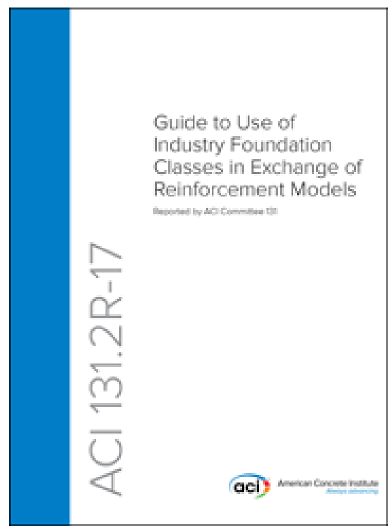
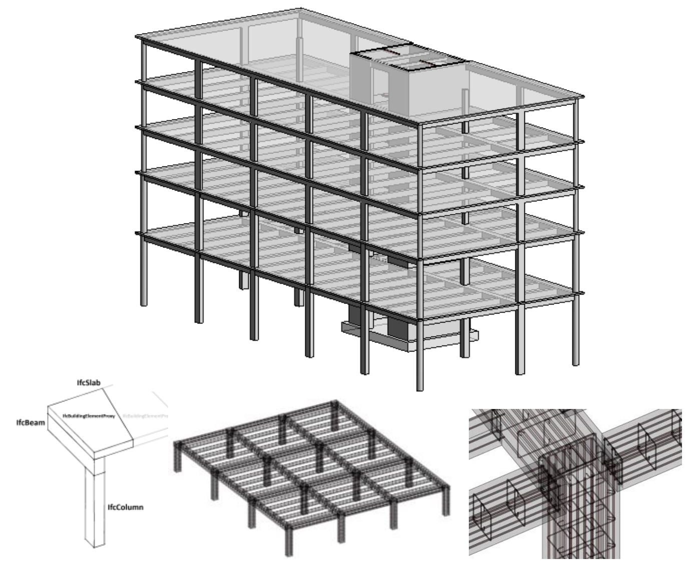
Concrete BIM Standards: Published and Ongoing Documents, Workflows, and Application





Leonardo Garcia Bottia, PE, PhD

Agenda

1. ACI 131 Committee Overview
2. Published Documents
3. Ongoing Developments
4. New Workflows and Implementation
5. Value Considerations

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1. **ACI 131 Committee Overview**
2. Published Documents
3. Ongoing Developments
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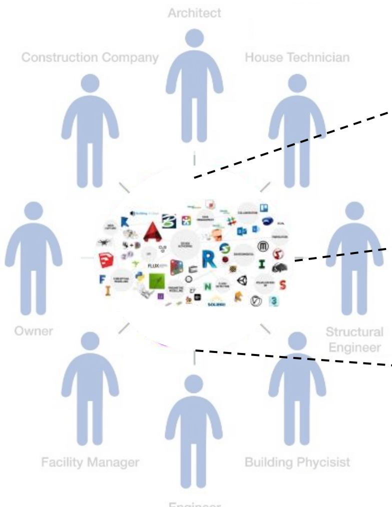
ACI 131 Committee Overview

ACI 131 – Building Information Modeling of Concrete Structures:
- Organized 2009 – Fall Convention in New Orleans

Current Membership:
- 17 Voting Members (many initial members still active)
- 21 Associate Members, 7 Consulting Members

Mission:
- Develop and report information on the application of Building Information Modeling (BIM) to concrete structures.

ACI 131 Committee Overview

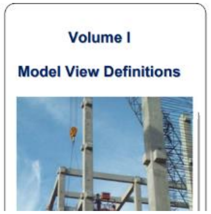


Industry Foundation Classes (IFC): Open standard to define and represent building objects, processes, relationships and other data. (ISO 16739)

Steel

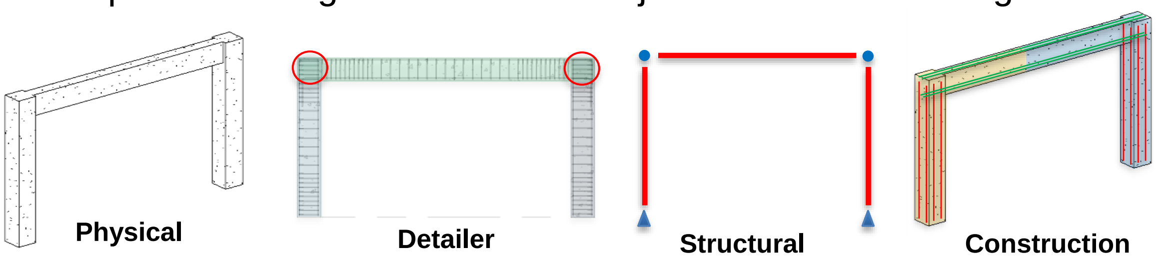
IFC2x3

Precast Concrete



Cast-in-Place Concrete

- Complex Supply Chain: **Design** (Arch, Struct, Detail)
Supply (Rebar, Concrete, Finish)
Temporary (Form, Scaffold, Shoring)
Build (GC, Trades)
- Complex Modeling: Monolithic vs. Object-Oriented Modeling



ACI 131 Committee Overview

- We don't need all the data in all the exchanges.
- We might need some additional data in some exchanges.

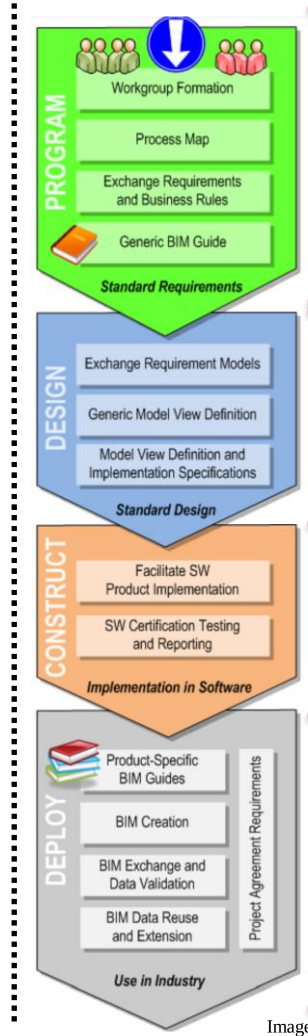


Image from NBIMS

IDM: Information Delivery Manual
- Process Map
- Exchange Requirements

MVD: Model View Definition
- Sub-set of IFC schema for (a) specific Exchange Model(s)

Test Models and Validation

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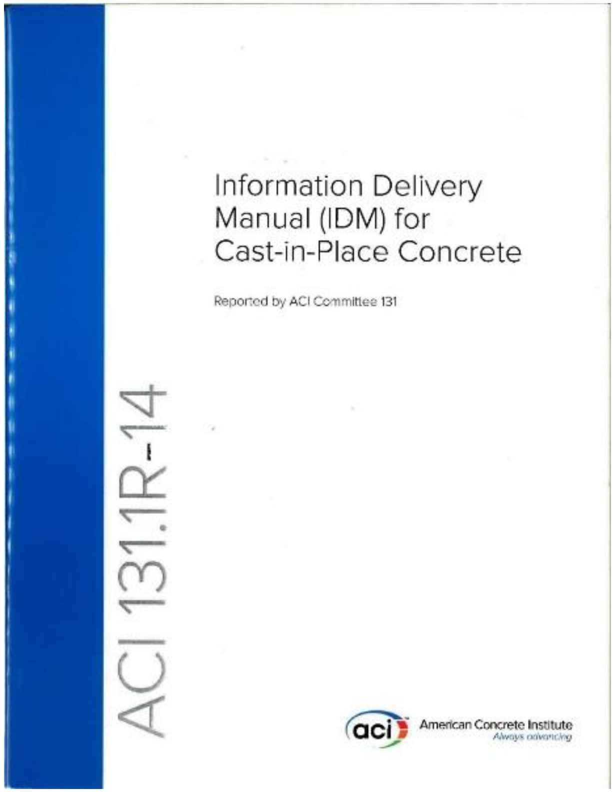
Published Documents

