The National Building Information Modeling Standards

Information Delivery Manual for Precast Concrete

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Executive Summary

February 2, 2009

Objectives:
The purpose of the National Building Information Model Standard (NBIMS) is to generate a set of interoperable standards for exchange of building and infrastructure data through the life-cycle of a project. The goal is to support transparent and robust information exchange in Building Information Modeling. The effort reported here is an early undertaking to develop such a standard for the project data exchanges associated with precast concrete. The exchanges defined cover the complete cycle of information sharing between all parties to the process, and cover the life-cycle of design, engineering and fabrication, but they are all specific to the context of precast concrete construction. Other structural systems and other building parts are included, but only in so far as they affect precast concrete engineering and fabrication. The exchanges between architect and engineer, architect and general contractor, or engineer and general contractor that are included in this standard are not appropriate for construction methods other than precast concrete.

Process:
The standards specification process consists of three major steps: (1) develop a functional specification based on input from the experts in the area being addressed; the specification is called an Information Delivery Manual (IDM), (2) translate the IDM into an implementable specification for software vendors, relying on an appropriate set of standard data models; in this and most exchanges of complex project data, the standard data model is the Industry Foundation Classes (IFC) schema, which is overseen by buildingSMART and the National Institute of Building Sciences (NIBS); (3) the implementation and testing of the exchange specifications, with possible final certification. Thus the output of these efforts is a set of Model View Definitions (MVDs) that define the exchange data needed to support robust and easy data exchange for various precast design, engineering and fabrication tasks. An overview of the process steps in shown in Figure A.

This document is the IDM for Precast Concrete, completing the first step. It addresses all exchanges associated with the major tasks of the precast fabricator, working with other groups. The document is the result of some five months of collaborative effort between the research technical advisory team and the BIM Advisory Committee of the Precast/Prestressed Concrete Institute (PCI). The members of the committee are experts in precast construction, including architects, architectural precast fabricators, structural engineering consultants, structural precast fabricators and a representative of NIBS. Twenty-two PCI members participated.

The group re-organized into four subgroups, each addressing a different aspect of the precast process. Because of different project delivery methods, three different early-stage processes were diagrammed, for precaster as lead contractor, precaster as sub-contractor, and architectural precaster. One backend fabrication process was thought to cover the different front ends. The process models are presented on pages 19, 27, 36 and 44 of this report. Each activity and each exchange are also described in text summaries.

The critical aspects of the exchange model specification are in what we call the ‘Exchange Models’ (EMs). An EM is a detailed functional specification of the precast data for a specific

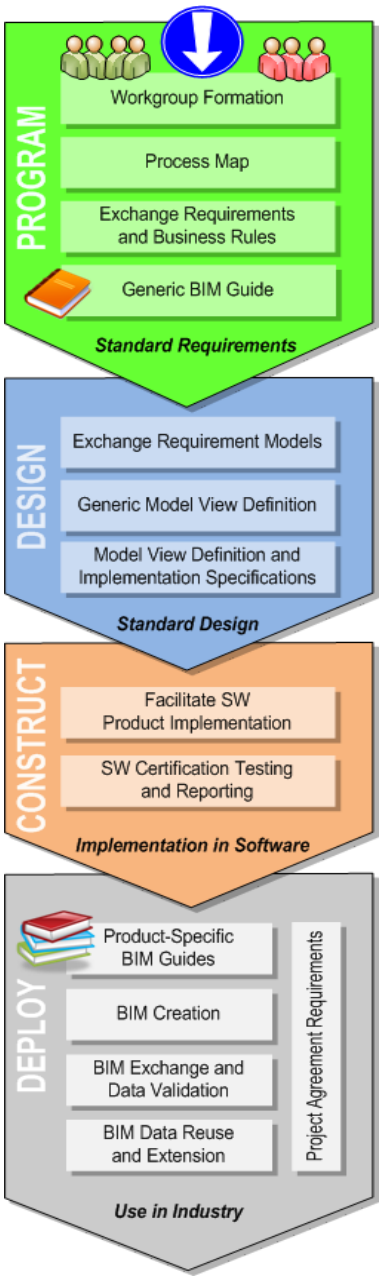

Fig. A: Overall Diagram of the NBIMS Process.

exchange (or use case), in terms of pieces, processes, attributes and relations, that are required for the exchange. In this respect, the technical advisory team attempted to generate as complete a specification as would be needed for implementation, rather than continuous dialogue throughout the process do deal with the specification in ad hoc manner. Of special concern was geometry, the largest and most complex type of project data. The geometry deformation, function, accuracy and level of detail were specified for the exchanges. Properties and relations between parts were also specified. Issues of dealing with user selected subsets of objects and what are minimal subsets for effective exchange are also defined.

Four sets of EMs were specified by the precast experts, with a total of 47 distinct exchanges. There are many similar exchanges and they were all compiled into an integrated exchange table, allowing integration and comparison, presented on page 53 of the report. Analytical comparisons of the degree of difference between the original EMs were made using an Excel macro, as shown on page 52. This enabled identification of EMs similar enough to warrant consolidation into a smaller number of representative EMs.

Thus the consolidated table is comprised of 40 different Exchange Models. Each EM carries up to 445 different parts, attributes, relations or functional capabilities (the effective rows). Although hard to digest as a whole, the consolidated table provides information about each type of precast information item, in terms of the needed functionality for the particular use, for all the 40 exchanges. The contents of this table will be the foundation for the development of implementation specifications in the next stage.

