

OpenBrIM Implementation

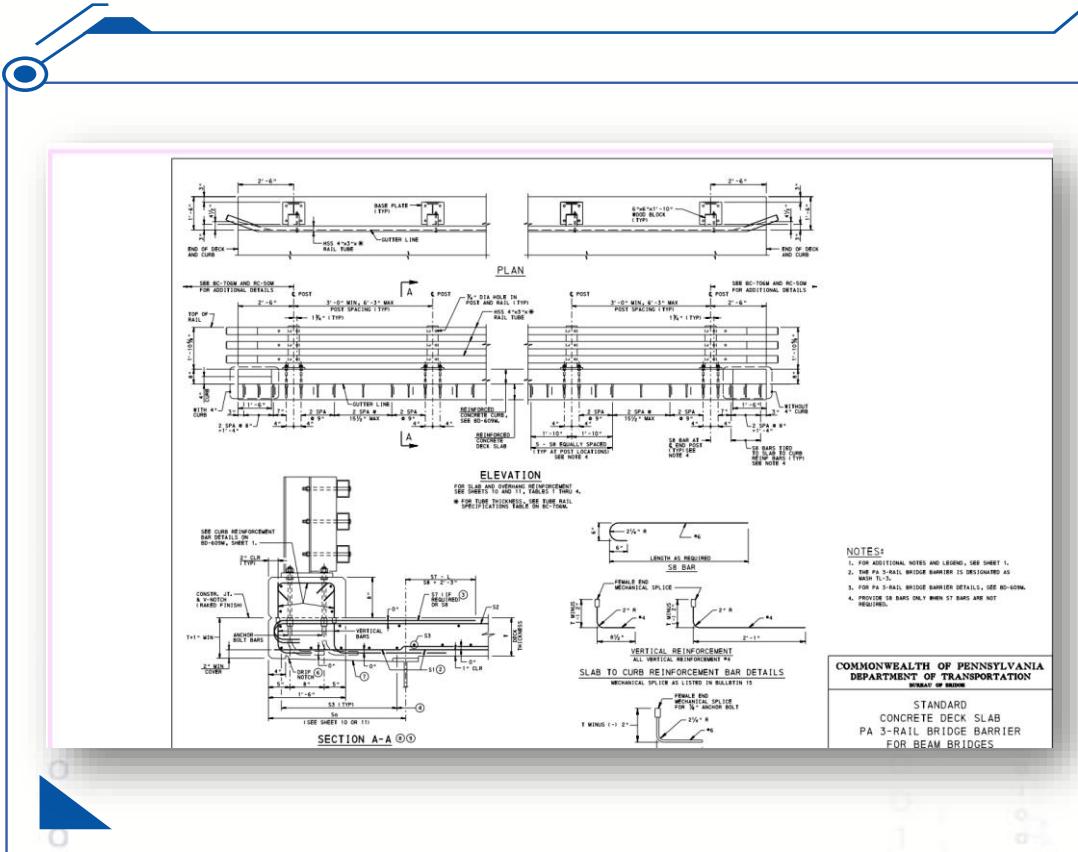
- Assign parameters easily (Excel-style references)
- Define parametric relationships to support change management
- Customize parameters flexibly
- Import predefined parameters quickly from the library

IFC Delivery: OpenBrIM Vision



Reimagining Standard Drawings as Parametric 3D IFC Objects

Current Practice (DOT Standard Contracts)



Proposed Future

- Same concept, but in **parametric 3D**
- Each typical drawing → **a parametric 3D object – open source**
- Direct export to **IFC 3D**
- Machine-readable, reusable, contract-compliant
- Collaboration Framework (if agencies provide funding):
 - Consultants (e.g., Michael Baker): Quality Control (QC)
 - Technology Providers (e.g., OpenBrIM): Coding and Implementation

Finding the Right Software Partner for Digital Delivery

The Reality Today

- Agencies and consultants expect “magic software” to solve all problems.
- Even project engineers may lack clarity on the exact requirements.
- Standards are still evolving and incomplete.
- IFC/IDS specifications are still under development.
- Project deliverables are frequently vague or inconsistently defined.

What to Look For

- Don’t just evaluate software features.
- Choose a **partner**, not just a vendor.
- Seek a team experienced with real bridge projects.
- Work with people who can help navigate unknowns and adapt as standards mature.
- A partner that applies agile development practices.
- A platform designed for rapid iteration and continuous improvement.