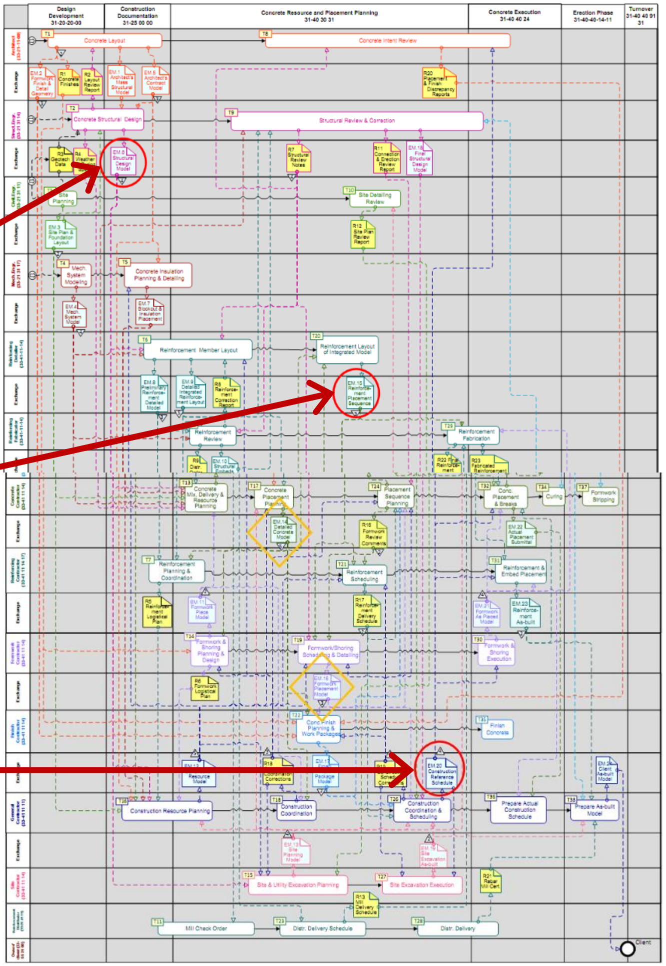
Information Delivery Manual (IDM) for Cast-in-Place Concrete - ACI 131.1R-14

- “Roadmap” for BIM Data Exchange for CIP Industry
- Includes all major “Stakeholders”
- Timing (or sequence) of delivery of Data
- Defines the Scope of Data
- Key first step to developing a standard



Published Documents

Information Delivery Manual (IDM) for Cast-in-Place Concrete - ACI 131.1R-14



EM-6: Structural Design Model: structural intent, specifying concrete profiles, steel reinforcing and tendons in members, spacing requirements

EM-15 Reinforcement Placement Model: full detailed rebar layout with ties, laps, from detailer to fabricator; tagged with placement sequence

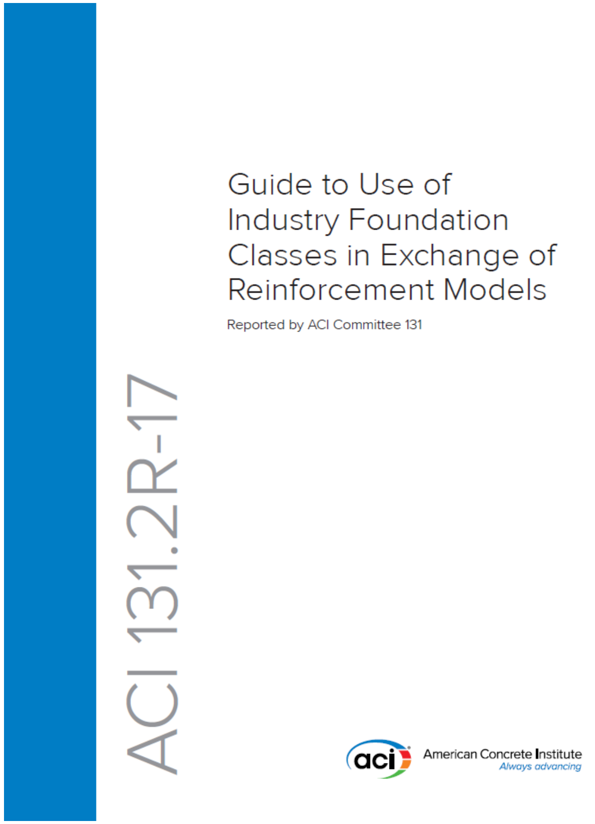
EM-20: Construction Reference Model: detailed placement model, with pour objects, finishes and formwork; for final coordination with all other systems.

Published Documents

Guide to Use of IFC in Exchange of Reinforcement Models- ACI 131.2R-17

- First BIM Data Exchange for Concrete Industry

- Rebar and mesh
- Terminators & couplers
- Cages, callouts, and other assemblies
- Releases, bundles, and shipping information.


ACI 131.2R-17

Guide to Use of Industry Foundation Classes in Exchange of Reinforcement Models

Reported by ACI Committee 131

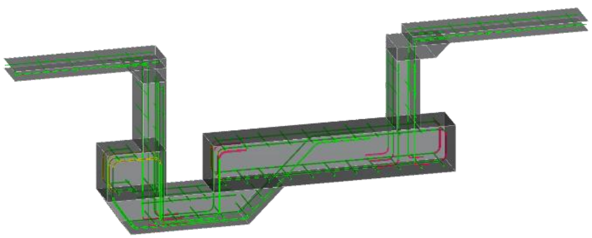
American Concrete Institute
Always advancing

Published Documents

Guide to Use of IFC in Exchange of Reinforcement Models- ACI 131.2R-17

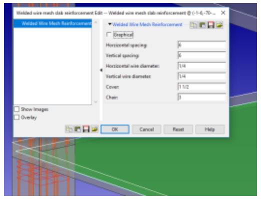
Bar Information

- Mark
- Size
- Area
- Surface
- Geometry
- Location
- Length & Mass
- Bar Element
- Bar Use
- Bar Position
- Material
- Coating

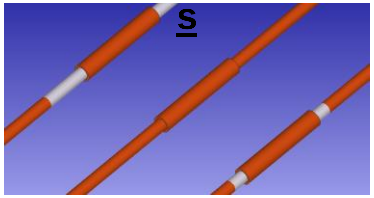


End Prep

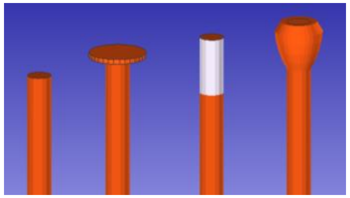
Welded Wire Reinf.



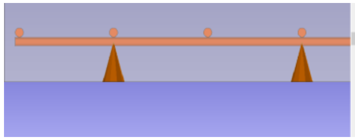
Couplers



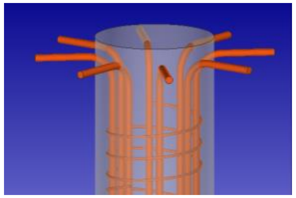
Terminators



Accessories



Callouts & Cages



SDS/2

Table 7.3e—BarPosition property usage

Value	Meaning
BOTTOM	The bar is near the bottom face of the element. This should only be used for elements that are primarily horizontal.
INSIDE	The bar is near the inside face of the element. This value should only be used in elements with a clear inside and outside face.
CENTER	The bar is in the center of the element.
OUTSIDE	The bar is near the outside face of the element. This value should only be used in elements with a clear inside and outside face.
SIDE	The bar is on the side face of the element.
TOP	The bar is on the top face of the element. This should only be used for elements that are primarily horizontal.
(user-defined)	User defined values should only be used when none of the above values is appropriate.

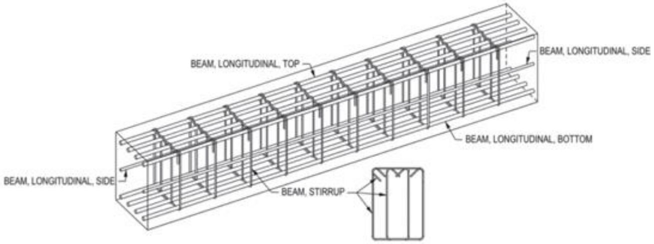


Fig. 7.3a—BarElement, BarUse, and BarPosition in beams.

aci CONCRETE CONVENTION

Published Documents

BIM Level of Development for CIP Concrete – TechNote ACI PRC-131.3-22

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ACI PRC-131.3-22
TechNote

BIM Level of Development for CIP Concrete—TechNote

LOD 400	
Concrete	Concrete columns, beams, slabs, walls, foundations, and other concrete elements are represented at specified locations with specified thicknesses and cross sections. All openings, insets, and protrusions are represented at specified locations. Expansion, contraction, and construction joints are represented at specified locations. Closure strips and other temporary voids such as stressing blockouts and crane openings are represented. Surface finish requirements and architectural forming requirements, such as chamfers, form liners, or board-forming are identified. Either a concrete mixture identifier or the following concrete mixture information is provided as nongraphical information associated with the concrete elements: a) Required strength b) Nonstandard weight characteristics (lightweight or heavyweight) c) Special durability requirement, such as sulfate-resistant cements d) Maximum *w/cm* e) Special serviceability requirements, such as modulus of elasticity and shrinkage limits f) Slump g) Maximum aggregate size h) Admixtures that can significantly influence placement rates and form pressures i) Cement substitutes that can significantly influence strength gain and heat of hydration

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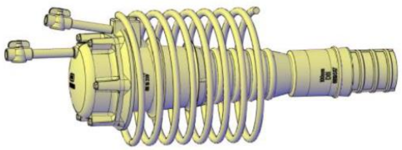
Ongoing Developments