The IDM report will be submitted for review by NIBS and the building SMART Executive Committee.

Information Delivery Manual

Name	Model Exchange for Precast

Change Log		
22-Jan-09	Version 2.0 for final review by PCI BIM Committee	chuck.eastman@coa.gatech.edu cvsacks@techunix.technion.ac.il ivan.panushev@gatech.edu
25-Nov-08	Version 1.0 created, based on Pankow project documents developed by Chuck Eastman and Ivan Panushev of Georgia Tech and Rafael Sacks at Technion	chuck.eastman@coa.gatech.edu cvsacks@techunix.technion.ac.il ivan.panushev@gatech.edu

Exchange Requirements	ER_Precast (all phases)

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BACKGROUND

The National Building Information Model Standard (NBIMS) is a set of interoperable standards for exchange of building and infrastructure data through the life-cycle of a project. NBIMS is a joint project coordinated by the National Institute of Building Sciences (NIBS) in conjunction with many other facilities-related associations and software companies.

The goal of the project within which this document was produced is to develop a national BIM standard for precast concrete design, engineering, fabrication and erection. The method of this work is to define first, the Information Delivery Manuals (IDM) and then, based on the IDM specifications, the Model View Definitions (MVD) for the significant communication and data exchanges associated with all use cases associated with precast concrete. The primary orientation is that of the precast concrete fabricator. The project is funded by the Charles Pankow Foundation and the Precast/Prestressed Concrete Institute (PCI).

This project was preceded by a feasibility study sponsored by the Charles Pankow Foundation to determine the issues of information exchange, focusing on architectural precast. This work has grown from and expands upon that study. IDM development builds on the earlier work coordinated through NIBS and FIATECH that tracked BIM modeling and exchange in a sample project. Related experimental work examined closely the exchange capabilities for precast concrete now available by all major BIM design tools.

Working teams were formed within the membership of the industry BIM Advisory Committee, which functions under the auspices of the Precast/Prestressed Concrete Institute to provide the domain expertise for this endeavor. The initial step has been to define the IDM use case specification. A use case is the functional context leading to one or more data exchanges. The MVD is a detailed specification of the data to be exchanged, in a format implementable by software companies. The MVD provides the mapping to IFC data objects. Upon completion, the MVD will be communicated with software implementers.

The members of each of the four working teams are listed in the following table. Their participation is gratefully acknowledged.

IDM OVERVIEW

This document defines the data exchange functional requirements and workflow scenarios for exchanges between an architects, engineers, general contractors and precast fabricators.

Precast concrete includes external cladding, structural elements, and entire building systems fabricated off-site of concrete, then erected to make up various portions of an overall project.. Precast as a building system, highly interacts with many other aspects of a building. It provides all or part of the external shell or the fundamental building structure; it must transfer its loads to the building foundation. Also, the precast pieces have multiple internal components, including pretension tendon, reinforcing, connection hardware, plus embedded components of other systems. These result in many needs for coordination and thus information exchanges throughout the design and fabrication process. This IDM incorporates exchanges between architects, engineers (structural, civil, MEP) of record, precast fabricators and general contractors and other subs, such as rebar benders, proprietary embed fabricators concrete plants and other procurement-oriented exchanges.

It was recognized throughout this group's meetings that precast project workflows are not standardized, but tuned dynamically to reflect what is most appropriate for a given project and stage. The definitions of workflows in this document are tied into an overall process, as a typical illustrative schedule, not as a prescriptive process. It is laid out to provide a structure for addressing different use case exchanges. These may be selected to define new processes as needed in practice. It is the exchanges that are the target of this document, not a prescribed process.

The PCI BIM Advisory Committee members noted that different workflows and exchanges are undertaken based on the contractual arrangements of the project. Processes are different for Design-Bid-Build delivery form Design-Build or other collaborative processes. Thus four different workflows were defined: three defining varied front-end exchanges, and a single one defining backend production exchanges, that were thought to be similar for all the front-end cases. The front-and cases are shown below:

1. Architectural precast (only) project : precast applied as façade to the building project
2. Precast-led project : these are projects where the precast fabricator also acts as the general contractor
3. Pre-caster as sub-contractor : this is the common case where the precast fabricator is a sub-contractor the general contractor

These three processes are diagrammed in Figure 1, against the general project stages listed across the top of the figure.