How We Actually Delivered the First Contractual IFC Bridge Project in the US



Live Support through Slack

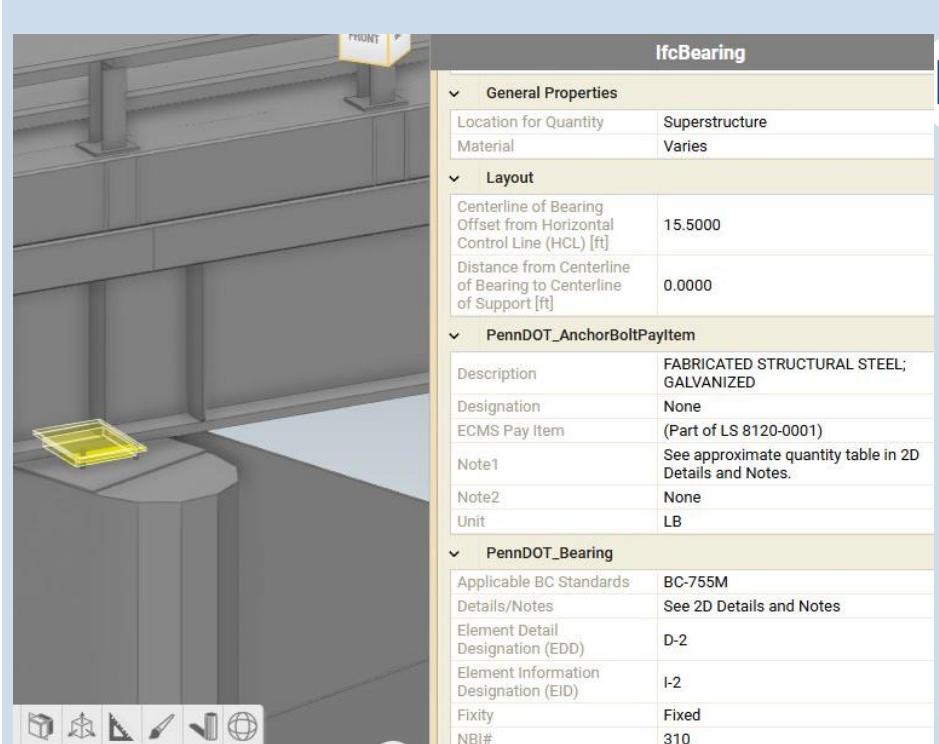
Rapid Continuous Iterations

Contents

OpenBIM Outstanding Requests.....	1
Top priority.....	3
1. Approach slab cross slope (ISS-00037).....	3
2. Cross frame station and flipping side.....	6
Critical.....	7
1. Anchor bolts in the bearing top plate (ISS-00019).....	7
2. Material for pedestal (ISS-00021).....	10
3. Chamfer @ Abutment Diaphragm (ISS-00060).....	11
4. Materials for bolt, nut, and washer.....	13
5. Barrier railing end – Follow up.....	14
6. Slope of top surface of pile cap (bearing seat).....	16
7. Cross frame stiffener must extend full height of web.....	18
8. Gap in abutment diaphragm and barrier.....	19
9. Shear Connector head diameter and thickness.....	20
Nice to have.....	22
1. 6" Structure Foundation Drain (ISS-00047) - TODO.....	22
2. Jacking inserts (ISS-00058) - TODO.....	23
3. Nut and washer in field splice.....	23
Investigate only if everything else is done.....	24
IFC Mapping.....	25
High Priority.....	25
1. Shear connector studs are not being exported.....	25
2. Properties need to be exported to IFC.....	26
3. IFC mapping.....	27
4. Drip bar and temporary shoring IFC export.....	28
5. Pedestal.....	29
6. Bearing properties (ISS-00020).....	30