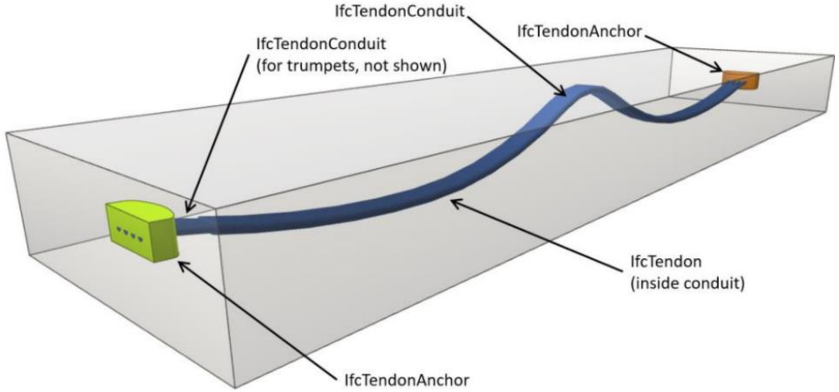
Guide to Use of IFC in Exchange of Reinforcement Models- ACI 131.2R-17 Update

- Update to include post-tensioned concrete.
- Work in conjunction with PTI
- Document has been balloted

12.2—Modeling of Complete Tendons



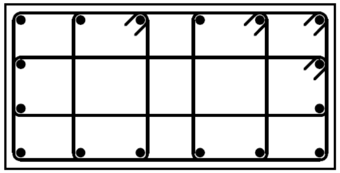
Real-world Component	IFC Mapping	Notes
Strand Bar Wire	IfcTendon	One IfcTendon may represent multiple items.
Anchor Bearing Plate Anchor Caps	IfcTendonAnchor	All anchor components modeled together as a single IfcAnchor
Coupler	IfcTendonAnchor	All components of the coupler are modeled as a single IfcTendonAnchor
Pocket Formers	(none)	Modeled as part of anchor
Wedges	(none)	Wedges not modeled
Jack	(none)	Jacks not modeled.
Duct Grout Tube Trumpet Sleeves	IfcTendonConduit	See 12.3 for Tightly-Sheathed Tendons
Grout Other Fillers	(none)	Grout and other fillers are not directly modeled.
Entire Tendon	IfcElementAssembly	
Tendon Bundle	IfcElementAssembly	



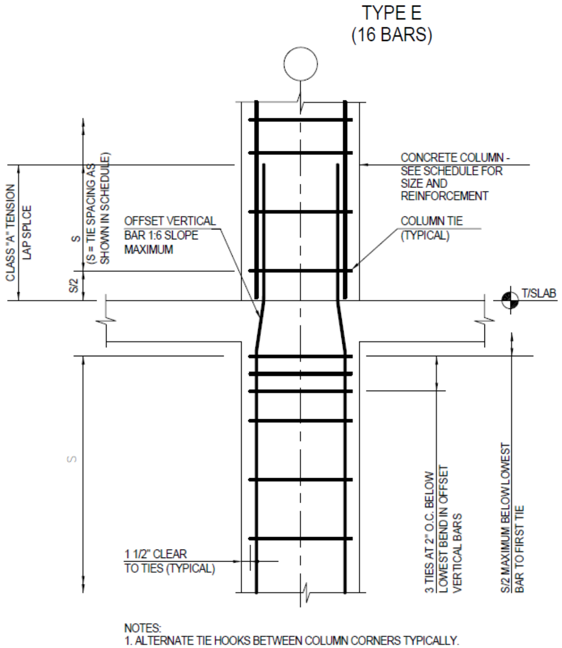
Ongoing Developments

EM.6 – Structural Design Model (Design Intent)

SIZE (IN)	24x36
TYPE	E
BARS	(16) - #7
TIES	#4 @ 9"



- Main Concrete Elements
- Concrete Material Specs
- Reinforcing Steel Material Specs
- “Design Intent” Rebar (“Digital” schedules)
- Rebar Layout (Detailing) Standards
- Ready for Scope Ballot



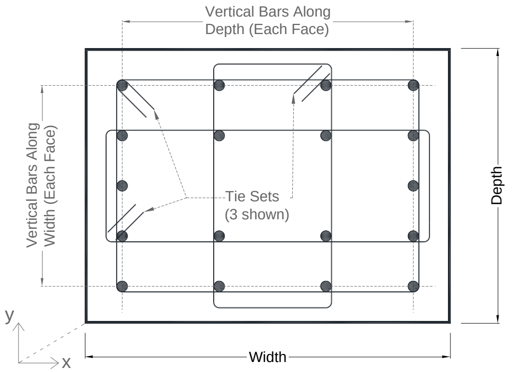
5 TYPICAL CONCRETE COLUMN SPLICE DETAIL
SCALE: NOT TO SCALE

LEVEL	COLUMN MARK	01 K-18, 01 L-18	01 B-15, 01 B-18, 01 N-15, 01 N-16, 01 N-17, 01 N-18
T/LEVEL 2 (MECH.) EL: SEE PLAN	SIZE (IN)	-	-
	TYPE	-	-
	BARS	-	-
	TIES	-	-
T/LEVEL 1 EL: SEE PLAN	SIZE (IN)	32x32	24x36
	TYPE	NOTE 9	NOTE 9
	BARS	(12) - #9	(16) - #7
	TIES	#4 @ 6"	#4 @ 9"
T/LEVEL A EL: SEE PLAN	SIZE (IN)	32x32	24x36
	TYPE	NOTE 9	NOTE 9
	BARS	(12) - #9	(16) - #7
	TIES	#4 @ 6"	#4 @ 9"
T/LEVEL B EL: SEE PLAN	SIZE (IN)	32x32	24x36
	TYPE	C1	E
	BARS	(12) - #9	(16) - #7
	TIES	#4 @ 12"	#4 @ 9"
T/LEVEL C EL: SEE PLAN	SIZE (IN)	32x32	24x36
	TYPE	C1	E
	BARS	(12) - #9	(16) - #7
	TIES	#4 @ 12"	#4 @ 9"
T/LEVEL D (FND) EL: SEE PLAN	DOWELS	(12) - #9	(16) - #7

Ongoing Developments

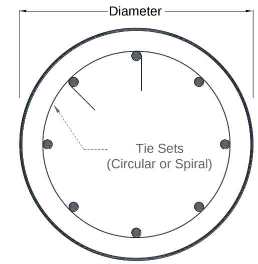
EM.6 – Structural Design Model (Design Intent)

Property Name	Type	Usage (Possible Data Values)	Required or Optional
ReinforcingMark	Label	C1	Required
VerticalBarMaterialName	Label	ExtColsGr80	Optional
VerticalBarGrade	Pressure	80,000 (or inherited from VerticalBarMaterialName)	Required
TotalVerticalBarsPerLayer	Label	10-#8, 8-#8 (Layer 1, Layer 2, etc)	Required
VerticalBarSizeAtCorners	Label	#11	Optional
VerticalBarsAlongWidthEachFace	Label	3-#8	Optional
VerticalBarsAlongDepthEachFace	Label	4-#8	Optional
VerticalBarsLegAlongWidth	Label	3-#8 (L-Shape Only)	Required
VerticalBarsLegAlongDepth	Label	3-#8 (L-Shape Only)	Required
VerticalBarsPerBundle	Integer	0 No Bundle, else 2, 3, etc.	Required
TiesByZone	Label	Typ-#3@8 or Bot-8#3@6, Mid-#3@12,Top-8#3@6	Required
TieBarMaterialName	Label	ExtColsGr60	Optional
TieBarGrade	Pressure	60,000 (or inherited from TieBarMaterialName)	Required
TieNumberSets	Integer	3	Required
TieLayoutType	Label	Rectangular, Circular, Spiral	Required
TieLayoutDetail	Label	Linked File or Tie Set Type from Detail Sheet	Required
VerticalBarSpliceType	Label	Tangential, Radial, Bearing, Mechanical	Required
VerticalBarCompressionSplice	Boolean	True or False	Required
ReinforcingCoatingType	Label	Epoxy, Stainless, etc.	Optional
DetailingCodeReference	Label	Seismic or Non-Seismic	Required
ReinforcingStandardDetails	Label	Name of Linked File transmitted as a URL via IfcURIReference	Required
Exposure Type	Label	Protected, exposed to weather, exposed to soil, cast against soil, corrosive, other.	Required

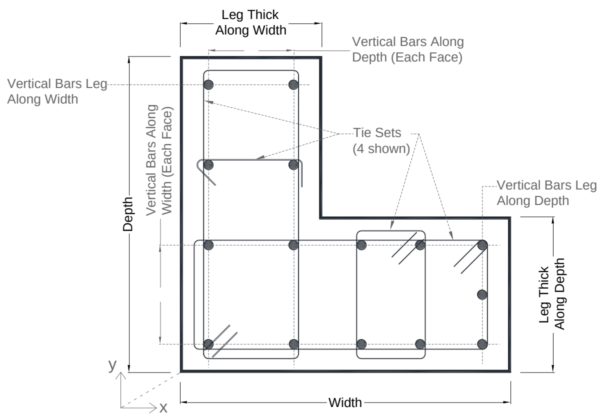


Cross Section View
Rectangular Column

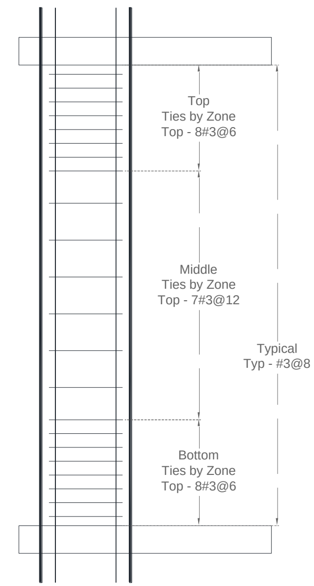
14 - Vertical Bars Layer 1
4 - Vertical Bars Layer 2