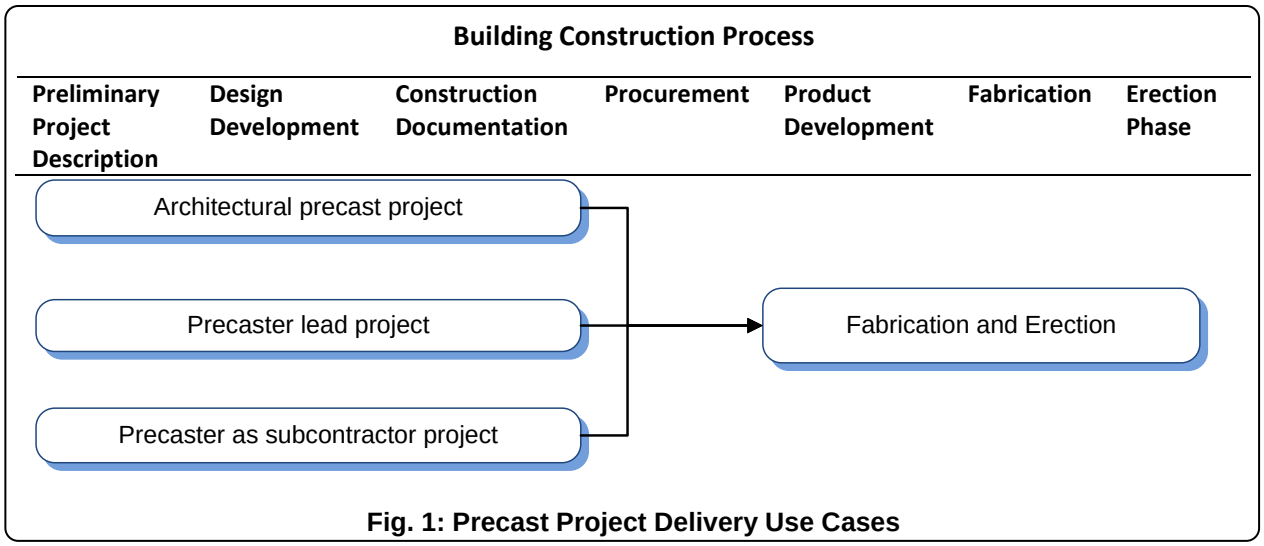


Fig. 1: Precast Project Delivery Use Cases

This document provides a hierarchical structure for access to the various parts of the IDM: These are:

1. **Process Maps and Activity Descriptions** These are defined for the four general processes defined for precast concrete, as per Figure 1. These diagrams and the activity descriptions identify the Activities carried out and the typical phase of design in which they are carried out. The Process map also defines the Exchanges defined by the Advisory Committee as needed to support the information needs to accomplish those activities. These are called Exchange Models (EMs).

2. **Exchange Model Descriptions:** The Exchange Models identified in the Process Maps are described in short paragraphs in the next section, allowing cross-referencing back to the process diagrams. The detailed reported Exchange Models are fully reported in the Consolidated Exchange (EM) Table on page 58, for each of the four Process Maps. These are highly overlapping in function and content. The full EMs have been selectively composed by the technical committee so that their similarities can be readily reviewed. This grouping is presented in the last section of this report (before the Appendices). It is thought to provide an initial structure allowing easy definition of the exchange functionality for later implementation.

3. **Appendices A1-4: Exchange Model Specifications;** the original detailed specification of each Exchange Model in the four process models.

Each use case describes the delivery of the information in the general context of a specific process map. Information exchanges occur within and across process activities and are identified as Exchange Models (or EMs). Exchange models are described with the content information they carry from one activity to another.

Process Map

All process maps were created using the Business Process Modeling Notation (BPMN) (www.bpmn.org). Horizontal swim lanes are used for the major disciplines in the precast process together with the corresponding Omniclass (www.omniclass.org) designation:

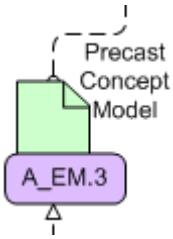
Discipline	Omniclass Designation
Architecture	(33-21-11-00)
Engineering	(33-21 31 00)
Building Product Manufacturing	(33-25 41 11 11)
General Contracting	(33-41 11 11)

Major process phases are identified in the context of their relation to precast construction. Omniclass classification is used to identify their relation to the overall construction process:

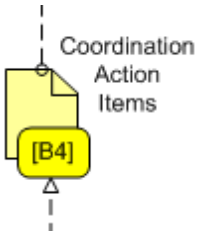
Project Phase	Omniclass Designation
Preliminary Project Description	31-20-10-00
Design Development	31-20-20-00
Construction Documentation	31-25-00-00
Procurement	31-25-00-00
Product Development	31-40-30-00
Fabrication	31-40-40-14-24
Erection Phase	31-40-40-14-11

In addition to the standard BPMN notation the IDM utilizes notation for information exchanges between activities called Exchange Models. Each exchange model is uniquely identified across all four use cases and besides its name caries abbreviated designation of the use case it belongs to:

- A_EM – Architectural precast use case exchange models
- P_EM – Precaster lead use case exchange models
- S_EM – Precaster as subcontractor use case exchange models
- EM – Fabrication and erection use case exchange models



Exchange Model Notation



Review Comments

The exchange model notation allows the unique identification of exchange models across all use cases as follows:

- A_EM.3 Precast Concept Model – Corresponds to Precast Concept Model created in the architectural precast use case and is described in the corresponding process map

Exchanges in the form of review comments are also identified however they are not the subject of this specification.

Activity Descriptions

All activities in the use case process maps are described in the context of their discipline and project phase. Activity descriptions are generic and outline the major tasks performed by the project participant.

Exchange Models

Exchange Models define the functional content of the information to be exchanged in a use case. They are the main information topic result in an ITM. We attempt to specify them in sufficient detail to determine how they should be implemented. We do this by anticipating the implementation choices, and to identify those choices by the functionality expected within the exchange. For example, what will the geometry be used for – editing, spatial coordination and clash checking, for visual review? Will assemblies need to be explicitly denoted, in addition to the pieces that comprise them? Are internal embeds required? By answering these questions, we gain very good information about the future detail requirements to be implemented in the MVDs.