IFC Export: Reviewing Properties

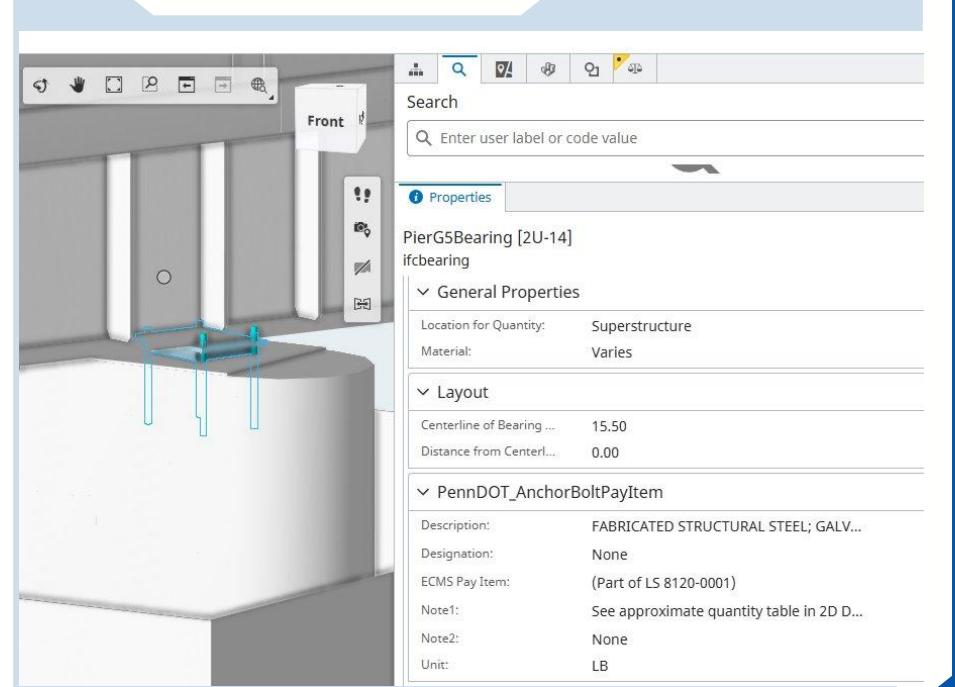
We verified the IFC properties using **IFC viewers** and **Infrastructure Cloud** to ensure accuracy and completeness.



IFC Properties for Bearing (IFC viewers)

IfcBearing

- General Properties**
 - Location for Quantity: Superstructure
 - Material: Varies
- Layout**
 - Centerline of Bearing Offset from Horizontal Control Line (HCL) [ft]: 15.5000
 - Distance from Centerline of Bearing to Centerline of Support [ft]: 0.0000
- PennDOT_AnchorBoltPayItem**
 - Description: FABRICATED STRUCTURAL STEEL; GALVANIZED
 - Designation: None
 - ECMS Pay Item: (Part of LS 8120-0001)
 - Note1: See approximate quantity table in 2D Details and Notes.
 - Note2: None
 - Unit: LB
- PennDOT_Bearing**
 - Applicable BC Standards: BC-755M
 - Details/Notes: See 2D Details and Notes
 - Element Detail Designation (EDD): D-2
 - Element Information Designation (EID): I-2
 - Fixity: Fixed
 - NBI#: 310



IFC Properties for Bearing (Infrastructure Cloud)