Cross Section View
Circular Column



Cross Section View
Lshape Column

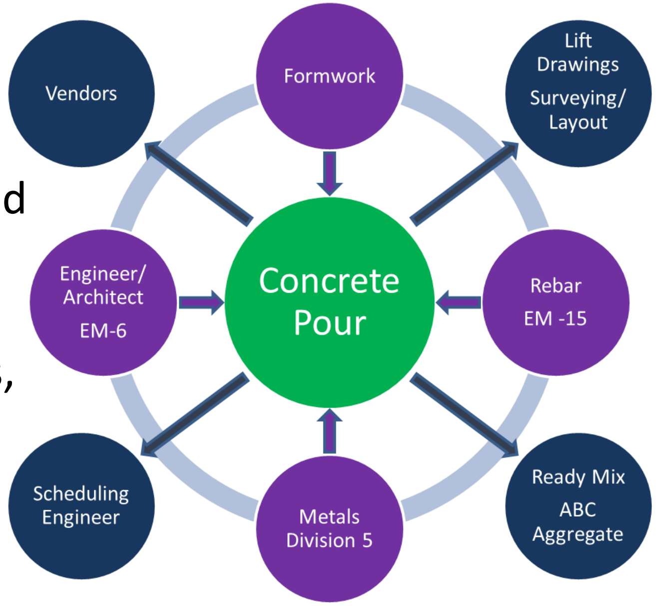


Elevation View

Ongoing Developments

EM.20 – Construction Reference Model

- Main Concrete Elements
- Concrete Material Specs
- General Information provided by the General Contractor
- Concrete Pour Sequences
- Embeds, Formwork, Finishes, etc
- Ready for Scope Ballot



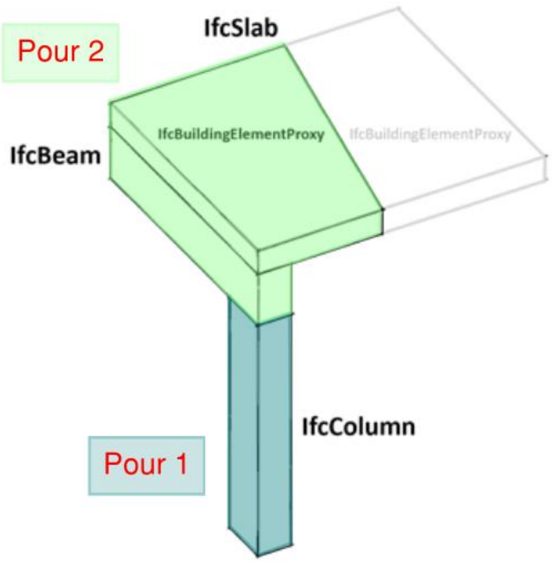
Ongoing Developments

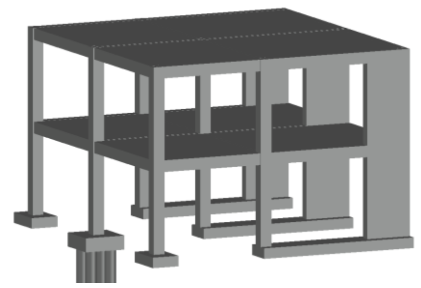
EM.20 – Construction Reference Model

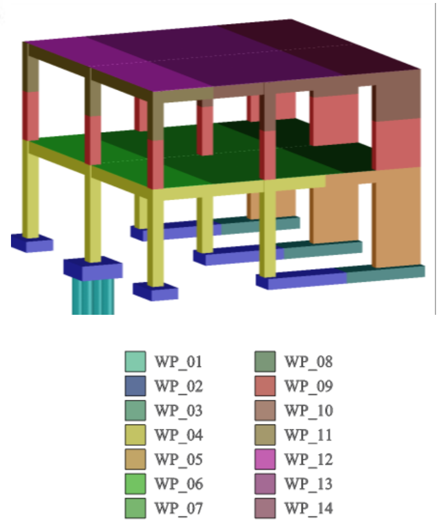
Pset_ACI_Schedule Property Set Usage:

This property set contains properties that describe the schedule information pertaining the Pour Object.

Property Name	Type	Usage	Required or Optional
ID	Alpha Numeric	A designation given to the object.	Required
Label	Text	Name of the object	Optional
Activity/Reference ID or Number	Alpha Numeric	A designation given to the object.	Optional
Start date	Date	Start Date of the Activity	Optional
Duration	Integer	Duration of the Activity	Optional
End Date	Date	End Date of the Activity	Optional
Sequence Information	Text	Order of the designated objects	Optional
Crew or resources	Alpha Numeric	Resources assigned to the object.	Optional
Production Rates	Number	Historical rate of placing the object.	Optional
Resource Utilization	Number	Number of resources used per the duration unit.	Optional
RFI	IFC Label	Associated RFI's to a pour object	Required
Concrete trucks spacing	Number	Time between concrete trucks in an hour Eg: 10 minutes spacing between trucks	Optional
Control Joints		Specified quantity location or spacing of control joints such as saw cuts, tooled edges for a pour object. Eg: 10 ' O.C Each Way	Optional
Revision	Alpha Numeric	Latest drawing revision of the object at the time of placement	Optional







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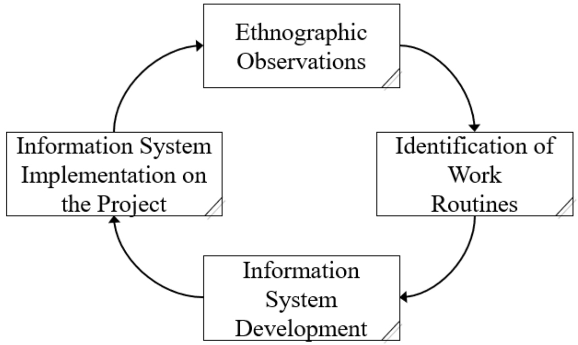
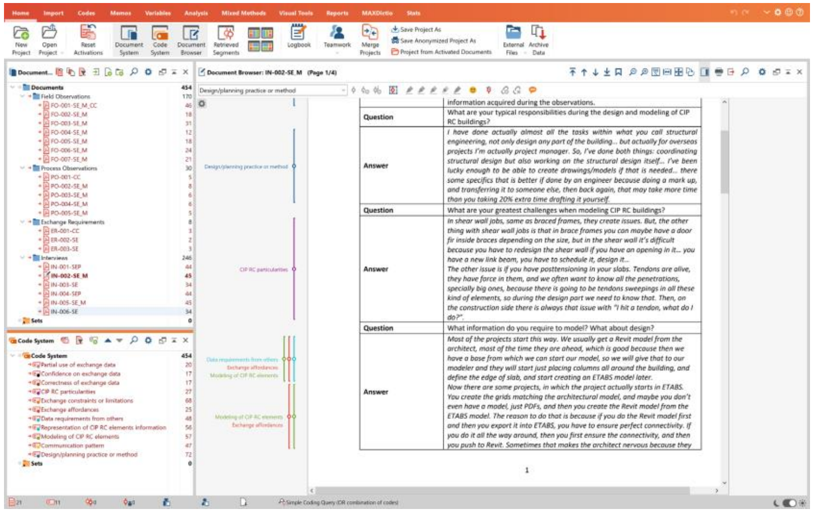
New Workflows and Implementation



Ethnographic-action research cycles (Hartmann, Fischer and Haymaker 2008).



Sample of Field **Observation**

Document No.	FO – 001 – SE/M
Document Type	Observation
Company/Discipline	Structural Engineering + Construction Coordination
Subject/Actor	Structural Engineer
Recording Method	Videocall
Date	4/15/2021
Duration	1.5 hours
Project	Healthcare Facility
Participants	Principal, Project Manager, Design Manager (responsible for project technical oversight), Lead Engineer, Lead Modeler, Technical Designer 1, Technical Designer 2, Director of Digital Practice.
Observations	The goal of the work session is to discuss the concrete matrix and using it as a live schedule to track the material information on the concrete elements, and go beyond the conventional "dumb" text methods. The goal is to have live tracking of concrete properties and quantities. The building is a new patient tower and emergency podium made of Cast-in-Place Reinforced Concrete Building that will serve as an expansion to an existing healthcare facility. There is a small metal building and a pre-cast concrete parking deck outside of the scope of the meeting. The project is on the early design development (DD) phase, still dealing with schematic design (SD) decisions. The building is a Cast-in-Place reinforce concrete intermediate moment frame (IMF) building, with no shear walls. Foundations consist of piles and pile-caps. This is standard for many framed projects made of CIP RC. The process wants to go beyond referencing the strength of the concrete, and wants to be able to track the details of the mix used, and its association with the corresponding elements made of that mix. The concrete matrix wants to be able to associate to each element the concrete material parameters, or types of concrete mix. (This is closely related to the intent to transmit material information during the EM.6 and EM.20 exchanges).