The Exchange Models are defined at three levels:

1. Exchange Model Descriptions: in short written text descriptions, to give an overview of each exchange model and its contents and purpose.
2. Exchange Model Specifications: a fully defined specification of each EM, defined in terms of the exchange requirements for each type of precast information in the exchange, and presented together with the other EMs belonging to the same use case process map.
3. a composite display of all the EMs in a single chart, allowing them to be reviewed and compared.

Exchange Model Descriptions

All exchange models in the use case process maps are described in the context of their project stage and exchange disciplines. Exchange model descriptions are generic and outline the typical content of the information exchanges between specified activities. Additionally related exchanges models are identified in order to allow for reconciliation between similar information exchanges across use cases.

Exchange Model Specifications

The exchange model specifications are detailed functional descriptions of the information exchanges for the use cases. They are initially identified in the process maps and are then defined in generic text in the Exchange Model Descriptions. Finally, they are specified in terms of the information items they must carry. All of the available information items for the domain (of precast concrete, in this case) are organized in a hierarchy of information item groups, information items, attribute sets and attributes, which are defined as follows:

- **Information Groups** represent the major classes of objects in a building model such as site, buildings, assemblies, precast pieces, openings, rebars, etc.
- **Information Items** are specific examples of the members of each information groups. They are defined subject to the assumption that every information item in an information group has the same attributes. As can be seen in the sample exchange specification table shown in Fig 2 below, the information group ‘Foundations’ has information items ‘Grade Beam’, ‘Pier Cap’, ‘Spread Footing’, etc.
- **Attribute Sets** are groups of properties that are used to describe an information group. The attributes are grouped in this way because sets occur in identical form across multiple information groups.
- **Attributes** are the properties that are needed to fully define the information group.

Information Group	Information Items	Attribute Set	Attributes		P_EM.1	P_EM.2	P_EM.3
Foundations							
	Grade Beam, Pier Cap, Spread Footing, Slab on Grade, Stem Wall, Retaining Wall, Drilled Pier, Cassion, Pile, Pile Cap	Shape	Geometry	Required?	R	R	R
				Deformations?	A	A	D
				Function?	V	F	E
				Level of	L	M	H
				Accuracy?	P	P	C
			Dimensional Tolerance	Required?	O	O	R
		Type	Structural Type (CIP	Required?	R	R	R
		Supplier	GC/Contractor/Fabricator	Required?	O	O	O
		Material	Material type	Required?	R	R	R
			Quantity	Required?	O	O	R
		Assembly relations	Part of structural system	Required?			R
		Nested relations	Contains	Required?			O
			Contains connection	Required?			O
		Connection relations	.. to Precast	Required?			O
			.. to CIP	Required?			O
			.. to Steel	Required?			O
		Meta Data	Author, Version, Date	Required?			O
			Approval Status, Date	Required?			O

Fig 2: Sample EM Specification Table

An exchange model specification consists of a listing of all of the information groups and all of their attributes that are needed when making the exchange. Thus given a full listing of available attributes, each exchange model specification must first identify whether each attribute is required, optional or not needed for its case. In Fig 2, the attributes are listed in the rows of the table. Each column on the right hand side specifies one exchange model (i.e. P_EM.1, P_EM.2 and P_EM.3).

Every attribute may be required, optional or not needed for any given exchange. Furthermore, if it is used and it describes geometry, then the minimum way in which the geometry must be provided must also be defined.

Required/Optional/Not needed Property
The first property of each attribute (for each EM) is chosen from the three options: 'Required' (R), 'Optional' (O) or 'Not needed' (blank). When an exchange model definition is specified for implementation by a software company, these values are interpreted in the following way:

1. The export and import functions of any BIM software must recognize and support all of the attributes that are denoted 'Required' AND those denoted 'Optional' in any given exchange in order to be certified as supporting that exchange. When a software company submits an exchange function for **certification**[1], it will be tested for its ability to carry all of the required and the optional attributes.

2. When a user prepares an export file for use in a specific exchange, he or she first selects those objects in their building model that they wish to exchange. This set may be the whole model, but it may also be a subset of the objects in a model – for example, all of the objects on a particular floor level, or all of the precast façade pieces. Once an export file has been compiled, the user can elect to check whether the export file they have generated actually contains all of the information that the receiver will be expecting: this check is called **validation**, and is done against the list of objects and their attributes in the exchange definition that were marked as 'Needed'. Objects and attributes marked 'Optional' are not required for passing the validation check.

3. When a user imports an exchange file, they too can select to import the whole exchange file or a subset of the objects provided in the exchange file. On receipt of the file, a user can also elect to run the same validation check described above, i.e. to validate whether the exchange

[1] This definition is in accordance with the definitions provided in the IAI document "IFC Model View Definition Format", Heitanen, J., 2008. (Page 3).

file contains the minimum set of objects and their attributes according to the exchange model specification.

The rules that are checked during validation can also be called the ‘business rules’ for the exchange.

In the specifications, both information groups and information attributes are marked as ‘Required’, ‘Optional’ or ‘Not needed’. This leads to different behavior in certification and in validation when different combinations of objects and their attributes are supported, and when different object instances and their attributes are provided. Table 1 defines the behavior that will occur in certification and in validation for the different situations that may arise.

Table 1: Certification and Validation testing for different information group and attribute occurrences.

