

Use of Industry Foundation Classes in a Unified Engineering Design and BIM Workflow

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Motivation

- To see what is over the “production fence” (structural design vs BIM).
- How can we streamline production within the office using established standards?
- BuildingSMART “IFC is the PDF of BIM”
<https://www.buildingsmart.org/standards/bsi-standards/industry-foundation-classes/>
- Is there something in IFC that can support sharing information from:

Structural Analysis → Structural Design → BIM

Abstract v1.0 (April 2023)

Description: The workflow from reinforced concrete column design to drawing production goes through many stages. The traditional approach is unidirectional: Engineers would use 2D drawing and engineering analysis to obtain the design loading and slenderness of the column, the column reinforcement would be designed, followed by a markup a column schedule to be drafted. This presentation describes a ~~bidirectional~~ workflow where the starting point is the Building Information Model (BIM). ~~Using the BIM geometry, the engineering analysis and design is performed, and an Industry Foundation Classes (IFC) model is generated for automatic population of the column schedule, including column reinforcement section and elevation details. Detailed aspects of this bidirectional workflow are presented, such as use of IFC reinforcement models and automated transmittal of column design loading for the column schedule.~~

Abstract Version 2.0 “Musings”

- Current column design workflow
- The future workflow
- Plugging into ACI 131 EM-6 and EM-15
- Summary and Conclusions

Column Design Workflow

Column Design Loads

CSI Applications:

ETABS (*Full-Building Model*)

SAFE (*Stacked Floor Models*)

Bentley:

RAM Concept (*Stacked Floor Models*)

Intermediate Loads

Access File
(Schema is CSI
version specific)

Flat File
(Schema is version
specific)

“I’m in the BIM Model”

spColumn Design

DeSimone Column
Load Takedown
Application

Pdf Markup
-OR-
XLS IO via Dynamo

One Way Trip

DESIMONE

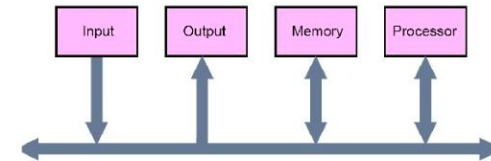
Vendor Lock-In Issue¹

Problem: Workflow that relies on a specific 3rd party application.

Solution: Central Data Repository with a standardized interface

“Data As A Service (DaaS)” via the “DCE Data Bus (DCEDB)”

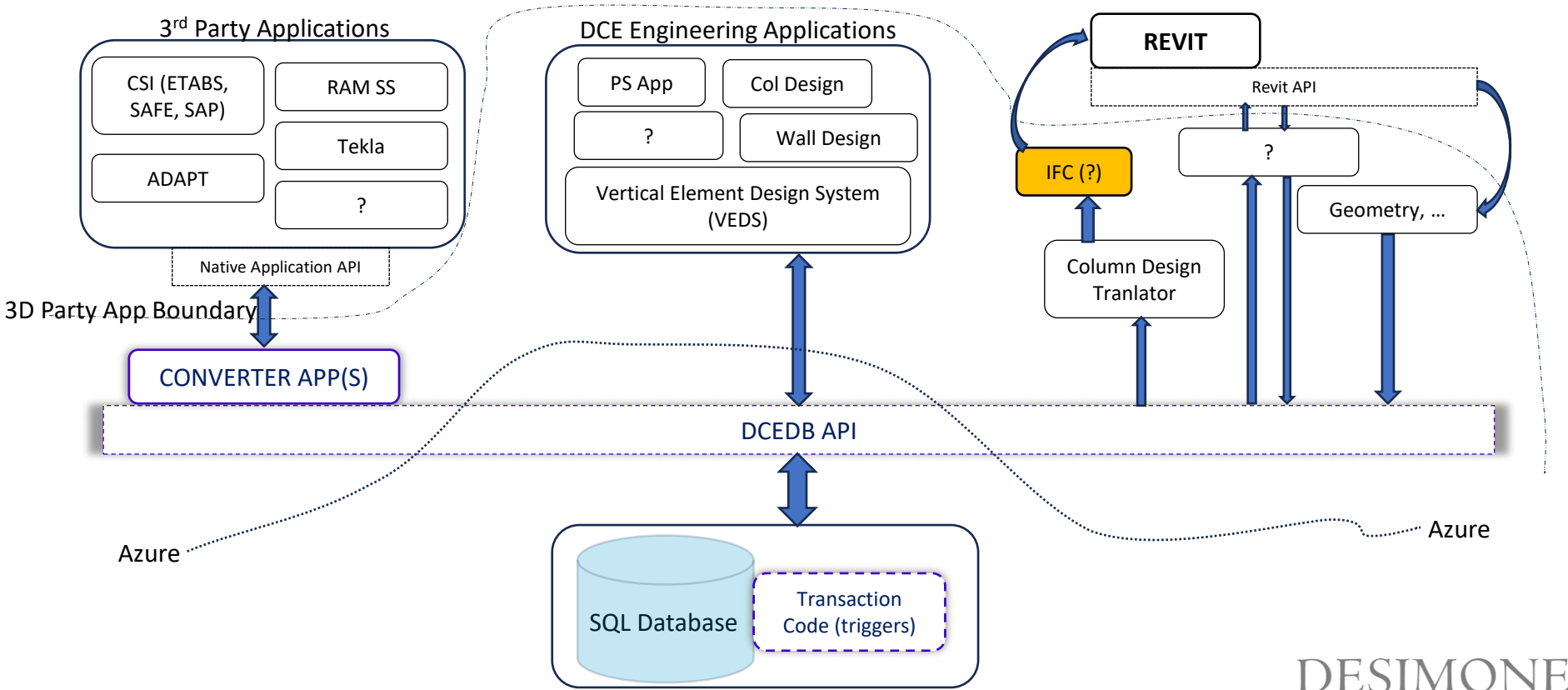
1. “In economics, vendor lock-in, also known as proprietary lock-in or customer lock-in, makes a customer dependent on a vendor for products, unable to use another vendor without substantial switching costs.” (Wikipedia)