Sample of Process **Observation**

Document No.	PO - 002 – SE/M
Process	Framing Structural Design
Company/Discipline	Structural Engineering
Subject/Actor	Structural Engineer + Modeler
Recording Method	Videocall
Date	8/26/2021
Duration	1.5 hours
Tools Used	ETABS, Autodesk Revit, Kodiak
General Considerations	The process intents to model and design CIP RC framing elements, particularly beams for vertical loads and deflections.
Steps and Processes	- Generate an analytical model in a structural analysis tool, to revise and correct the connectivity between the elements. Sometimes modeling starts in BIM tool, in which case the model is later pushed into the analytical model for connectivity revision and analysis. - Push model to BIM tool to add information and hold a structural BIM model for coordination. If modeling starts in BIM tool, model CIP RC elements in BIM tool (Revit), ensuring proper dimensions and 3D interactions. - Export the model with the proper connectivity to a central database or neutral file, that can be used to retrieve the geometry and connectivity. - Import the geometric model in the design tool and verify consistency in relationships and connectivity. - Assign loads and load patters to the different elements based on the use of the facility. - Run the analysis and design program. - Verify force diagrams for logic, consistency. and output of design results. Note potential necessary connectivity and geometry adjustments.

Sample of **Interview**

Document No.	IN - 002 – SE/M
Document Type	Interview
Company/Discipline	Structural Engineering
Subject/Actor	Structural Engineer 1
Recording Method	Videocall
Date	3/25/2022
Duration	1 hour
Description	This interview was intended to gather information from one of the key actors involved in the processes observed, and gain information on his perspective and approaches. This information is also used for triangulation with the information acquired during the observations.
Question	How do you typically communicate design intent information to the detailer or contractor?
Answer	*Luckily we do have some tools internally. Let's talk about columns. We have a tool internally which lets us take the results from ETABS, and then process those results, because ETABS only yields area reinforcement, not number of bars, so we process that into number of bars and spacing. Then we push it to Revit which Is the important part, Once it is in Revit we can create a column schedule from that…. The out of the box family does not have a lot of things that we want to populate, we have created parameters in the family… and our tool can populate that.* *For beams we also have an internal tool, Kodiak, which basically does design, and pushed that design into Revit. The design is pushed and also the labels are pushed, I mean the beam types, so if you do a beam schedule, its already there.* *We also have tools to create foundations. We have a tool that does that and then pushes it to Revit. The one that is a little bit green is shear walls, and link beams, we don't have any sophisticated tool that helps us push from ETABS to Revit. Let's say it's yellow. The design of a two-way slab has always been a challenge for any company, we do have an internal tool that has been developed. I think it's at 75%. It's pretty good but still needs some tweaks. Most of the times it's schedules.*

Sample of Exchange **Observation**

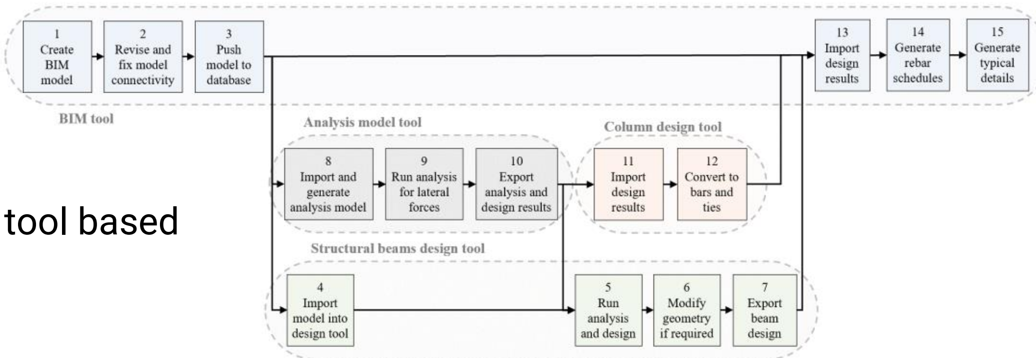
Exchange Requirement	Concrete Material		
File Type	PDF		
Producing Actor(s)	Structural Designer / Revit		
Consuming Actor(s)	General Contractor / PDF		
Description	The purpose of this exchange is to transfer concrete material information from the structural engineer to the contractor. Information is produced by a tool, but communicated through conventional 2D schedules. The concrete material is associated with the relevant concrete elements		
Information Units	Concrete Element	ID	Concrete Element ID
		Type	Concrete Element Type
		Dimensions	Concrete Element Dimensions
		Material	Concrete Mix Assignment
		ID	Unique identifier of the Mix
		Material Class	Class of material classification
		Name	Name of the mix
		Description	Description of the mix