Case	Group REQUIRED, Attribute REQUIRED	Group REQUIRED, Attribute OPTIONAL	Group OPTIONAL, Attribute REQUIRED	Group OPTIONAL, Attribute OPTIONAL
Certification checking of a software's import and export exchange functions				
Both object and attribute are supported	Pass	Pass	Pass	Pass
Object is supported, but the attribute is not supported	Fail	Pass	Fail	Pass
Object is not supported	Fail	Fail	Fail	Pass
Validation of a specific exchange file				
No instances of the group are provided	Fail	Fail	Pass	Pass
An instance of a group is provided, but the attribute is absent	Fail	Pass	Fail	Pass
An instance of the group is provided, and the attribute is present	Pass	Pass	Pass	Pass

Geometry Attribute Properties
However, it is not sufficient to know only whether an attribute is required or not; some attributes represent geometry, and for them, it is important to know what form that geometry description should take in any given exchange. The geometry attributes are classified according to four characteristics:

- **Geometry Deformations** - whether one requires the original geometry defined for casting the piece or the geometry of the piece in its final intended position and shape. The possible values are:
  - *As Cast* - the shape the piece will have in the mold.
  - *Deformed* – the shape the piece will take on in service in the building structure. If a piece is prestressed, it will shorten as soon as it is released from the mold and the cables are cut, and, if eccentrically prestressed, it will also have camber. When installed on site, and possibly with topping concrete added, it may be further deformed as it takes on its live loads. If its supports do not have the same slope, warping might also be introduced.

- **Geometry Function** – how the geometry will be used.
  - *Viewable* – the user can only view the objects without the ability to edit or use them as reference to create associated geometry (e.g. not being able to use the grid lines from one model as reference in another);
  - *Referenceable* – the geometry is viewable and referenceable (e.g. the fabricator can associate geometry in his model to geometry coming from the engineer, geometry can be used for clash detection);
  - *Editable* – the geometry is fully editable (typically parametric).

- **Geometry Accuracy** – what level of definition is required for surfaces.
  - *Planar* - mesh representation with planar segments is sufficient.
  - *Curved* – fully defined curved geometry is required.

- **Geometry Level of Detail** – Level of Detail indicates the amount of detail or the smallest feature that is required for an attribute.
  - *Low*: no chamfers/recesses, no panelization;

- *Medium*: no features, dimensions and model representations are to planar surfaces (not deformed or cast);
- *High*: full fabrication detail as cast; all features including chamfers are shown.

Group and Attribute Property Codes
In the tables that provide the exchange model specifications, letter and color codes are used to indicate the status of each attribute in each model specification. They are defined in Fig. below.

	Variables	**Value Codes**		
Information Group or Attribute	Required/Optional	**R**	**O**	
Geometry Deformations	As Cast/Deformed	**A**	**D**	
Geometry Function	Viewable/Referenceable/Editable	**V**	**F**	**E**
Geometry Accuracy	Planar/Curved	**P**	**C**	
Geometry Level of Detail	Level of Detail High/Medium/Low	**H**	**M**	**L**

Fig. 3 Letter and Color codes used in exchange specification tables.

Exchange model specification tables are based on the process maps, activity descriptions and EM descriptions. The variables are used to make individual selections for each attribute and shown in the sample on the following page.

What can and cannot be carried in a BIM exchange?
How does that influence what should be specified for an exchange model?

To specify an exchange model well, it is useful to understand the mechanics of the BIM exchanges that will eventually be made possible by them. Fig. 4 shows the basic situation.

Fig. 4: Exchanging a model from one BIM software application to another.

However, in any export/import, the user of Software A must define what is to be exported and how it is to be exported (i.e. what attributes and what level of detail). To do this, the export function will allow the Software A user to select a subset of the objects in his or her model for export, and to select a specific exchange model specification that is suitable for the workflow situation. These operations are detailed in Fig. 5.

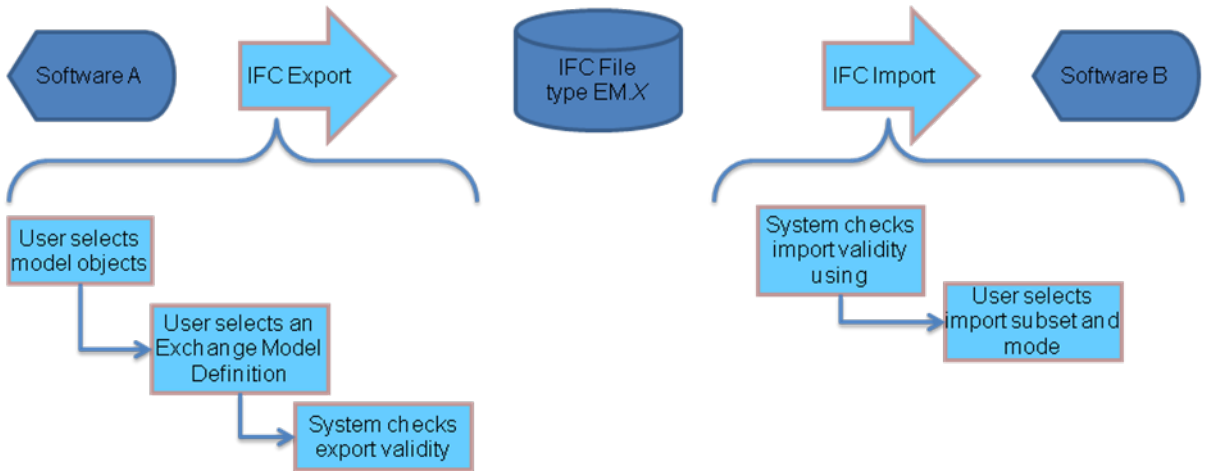


Fig. 5: Detailed process of exchanging a model from one BIM software application to another.