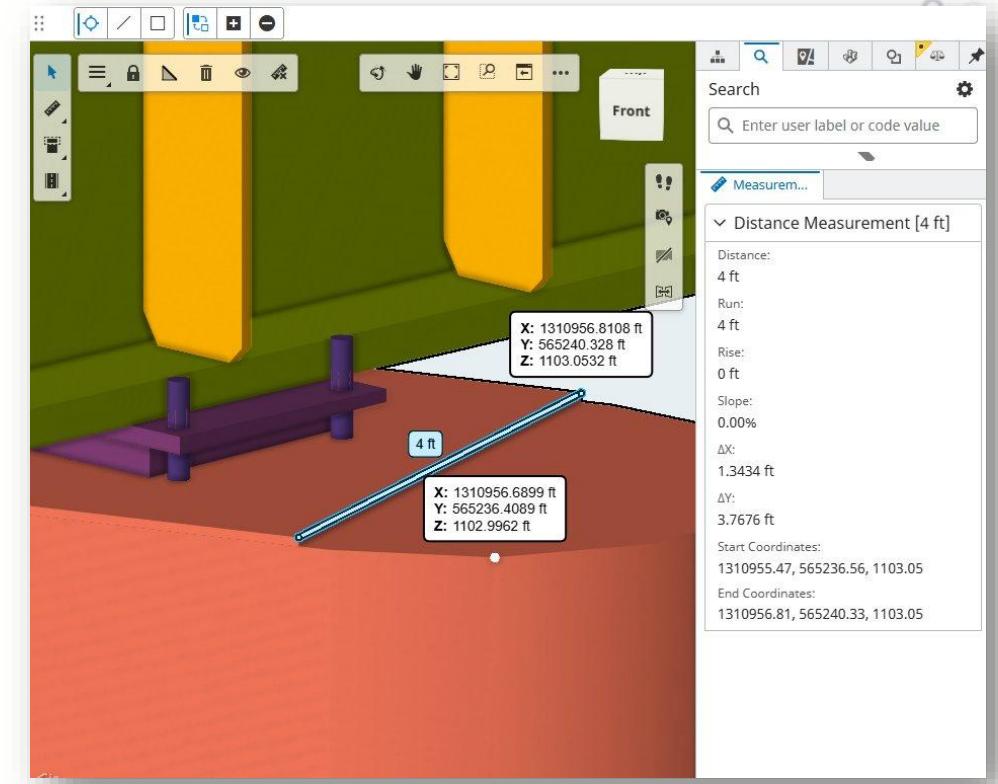
PierGSBearing [2U-14]
ifcbearing

- General Properties**
 - Location for Quantity: Superstructure
 - Material: Varies
- Layout**
 - Centerline of Bearing ...: 15.50
 - Distance from Centerl...: 0.00
- PennDOT_AnchorBoltPayItem**
 - Description: FABRICATED STRUCTURAL STEEL; GALV...
 - Designation: None
 - ECMS Pay Item: (Part of LS 8120-0001)
 - Note1: See approximate quantity table in 2D D...
 - Note2: None
 - Unit: LB

Review: QA/QC Using Infrastructure Cloud

Review Contents

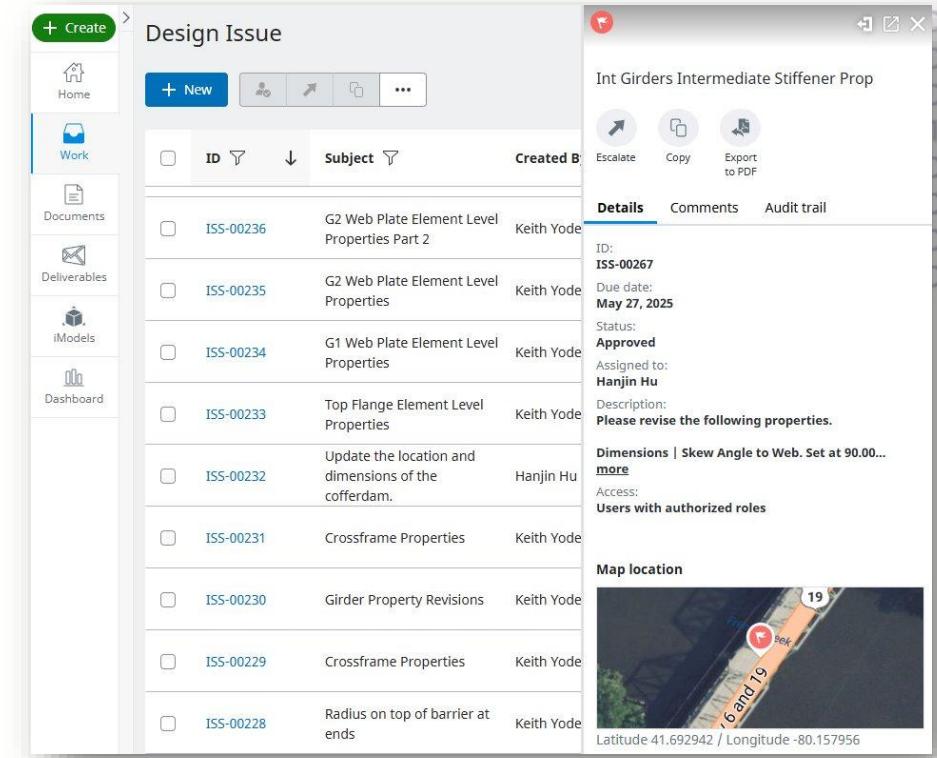
- **Geometry:** Roadway and bridge stationing and elevation
- **Locations:** Placement of bearings, cross frames, and key elements
- **Dimensions:** Girder sizes and section transitions
- **Studs and bolts:** Shear stud and splice bolt counts and spacing
- **Details:** Curb transitions, v-notches, jacking holes
- **IFC properties:** Materials and PennDOT items



Review: Issue Documentation in Infrastructure Cloud

Issue Logging

- Reviewers documented issues directly in the platform.
- Each issue entry included:
 - Descriptive comments
 - Precise location references
 - Annotated screenshots for visual clarity
- Issues were assigned to designers, triggering notifications for action.
- After addressing each issue, designers reassigned it to the original reviewer for backcheck and confirmation.