New Workflows and Implementation

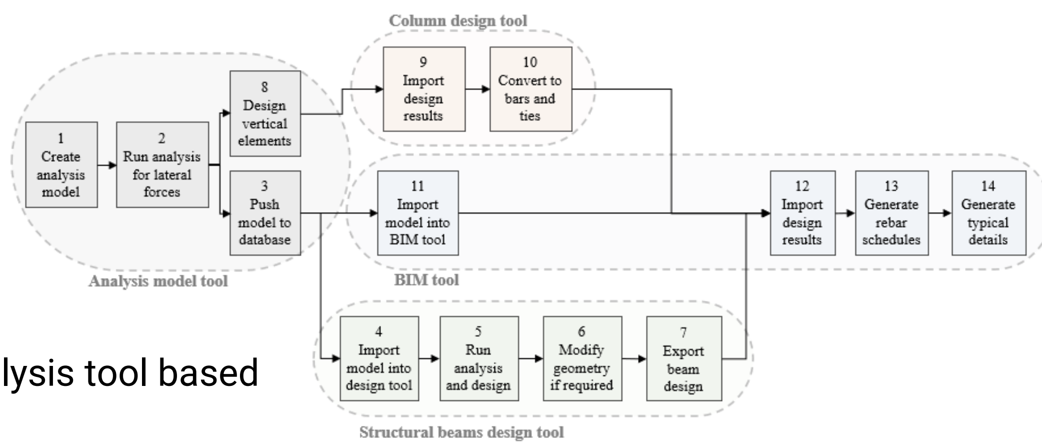
Structural Design Intent

Design intent information preparation

BIM tool based

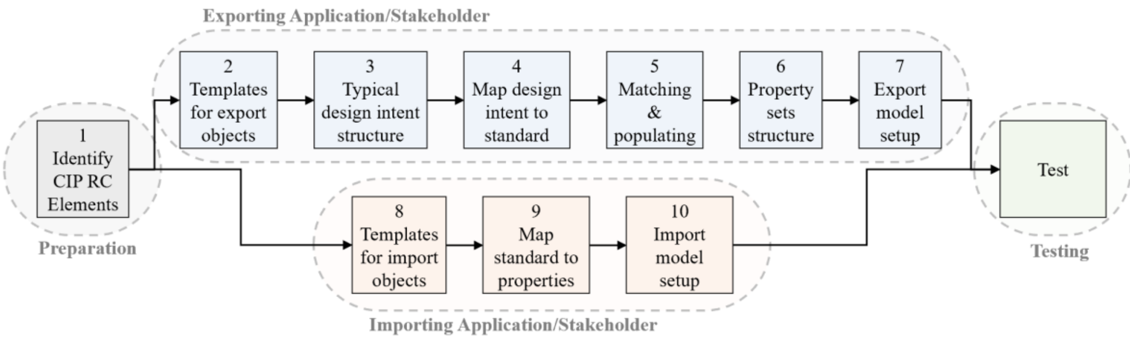


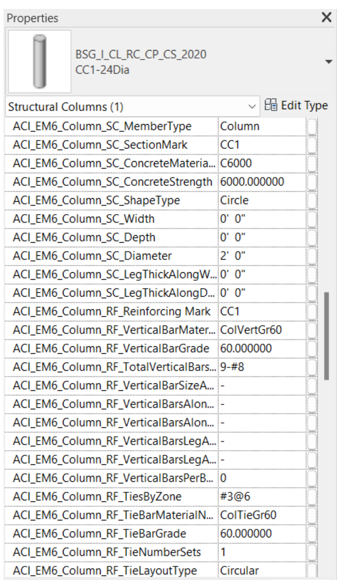
Analysis tool based



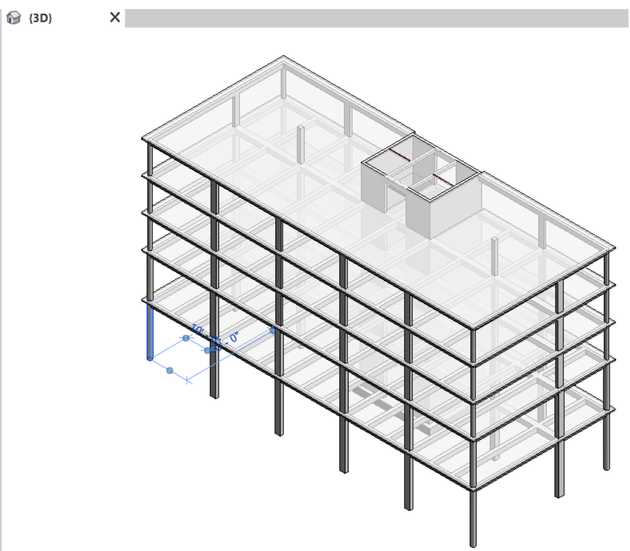
New Workflows and Implementation

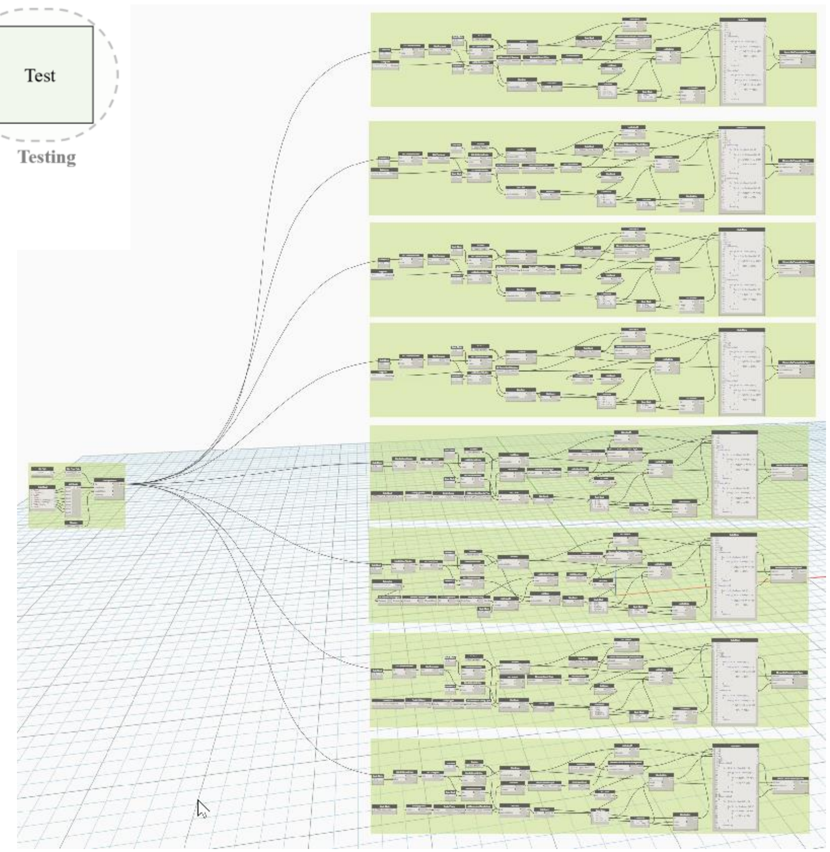
Structural Design Intent




Properties
BSG_I_CL_RC_CP_CS_2020
CC1-24Dia
Structural Columns (1) Edit Type

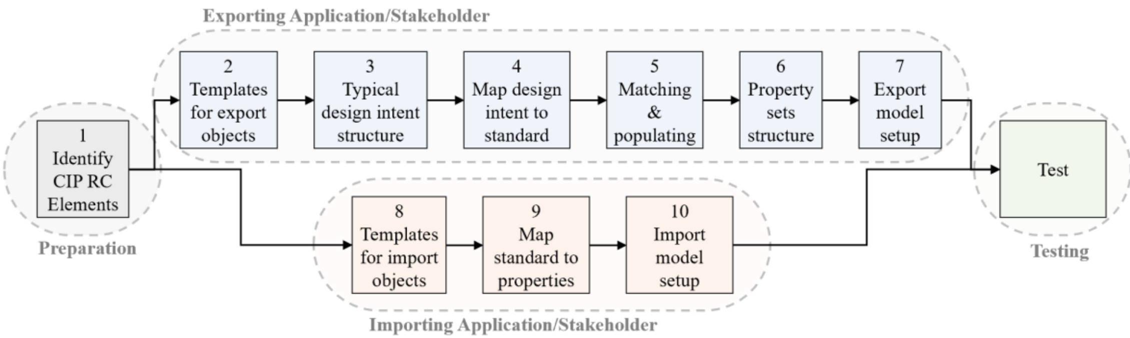
ACI_EM6_Column_SC_MemberType	Column
ACI_EM6_Column_SC_SectionMark	CC1
ACI_EM6_Column_SC_ConcreteMateria...	C6000
ACI_EM6_Column_SC_ConcreteStrength	6000.000000
ACI_EM6_Column_SC_ShapeType	Circle
ACI_EM6_Column_SC_Width	0' 0"
ACI_EM6_Column_SC_Depth	0' 0"
ACI_EM6_Column_SC_Diameter	2' 0"
ACI_EM6_Column_SC_LegThickAlongW...	0' 0"
ACI_EM6_Column_SC_LegThickAlongD...	0' 0"
ACI_EM6_Column_RF_Reinforcing Mark	CC1
ACI_EM6_Column_RF_VerticalBarMater...	ColVertGr60
ACI_EM6_Column_RF_VerticalBarGrade	60.000000
ACI_EM6_Column_RF_TotalVerticalBars...	9-#8
ACI_EM6_Column_RF_VerticalBarSizeA...	-
ACI_EM6_Column_RF_VerticalBarsAlon...	-
ACI_EM6_Column_RF_VerticalBarsAlon...	-
ACI_EM6_Column_RF_VerticalBarsLegA...	-
ACI_EM6_Column_RF_VerticalBarsLegA...	-
ACI_EM6_Column_RF_VerticalBarsPerB...	0
ACI_EM6_Column_RF_TiesByZone	#3@6
ACI_EM6_Column_RF_TieBarMaterialN...	ColTieGr60
ACI_EM6_Column_RF_TieBarGrade	60.000000
ACI_EM6_Column_RF_TieNumberSets	1
ACI_EM6_Column_RF_TieLayoutType	Circular