Similarly, the user of Software B can select to import a subset of the objects contained in the IFC exchange file that user A provides. Both users can also opt to run a 'validation check' on the IFC file to check whether it contains all of the information that it should contain according to the exchange model specification.

Within this framework, the information that will in fact be exchanged is limited by the capabilities of the two software applications, the contents of the exchange specification, and the selections of the users. In fact, the amount of information transferred is potentially reduced at every step. This influences the way in which an exchange should be specified in the following ways:

a) If an object or attribute is not supported by Software A (e.g., an architectural BIM application will not model reinforcement), then it cannot appear in an exchange originating in workflows where software like A is used. Specifying such an object or attribute as required or optional in an exchange in which it cannot appear is incorrect – it could mean that no software can pass export certification for that exchange.

b) Likewise, if an object or attribute is not supported by Software B, then specifying it as required or optional in an exchange is similarly meaningless. It could prevent applications like Software B from passing the import certification for the exchange.

An important qualification to item b) above is that some applications can import models at two levels of detail: as internal objects (which can be edited) or as reference objects (which are not converted to the software's own object schema, but simply shown as reference geometry, separate from the actual model, and without any ability to edit the imported objects). Software applications that support import of reference objects can display any valid objects that can occur in an IFC exchange, because it is only their geometry that is used. *As such, information that is not recognized as internal objects by software B can still be relevant and valid for exchanges made from A to B, because it can be recognized and used by the operator of software B.*

Thus any exchange specification should be limited by the capabilities of both types of software applications i.e. to the objects and attributes that are recognized by software type A and can be used by software type B (whether as internal editable objects or as reference information only).

Consistent and Consolidated Exchange Models

The exchange models initially defined by the four working groups displayed a degree of inconsistency in their use of the specification terms and in timing of their appearance vis-à-vis the process stages for which they were specified. This was revealed by analysis in which each EM specification was compared with every other EM specification, using an automated routine (see page 53).

An iterative cycle of review was initiated, in which the technical advisory team distributed an expanded set of guidelines, and in which BIM advisory committee members reviewed models across groups. Finally, the advisory team edited the specifications to implement the review comments.

The final step in this process was to consolidate EM specifications that were close to identical. The motivation for consolidation is that if the full number were considered for implementation separately, it would have the following ramifications:

1. users would have a large number of exchanges to select from and manage
2. implementers would have an onerous task for implementation.

In reality, many of the exchanges are similar, based on the project phase when the exchange is made, and between which roles. The consolidation effort reduced the number of discrete EMs. However, full rationalization will be achieved at the level of concepts and constructs[2] in the Model View Definitions (MVD), which is beyond the scope of this document. Together the separate EMs and undertakes an initial comparison of the differences between all pairs, as a first assessment to be used for future integration.

[2] Constructs are the basic building blocks of information items that are defined for model view specification of an exchange model. They can be directly bound to entities from a product model schema. Constructs are detailed specifications of information items in which specific sets of attributes are activated, while others are not activated. In this way, a single construct, say of a structural precast piece at a conceptual level of detail, can serve multiple exchange models. A separate construct of the same structural precast piece information item, with a level of detail appropriate for fabrication, can serve multiple other exchange models. Thus the number of constructs (for any given information item) will be significantly smaller than the number of exchange models that contain that information item.

USE CASE DESCRIPTIONS

ARCHITECTURAL PRECAST

Specification of the Architectural Precast Process

The following tasks and sub-processes refer to the process diagram shown on the following page. The process diagram uses Business Process Modeling Notation.

[1.1] Schematic Design Facade

Type	Task
Name	Schematic Design Facade
Omniclass Code	31-20-10-00 Preliminary Project Description
Documentation	The architects or designers will use an approved or certified BIM authoring application to develop a Building Model that may include non-structural precast façade panels. They will define the panel layout, fenestration, and surface patterning. They will place structural elements needed to carry the precast pieces. They will identify elements that are embedded within the precast or are attached to it. The proposed layout may be made available for review in sketch and drawings or as a model.

[1.2] Structural Concept

Type	Task
Name	Structural Concept
Omniclass Code	31-20-10-00 Preliminary Project Description
Documentation	Engineer uses concept model from architect to provide feedback on the structural grid, structural system, major precast connections issues, interfaces between precast and other structural and curtain wall system.

[1.3] Design Review and Concept Modeling

Type	Task
Name	Design Review and Concept Modeling
Omniclass Code	31-20-10-00 Preliminary Project Description
Documentation	Precaster uses schematic design model from architect to propose major architectural/structural precast components. This may deal with precast structural system, panelization, architectural panel finishes, and site logistics.

[1.4] Design Development

Type	Task
Name	Design Development
Omniclass Code	31-20-20-00 Design Development
Documentation	Architects continue building design by reviewing models or documentation provided by fabricators or installers regarding precast design intent. This may deal with incorporating precasters' proposals for structural system and penalization in architects'' models. Precast finishes are reviewed and further specified. Architect specifies doors, windows, interior wall partitions, curtain wall systems.

[1.5] Engineering Requirements

Type	Task
Name	Structural Requirements
Omniclass Code	31-20-20-00 Design Development
Documentation	Structural engineers review architects' models and define the structural requirements on the building. This may include load calculations, precast connection design, precast-to-structural steel connection design, and foundation design. Engineers work with precasters to determine precast and connection element capacities.