The screenshot shows the Infrastructure Cloud interface. On the left, a sidebar lists 'Home', 'Work' (selected), 'Documents', 'Deliverables', 'iModels', and 'Dashboard'. The main area is titled 'Design Issue' with a sub-tab 'New'. A table lists issues with columns for 'ID', 'Subject', 'Created By', and 'Last Modified'. The first issue is 'ISS-00236: G2 Web Plate Element Level Properties Part 2' by Keith Yode. The right side shows a detailed view of 'ISS-00267: Int Girders Intermediate Stiffener Prop' by Hanjin Hu. It includes fields for ID, Due date (May 27, 2025), Status (Approved), Assigned to (Hanjin Hu), and Description (Please revise the following properties). It also shows a 'Dimensions' section, 'Access' (Users with authorized roles), and a 'Map location' with a coordinate overlay.

Issue Documented in Infrastructure Cloud

Review: Issue Summary and Tracking using Excel

Summary and Tracking:

- Documented which components were reviewed and by whom.
- Tracked **issue ownership**: who identified, addressed, and backchecked each item.
- Recorded **timestamps** for each stage of issue resolution.
- Maintained **status updates** and reviewer **comments** for transparency and follow-up.

A	B	C	D	E
1	Bridge #: US Route 6 French Creek Parkway			
5	Element	Criteria	(Initials and Date)	Checked By (Initials and Date)
6	Element Definitions	Elements on correct Feature Definitions/Element Templates/IFC Classifications per PennDOT Recommended Digital Delivery Guides	HH	KMY - Various Dates
9		Horizontal and vertical alignments in 3D model match the roadway geometry	HH	KMY 3/17/25
10	Stations & Elevations	Begin/End of Bridge Stations	HH	KMY 3/14/25
11		Abutment - C/L Bearing Stations	HH	KMY 3/14/25
12		Pier - C/L Bearing Station	HH	KMY 3/14/25
13		Begin/End Approach Slab Stations	HH	KMY 3/14/25
14		Begin/End Header Slab Stations	HH	KMY 3/14/25
16	Deck	Lane widths	HH	RMS 2/19/25
17		Shoulder widths	HH	RMS 2/19/25
19		Outside barrier widths	HH	RMS 2/19/25
20		Increased Thickness of Overhangs	HH	KMY 6-6-25
21		Width of Bridge (Provide min-max range where variable width is present)	HH	RMS 2/19/25

Issue Summary and Tracking with Excel

Validation: bSI Validation Service

To verify IFC file quality and compliance, we used the bSI Validation Service to check syntax, schema rules, normative standards, and industry practices.

bSI Validation Service Dashboard

File Name	STEP Syntax	IFC Schema	Normative IFC Rules	Industry Practices
20250718_4pm_SR0006_OpenBrIM.ifc	✓	✓	✓	✓
20250715_9am_SR0006_OpenBrIM.ifc	✓	✓	✓	✓
20250710_1pm_SR0006_OpenBrIM.ifc	✓	✓	!	⚠
20250617_10am_SR0006_OpenBrIM.ifc	✓	✓	✓	✓
20250612_9am_SR0006_OpenBrIM.ifc	✓	✓	✓	✓

Sample Validation Warning

File Name in Header	20250710_1pm_SR0006_OpenBrIM.ifc
File Name	20250710_1pm_SR0006_OpenBrIM.ifc
File Size	59.69 MB
File Date	2025-07-10T17:19:06.636Z
Industry Practices	<input type="checkbox"/> include Passed, Disabled and N

GRF002 - EPSG Code In Coordinate Reference System (occurred 1 time)

The rule verifies that the name of the coordinate reference system refers to a valid EPSG code from the official EPSG geodetic parameter dataset. EPSG code validation is performed using the pyproj library, which includes a local copy of the official EPSG dataset (<https://epsg.org>) maintained by IOGP. <https://pyproj4.github.io/pyproj/stable/api/database.html>