DESIMONE

Future Workflow (WIP)

A Solution to Vendor Lock-in: The DeSimone "Data Bus" (DCEDB)



EM.6—Structural design model

Project stage

Construction documentation 31-25 00 00

Exchange disciplines

Sender: Structural engineer 33-21 31 14

Receiver(s): General contractor 33-41 11 11

Concrete contractor 33-41 11 14

Site contractor 33-41 11 14

Reinforcing detailer 33-41 11 14

Description

Purpose: Report of detail structural design to determine steel reinforcing sections, lap standard details, and special connections. Optionally provide early mill order for reinforcing and early shoring needs.

Major elements: Reinforced concrete members and reinforcing cross section layouts and spacing requirements; standard details; lap lengths; special connections; concrete strength; steel reinforcing and tendon specifications, including coatings, expansion joints, and post-tensioned tendon placement joints. Includes geophysical data and foundation spatial requirements.

Level of detail: Sufficient for determining detailing to realize project structural requirements, as defined by structural engineer.

Special attributes: Reinforcing bar layout for member sections, reinforcing lap requirements, required concrete joints, major embeds, and cutouts.

Software functionality: export and import

Export: Structural analysis application

Import: Concrete detailing application

EM.15—Reinforcement placement sequence

Project stage

Concrete resource and placement planning 31-40 30 31

Exchange disciplines

Sender: Reinforcing detailer 33-21 31 14

Receiver(s): Formwork contractor 33-41 11 14

Reinforcing fabricator 33-41 11 14

Reinforcing contractor 33-41 11 14 17

Description

Purpose of exchange: Coordinate reinforcement and tendon placement with placement sequence and schedule.

Major elements: All reinforcement and tendon items, embeds, and formwork including formwork for special finishes, blockouts, insulation, to be associated with schedule and placement.

Level of detail: Complete detail; schedule for formwork and reinforcing elements.

Software functionality: export and import

Export: Reinforced concrete detailed model, with definition of placement schedule related to pour sequence.

Import: Construction coordination model applications able to show both model detailing and sequencing.

May be one-way or round trip.

EM-6

LEVEL	COLUMN	LEVEL B1	NOTES	LEVEL
	A-1			A-1
	B-1	24"x36" 12#8 T: #5@6" E: #5@6"		B-1
	D-1	24"x36" 12#8 T: #5@6" E: #5@6"		D-1
	E-1	24"x36" 12#8 T: #5@6" E: #5@6"		E-1
	G-1	24"x30" 10#8 T: #4@6" E: #4@6"		G-1
	A-2			A-2
	B-2	24"x36" 12#9 T: #5@6" E: #5@6"		B-2
	D-2	32"x32" 14#8 T: #5@6" E: #5@6"		D-2
	E-2	24"x30" 10#8 T: #5@6" E: #5@6"		E-2
	G-2	24"x30" 10#8 T: #4@6" E: #4@6"		G-2
	B-3	24"x36" SEE 3/S-3.50		B-3
	D-3	24"x32" 16#11 T: #5@6" E: #5@6"		D-3
	E-3	24"x30" SEE 3/S-3.50		E-3
	G-3	24"x30" SEE 3/S-3.50.2		G-3
	A-4			A-4
	B-4	36"x20" SEE 1/S-3.50.3		B-4