[1.6] Precast Bid Preparation

Type	Task
Name	Precast Bid Preparation
Omniclass Code	31-20-20-00 Design Development
Documentation	Precaster prepares precast cost estimate based on the architectural and structural construction documents. The bid estimate may include schematic fabrication drawings, specifications, and subcontractor procurement information.

[1.7] GC Bid Preparation

Type	Task
Name	GC Bid Preparation
Omniclass Code	31-20-20-00 Design Development
Documentation	General contractor receives building requirements from architect and engineer and prepares information to issue to subcontractors for bidding. This information includes identification which suppliers are to bid on which elements of the building. The General contractor receives bids for all of the elements and systems from several precasters or other subcontractors. The GC reviews the budget, schedule, models, drawings and specifications. The GC makes the precaster selection decision.

[1.8] Precast Detailing

Type	Task
Name	Precast Detailing
Omniclass Code	31-30-00-00 Procurement
Documentation	High-level description of precast piece detailing. Includes detailing of all details, finishes, joints and connections. Includes all embeds, reinforcing, tensioning cable layout and block outs. Precast pieces adjusted for fabrication, including dimensional corrections for pre-tensioning, raking of vertical mold surfaces to facilitate release and lifting hooks for lifting and transporting.

[1.9] Design Intent Validation

Type	Task
Name	Design Intent Validation
Omniclass Code	31-30-00-00 Procurement
Documentation	The architects or designers review precast fabricator detailed model with corrections as required.

[1.10] Structural Design Review

Type	Task
Name	Structural Design Review
Omniclass Code	31-30-00-00 Procurement
Documentation	Structural engineers review the models and drawings prepared by the precaster. Structural integrity of the building is evaluated in cases where structural design changes are needed due to building trade coordination.

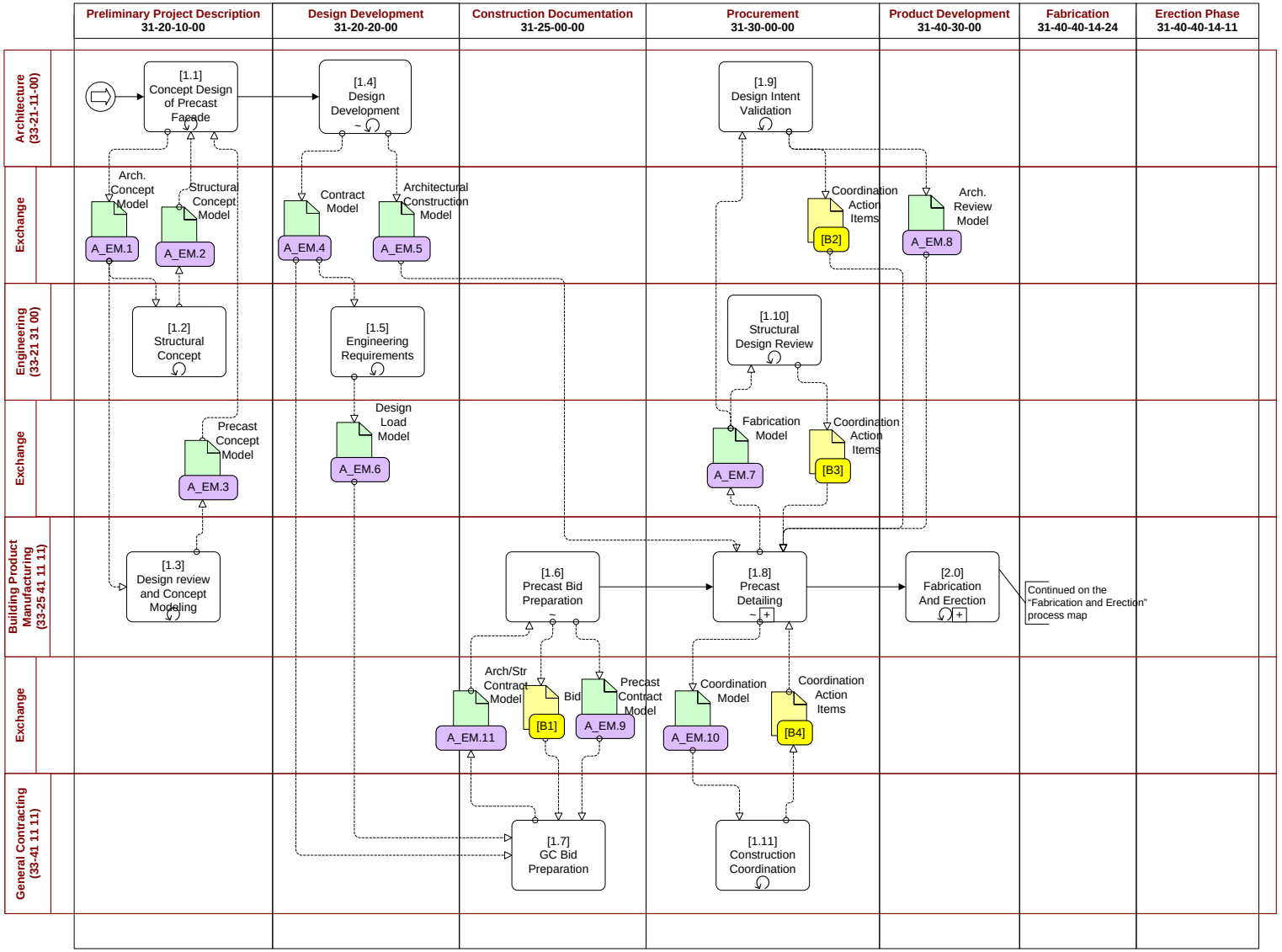
[1.11] Construction Coordination

Type	Task
Name	Construction Coordination
Omniclass Code	31-30-00-00 Procurement
Documentation	The General contractor coordinates with all subcontractors regarding the sequence of construction and there for delivery and erection sequences. Initially these are at a high level. The models are used to review complex conditions needed special attention.