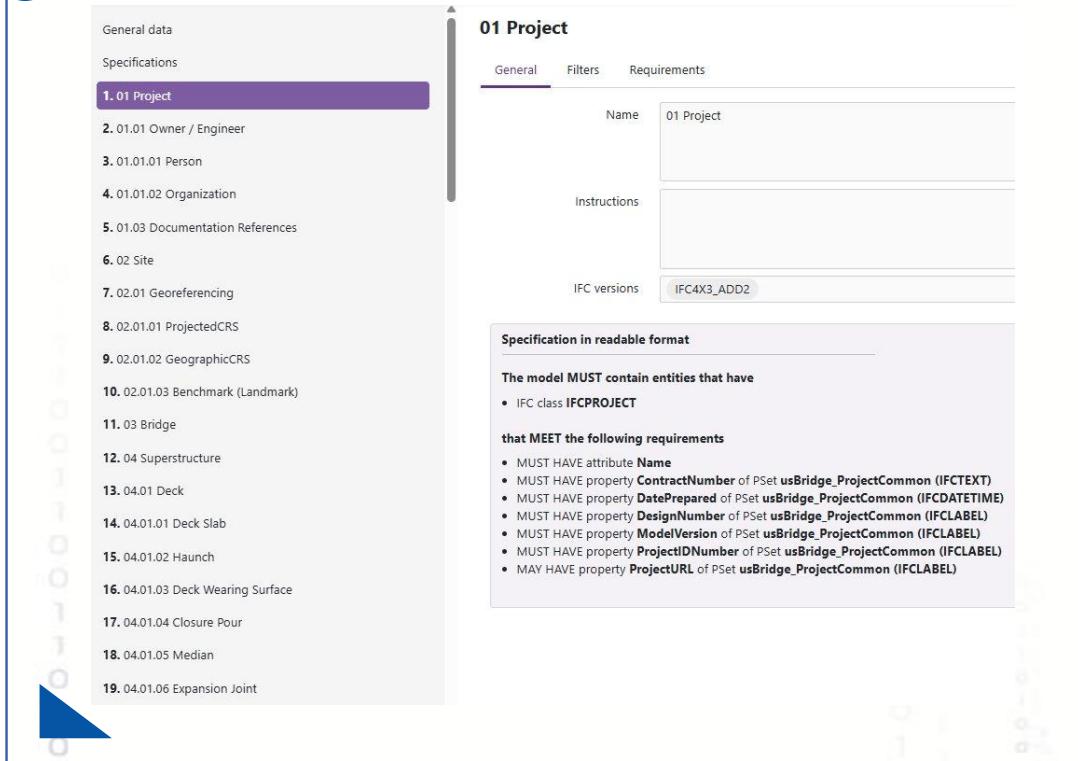
https://github.com/buildingSMART/ifc-gherkin-rules/blob/main/features/rules/GRF/GRF002_EPSG-code-in-coordinate-reference-system.feature

Severity	Id	Entity	Expected	Observed
Warning	#36	IfcProjectedCRS	The value must refer to a valid EPSG code	PA_North_83GC5_2011

Validation: bSI Validation Service

To verify the IFC model against specific data requirements for bridge design handover, we used an IDS developed for TPF-5(372), BIM for Bridges.

IDS Snippet



General data
Specifications
1. 01 Project
2. 01.01 Owner / Engineer
3. 01.01.01 Person
4. 01.01.02 Organization
5. 01.03 Documentation References
6. 02 Site
7. 02.01 Georeferencing
8. 02.01.01 ProjectedCRS
9. 02.01.02 GeographicCRS
10. 02.01.03 Benchmark (Landmark)
11. 03 Bridge
12. 04 Superstructure
13. 04.01 Deck
14. 04.01.01 Deck Slab
15. 04.01.02 Haunch
16. 04.01.03 Deck Wearing Surface
17. 04.01.04 Closure Pour
18. 04.01.05 Median
19. 04.01.06 Expansion Joint