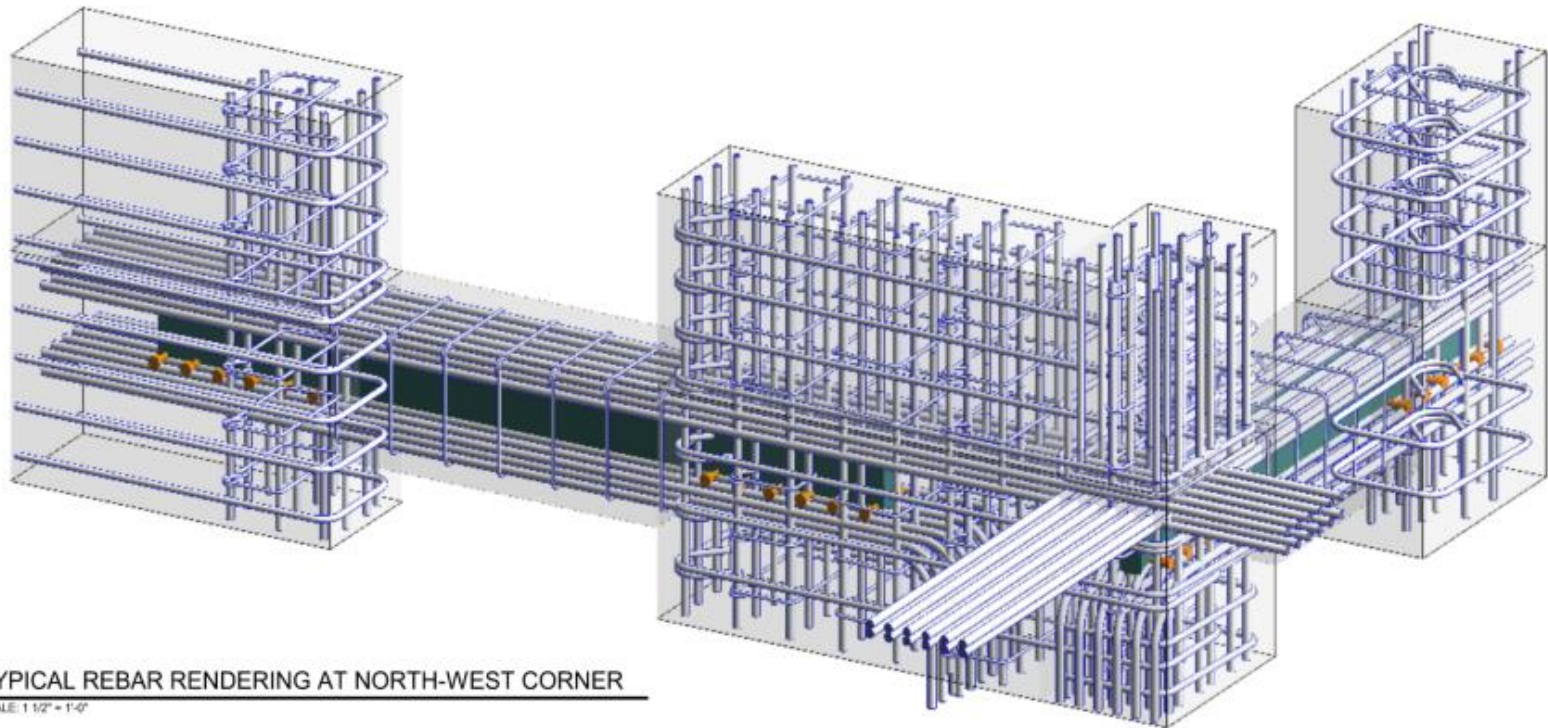
TYPE 'S'	
	4 BARS
	6 BARS
	8 BARS
	10 BARS
	12 BARS
	15 BARS
	20 BARS
	4 BARS
	6 BARS
	8 BARS
	8A BARS
	8B BARS
	10 BARS
	12A BARS
	12B BARS
	14 BARS
	14A BARS
	14B BARS
	16 BARS
	16B BARS
	18 BARS
	20 BARS
	24 BARS

TYPE 'R'	
	10 BARS
	12A BARS
	12B BARS
	14 BARS
	14A BARS
	14B BARS
	16 BARS
	16B BARS
	18 BARS
	20 BARS
	24 BARS

SEE 1/S-3.52.6	SEE 2/S-3.52.6	SEE 3/S-3.52.6	SEE 10#8 T: #4@6" E: #4@6"
30"X12" (R-6) 6#8 T: #5@3" E: #5@3"	36"X20" (R-10) 10#9 T: #5@3" E: #5@3"	36"X20" (R-10) 10#9 T: #5@3" E: #5@3"	36"X37" (R-14A) 14#11 T: #5@4" E: #5@4"

3/S-3.50.2	1/S-3.52.6	2/S-3.52.6	3/S-3.52.6
	30"X12" (R-6) 6#8 T: #5@3" E: #5@3"		
			36"X20" (R-10) 10#11 T: #5@3" E: #5@3"
36"X20"			
SEE 1/S-3.50.3			

EM-15



4 TYPICAL REBAR RENDERING AT NORTH-WEST CORNER
SCALE: 1 1/2" = 1'-0"

Concluding Remarks and Summary

- Work has just begun on the DCE Data Bus
- To Start: EM-6 has the potential to be used as a data exchange format for internal design workflows
 - Design stored in the DCEBD and converted to IFC for import to Revit
- EM-10 used on a localized region can aid engineers in evaluating rebar congestion issues (Direct DCE App to IFC – A “one off” use)
- Not presented, but:
 - ifcSQL looks like a complimentary technology in the DCEDB
<https://forums.buildingsmart.org/t/ifc-for-relational-databases-ifcsql/1524>
 - Can IFC be leveraged to transmit data between vendor specific structural analysis models ?

Thank You

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