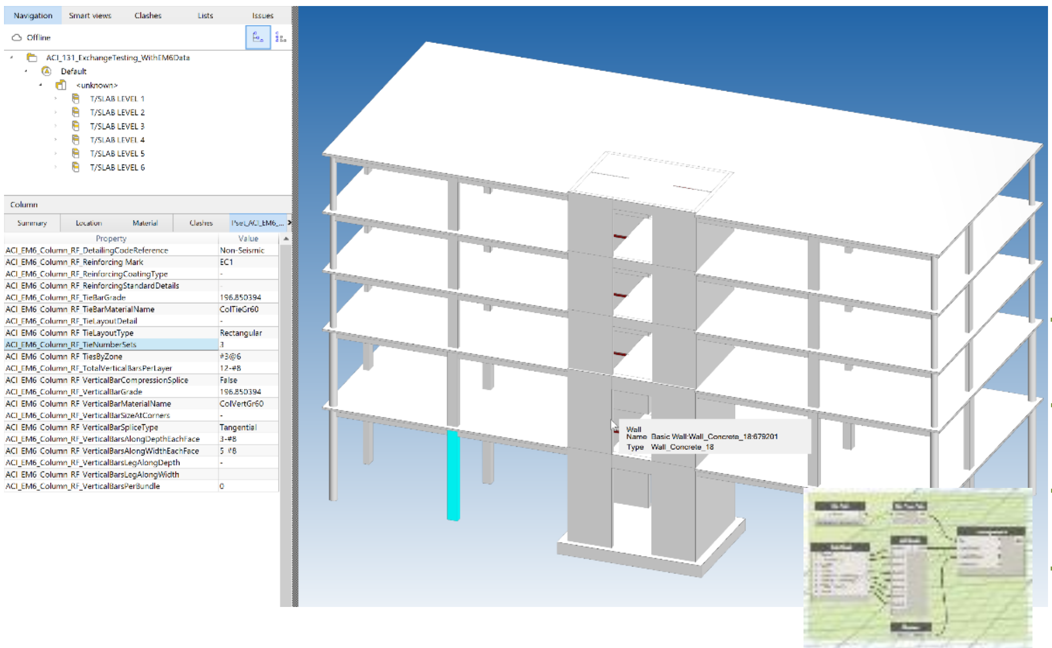


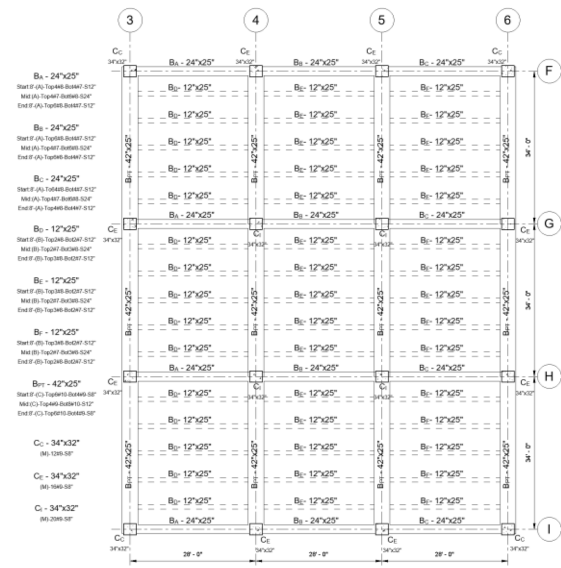


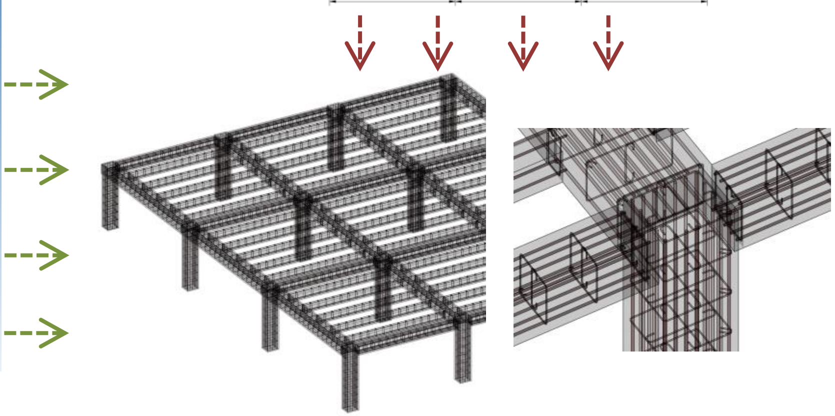
New Workflows and Implementation

Structural Design Intent





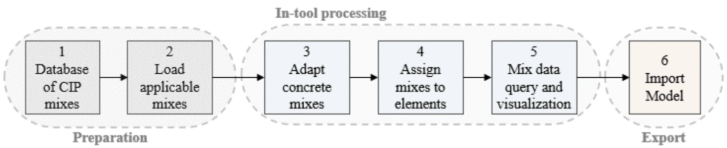




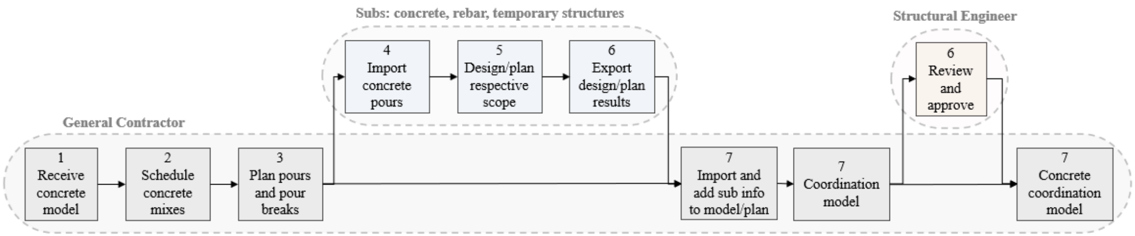
New Workflows and Implementation

Construction Coordination

Concrete mix information preparation

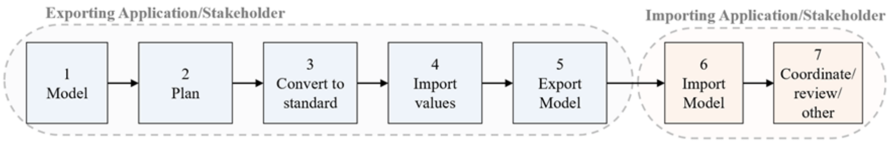


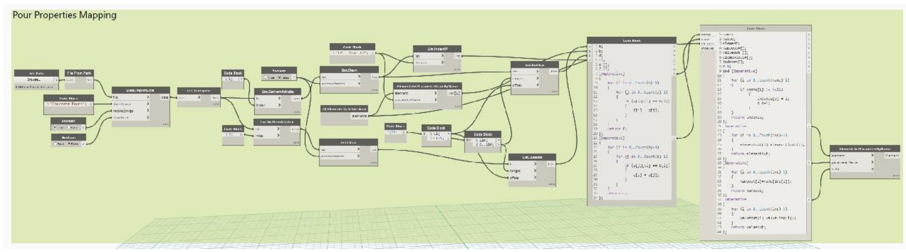
Construction planning information preparation