01 Project

General Filters Requirements

Name: 01 Project

Instructions

IFC versions: IFC4X3_ADD2

Specification in readable format

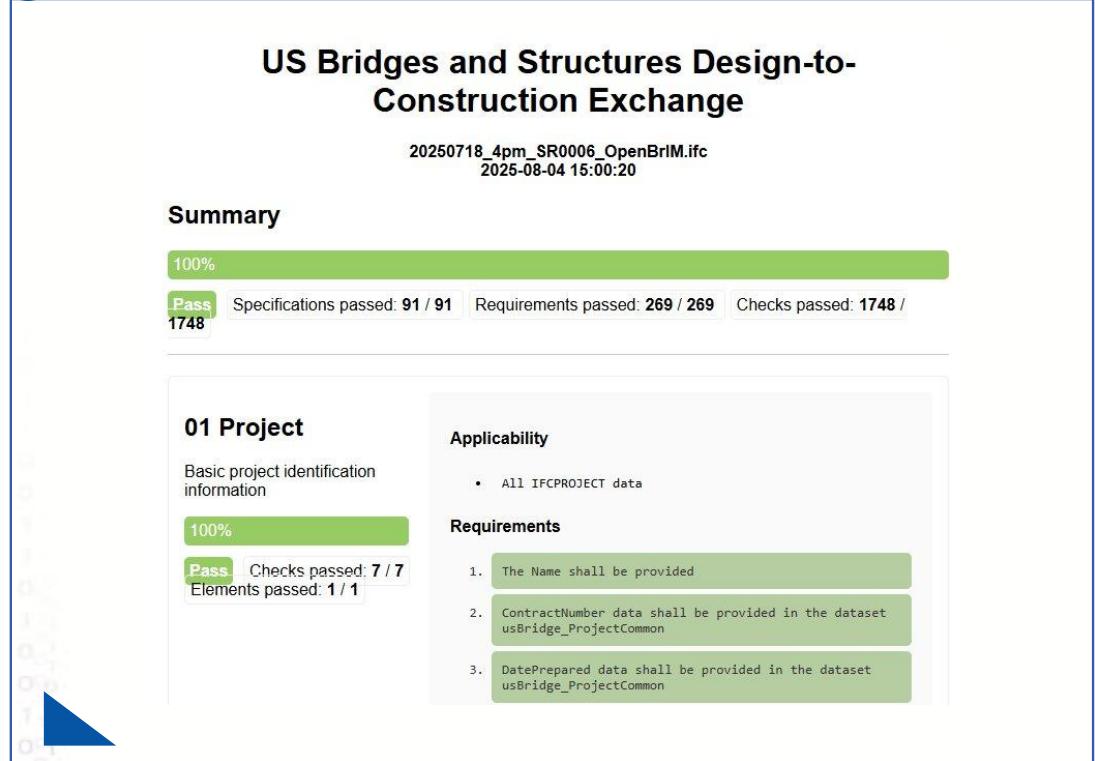
The model **MUST** contain entities that have

- IFC class **IFCPROJECT**

that **MEET** the following requirements

- **MUST HAVE** attribute **Name**
- **MUST HAVE** property **ContractNumber** of PSet **usBridge_ProjectCommon** (IFCTEXT)
- **MUST HAVE** property **DatePrepared** of PSet **usBridge_ProjectCommon** (IFCDATETIME)
- **MUST HAVE** property **DesignNumber** of PSet **usBridge_ProjectCommon** (IFCLABEL)
- **MUST HAVE** property **ModelVersion** of PSet **usBridge_ProjectCommon** (IFCLABEL)
- **MUST HAVE** property **ProjectIDNumber** of PSet **usBridge_ProjectCommon** (IFCLABEL)
- **MAY HAVE** property **ProjectURL** of PSet **usBridge_ProjectCommon** (IFCLABEL)

IDS Validation Results



US Bridges and Structures Design-to-Construction Exchange

20250718_4pm_SR0006_OpenBrIM.ifc
2025-08-04 15:00:20

Summary

100%

Pass Specifications passed: 91 / 91 Requirements passed: 269 / 269 Checks passed: 1748 / 1748

01 Project

Basic project identification information

100%

Pass Checks passed: 7 / 7 Elements passed: 1 / 1

Applicability

- All IFCPROJECT data

Requirements

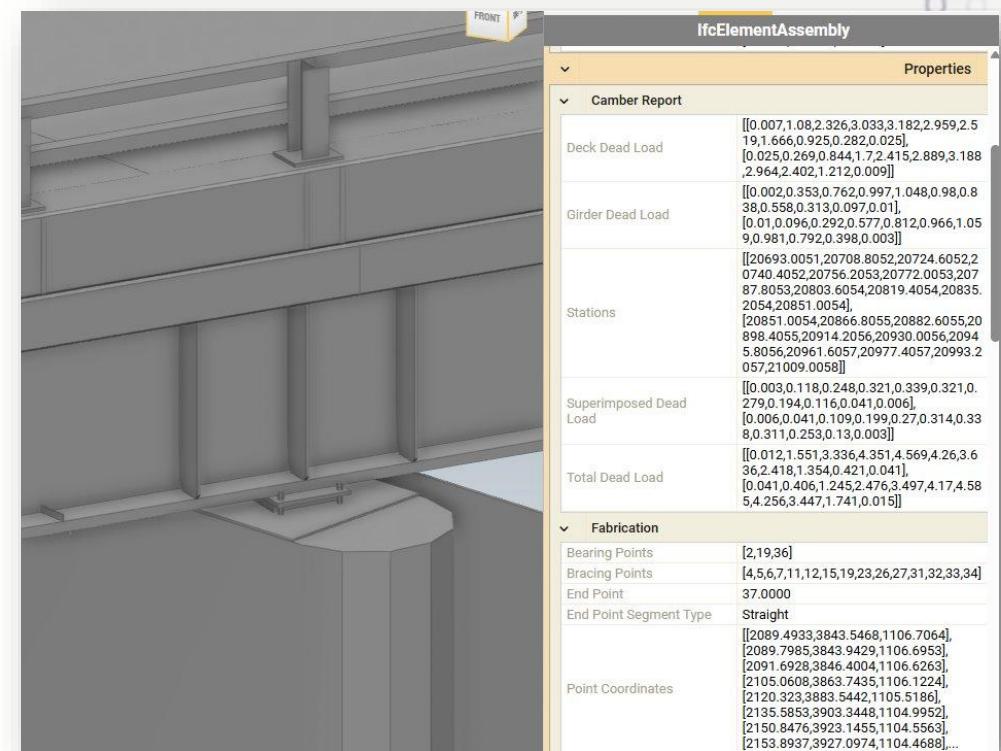
1. The Name shall be provided
2. ContractNumber data shall be provided in the dataset usBridge_ProjectCommon
3. DatePrepared data shall be provided in the dataset usBridge_ProjectCommon

Downstream Use Case: Data for Fabricator

To support fabrication, key data were embedded in the IFC model based on fabricator requirements.

Data Provided

- Control point coordinates
- Camber values
- Girder transitions
- Additional fabrication details



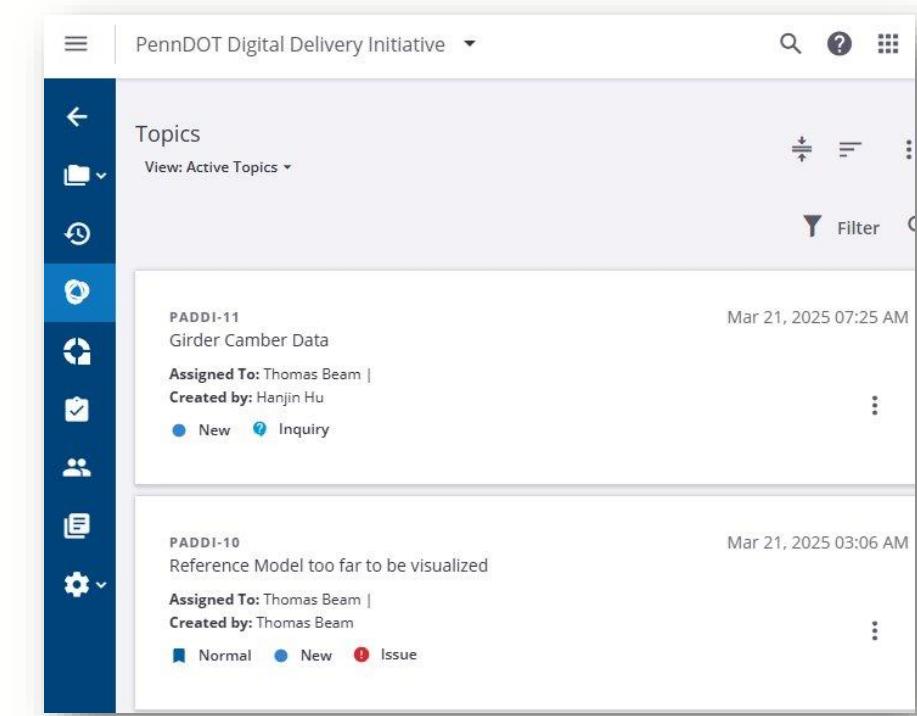
IFC Properties for Fabricators

Downstream Use Case: Communication

Coordination with fabricator was managed through Trimble Connect using BCF for issue tracking and resolution.

Communication

- **Trimble Connect** platform: Enabled real-time collaboration and model-based communication.
- **BCF threads**: Used to raise questions, assign tasks, and share feedback.
- **Issue lifecycle**: Designers responded to fabricator comments and provided updates directly in the shared environment.



Communication with Trimble Connect

Replication Path for Other Agencies

- Steps a DOT can take now
- How this project sets a framework for future digital delivery