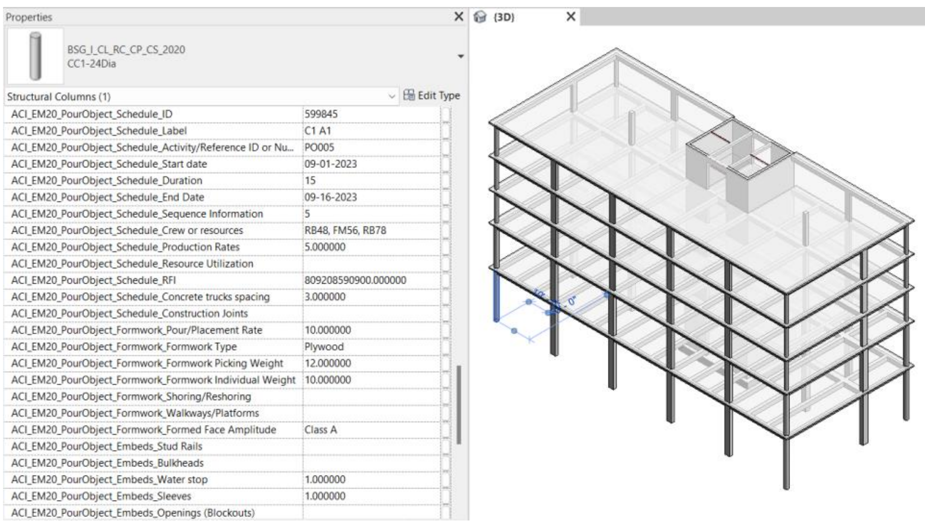


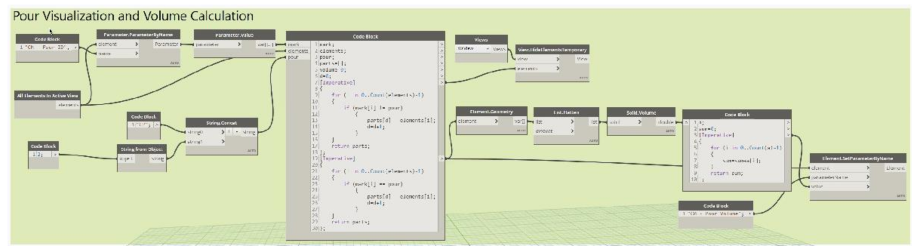
New Workflows and Implementation

Construction Coordination



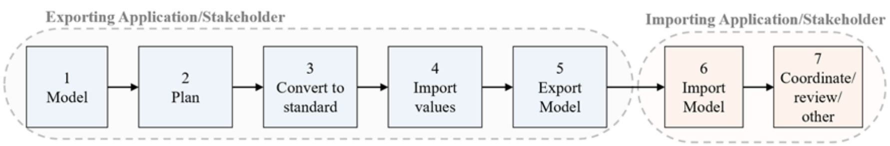


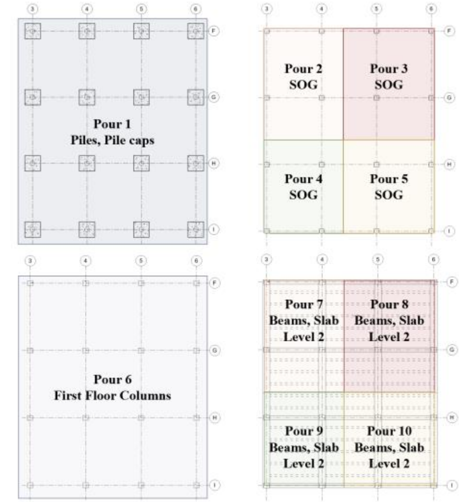




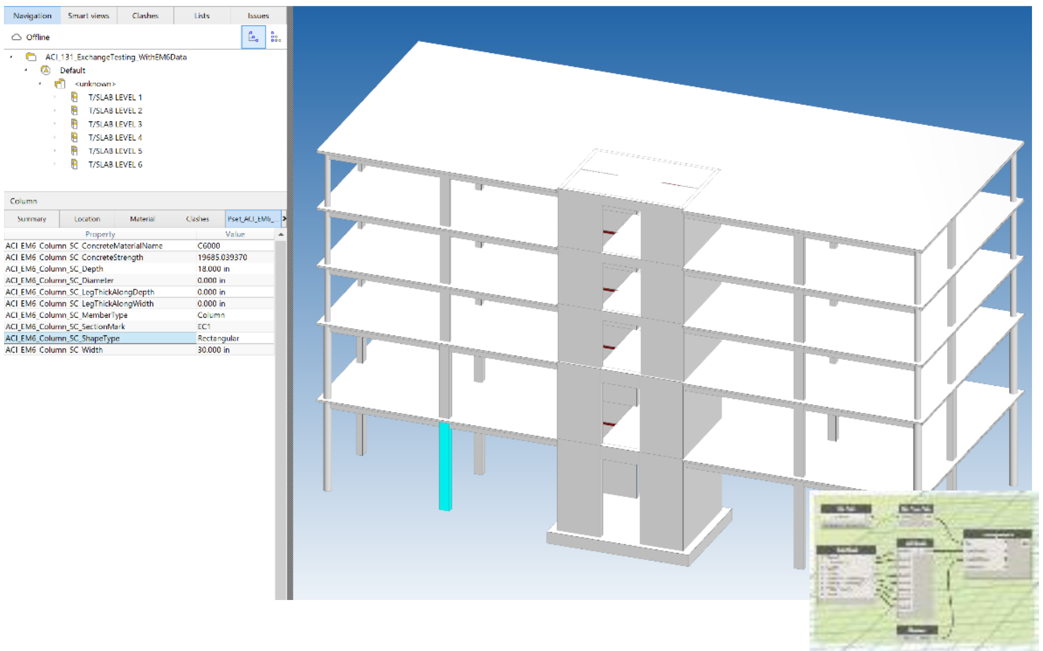
New Workflows and Implementation

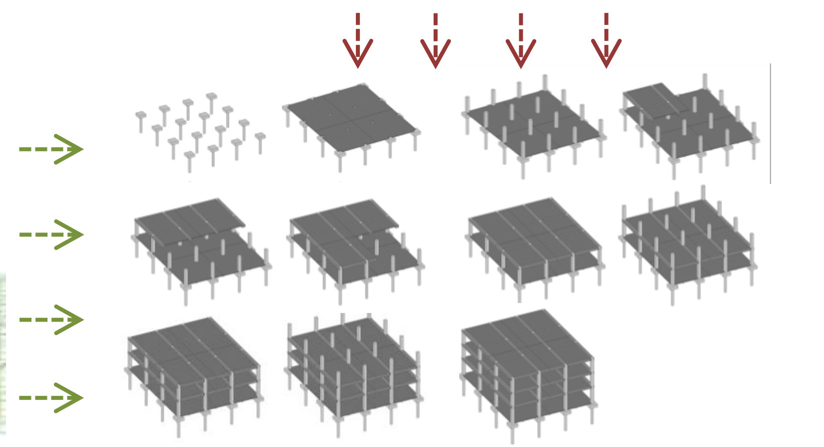
Construction Coordination





Pour	Elements	Vol (CY)	Mix	Start	End
1	Foundations	170	Fou-5k-N	08/01/22	08/03/22
2	SOG	56	Sog-3k-N	08/07/22	08/07/22
3	SOG	64	Sog-3k-N	08/08/22	08/08/22
4	SOG	47	Sog-3k-N	08/09/22	08/09/22
5	SOG	54	Sog-3k-N	08/10/22	08/10/22
6	Columns	72	Col-4k-N	08/14/22	08/16/22
7	Beams, Slab	88	Flo-4k-N	09/07/22	09/07/22
8	Beams, Slab	100	Flo-4k-N	09/08/22	09/08/22
9	Beams, Slab	74	Flo-4k-N	09/09/22	09/09/22
10	Beams, Slab	85	Flo-4k-N	09/10/22	09/10/22





Agenda

1. ACI 131 Committee Overview
2. Published Documents
3. Ongoing Developments
4. New Workflows and Implementation
5. **Value Considerations**

Value Considerations

Dimension	Category	Metric (Sources of Measurement)	Reference
Cost	Design Cost/ Benefit	Design cost	(Barlish and Sullivan 2012)
		Labor	(Khanzode, Fischer and Reed 2008)
		Costs	(Abdirad 2016), (Lu, Peng, et al. 2013), (W. Lu, A. Fung, et al. 2014)
		Cost benefit/savings	(Azhar 2011), (Kuprenas and Mock 2009), (PwC 2018)
		Reduced costs of engineering	(R. Sacks 2004), (Gilligan and Kunz 2007)
		BIM Contribution Value (BCV)	(Kim, et al. 2017)
		ROI	(Azhar 2011), (Walasek and Barszcz 2017), (Lee, Park and Won 2012), (Giel and Issa 2013)
		Enhanced cost estimating accuracy	(R. Sacks 2004)
	Direct Technology Cost	3D Background Modeling Cost	(Barlish and Sullivan 2012)
		Investment cost	(Walasek and Barszcz 2017), (Giel and Issa 2013)
		BIM cost to project	(Azhar 2011), (Gilligan and Kunz 2007)
		Direct costs of 3D BIM stations	(R. Sacks 2004)
		Replacement cost: existing systems	(R. Sacks 2004)
		BIM Utilization Value (BUV)	(Kim, et al. 2017)
	Other Related Costs	Construction cost	(Barlish and Sullivan 2012), (Dodge Data and Analytics 2015), (Azhar 2011)
		Project cost	(Khanzode, Fischer and Reed 2008)
		Prefabrication	(Khanzode, Fischer and Reed 2008), (Kuprenas and Mock 2009)
Time	Time Loss/ Benefit	Time savings	(Barlish and Sullivan 2012), (Azhar 2011), (Giel and Issa 2013), (Gilligan and Kunz 2007)
		Time	(Khanzode, Fischer and Reed 2008), (Abdirad 2016), (Lu, Peng, et al. 2013), (Kaner, et al. 2008)
		Construction duration	(Kuprenas and Mock 2009)
		Accelerated project completion	(Dodge Data and Analytics 2015)
		Time savings in design	(PwC 2018)
	Productivity	Documentation productivity	(Sacks and Barak 2008)
		Productivity	(Lu, Peng, et al. 2013), (Kaner, et al. 2008)
		Productivity gain: design/drafting	(R. Sacks 2004)
		Modeling Productivity	(R. Sacks, C. Eastman, et al. 2005), (Dodge Data and Analytics 2015)

Dimension	Category	Metric (Sources of Measurement)	Reference
Performance	RFIs	RFIs	(Barlish and Sullivan 2012), (Khanzode, Fischer and Reed 2008), (Giel and Issa 2013), (Abdirad 2016)
		RFI Reduction	(Dodge Data and Analytics 2015)
	COs	COs	(Barlish and Sullivan 2012), (Cannistraro 2010), (Giel and Issa 2013), (Abdirad 2016), (Kuprenas and Mock 2009).
		CO Processing Time	(Francom and Asmar 2015)
	Rework/ Errors	Rework	(Kuprenas and Mock 2009), (Khanzode, Fischer and Reed 2008), (Abdirad 2016)
		Errors & Omissions	(Abdirad 2016)
		Error reduction: design & drafting	(R. Sacks 2004)
		Completeness of Information	(Abdirad 2016)
		Illogical design	(Lee, Park and Won 2012)
		Discrepancies	(Lee, Park and Won 2012)
		Missing Items	(Lee, Park and Won 2012)
		Cost: Warranty & Latent Defects	(Francom and Asmar 2015)
		Material savings in design	(PwC 2018)
		Risk savings in design	(PwC 2018)
		Conflict Checking	(Kuprenas and Mock 2009)
		Coordination	(Khanzode, Fischer and Reed 2008)
	Safety	Safety	(Khanzode, Fischer and Reed 2008)
		Reduction in Safety Incidents	(Dodge Data and Analytics 2015)
Qualitative	General	Improved project definition	(R. Sacks 2004)
		Enhanced estimating accuracy	(R. Sacks 2004)
		Streamlined logistics	(R. Sacks 2004)
		Production automation	(R. Sacks 2004)
		BIM Sensible Value (BSV)	(Kim, et al. 2017)

Value Considerations

Metric	Value Considerations
Implementation Time	• Time required to implement standard processes varies based on IT capabilities • May take weeks but is a one-time investment
Information Production Time	• Time spent on information production varies depending on degree of automation • Structural information production w/ conventional methods: 30 min/1,000 CY • Construction information production w/ conventional methods: 15 min/1,000 CY
Reinforcement Detailing Time	• Manual set up of basic reinforcement: 45 min/1,000 CY • Manual QTO of reinforcement (early estimating): 15 min/1,000 CY
Construction Coordination Time	• Setting up the construction simulation and coordination: 20 min/1,000 CY • Subcontractor task durations vary, but re-modeling information is very time consuming • Most of this time could be saved by producing stakeholder w/ exchange standards
Errors & Omissions	• Several errors and omissions caught during the manual set up of models and information • Specific values for errors and omissions depend on modeler and proficiency with tools

ACI CONCRETE CONVENTION

Thank you!