[2.0] Fabrication and Erection

Type	Task
Name	Fabrication and Erection
Omniclass Code	31-40-30-00 Product Development
Documentation	The General contractor coordinates with all subcontractors regarding the sequence of construction and there for delivery and erection sequences. Initially these are at a high level. The models are used to review complex conditions needed special attention.

Process Map: Architectural Precast Project



Specification of Exchange Models for Architectural Precast

This section defines the contents required for each exchange model in terms of functional exchange objects. The exchange objects are specified in the following section.

Change Log		
25-Nov-08	Version 1.0 created, based on Pankow project documents developed by Chuck Eastman and Ivan Panushev of Georgia Tech and Rafael Sacks at Technion	chuck.eastman@coa.gatech.edu cvsacks@techunix.technion.ac.il ivan.panushev@gatech.edu

Exchange Model Definitions

			Architectural Concept Model	Structural Concept Model	Precast Concept Model	Contract Model	Arch. Construction Model	Design Load Model	Fabrication Model	Architectural Review Model	Precast Contract Model	Coordination Model	Arch/Structural Contract Model
	Omniclass		A_EM.1	A_EM.2	A_EM.3	A_EM.4	A_EM.5	A_EM.6	A_EM.7	A_EM.8	A_EM.9	A_EM.10	A_EM.11
Project Stage	31-20-10-00	Preliminary Project Description	✓	✓	✓								
	31-20-20-00	Design Development				✓	✓	✓					
	31-25-00-00	Construction Documentation									✓		✓
	31-25-00-00	Procurement							✓	✓		✓	
	31-40-30-00	Product Development											
	31-40-40-14-24	Fabrication											
	31-40-40-14-11	Erection Phase											
Discipline	(33-21-11-00)	Architecture	✓	✓	✓	✓	✓		✓	✓	✓		
	(33-21 31 00)	Engineering	✓	✓		✓		✓	✓				
	(33-25 41 11 11)	Building Product Manufacturing	✓		✓		✓		✓	✓		✓	✓
	(33-41 11 11)	General Contracting				✓		✓			✓	✓	✓

Exchange Model Descriptions for Architectural Precast

The following descriptions refer to the process diagram shown on the following page. The process diagram uses Business Process Modeling Notation.

[A_EM.1] Architectural Concept Model

Project Stage	31-20-10-00 Preliminary Project Description
Exchange Disciplines	(33-21-11-00) Architecture (33-21 31 00) Engineering (33-25 41 11 11) Building Product Manufacturing
Description	Architectural concept model consists of concept layout of precast pieces into simple assemblies, without surface or structural detailing. Building model includes massing models, structural and other grid controls, building program and space layout and use, expected thermal and acoustic functions, if known, It might involve major architectural finishes, structural system selection, structural grid and site analysis.
Related Exchange Models	A_EM.1, P_EM.1, S_EM.1

[A_EM.2] Structural Concept Model

Project Stage	31-20-10-00 Preliminary Project Description
Exchange Disciplines	(33-21-11-00) Architecture (33-21 31 00) Engineering
Description	The engineering concept model provides information about the structural grid, structural system, major precast connections and issues, interfaces between precast and other structural and curtain wall systems.
Related Exchange Models	A_EM.2, P_EM.2, S_EM.2

[A_EM.3] Precast Concept Model

Project Stage	31-20-10-00 Preliminary Project Description
Exchange Disciplines	(33-21-11-00) Architecture (33-25 41 11 11) Building Product Manufacturing
Description	Precast concept model is based on architectural concept models from architects and specifies major architectural/structural precast components. This may deal with precast structural system, panelization, architectural panel finishes, and site logistics.
Related Exchange Models	

[A_EM.4] Contract Model

Project Stage	31-20-20-00 Design Development
Exchange Disciplines	(33-21-11-00) Architecture (33-21 31 00) Engineering (33-25 41 11 11) Building Product Manufacturing (33-41 11 11) General Contracting
Description	The architectural contract model integrates the building layout of all precast pieces with all other building systems. It includes precast the layout of surface finishes, molding, reveals and other decorative features. Other system interacting with precast are also passed. The pass-off exchange is prepared to support production of a construction drawing set.
Related Exchange Models	A_EM.4, P_EM.9, S_EM.4

[A_EM.5] Arch. Construction Model

Project Stage	31-20-20-00 Design Development
Exchange Disciplines	(33-21-11-00) Architecture (33-21 31 00) Engineering (33-41 11 11) General Contracting
Description	The architectural construction model is further refinement of the contract model and may include new information about finishes, layout and precast elements, methods of interacting with other systems (pass-throughs, connections). The exchange is prepared as revised construction -level model and optionally drawings.
Related Exchange Models	

[A_EM.6] Design Load Model

Project Stage	31-20-20-00 Design Development
Exchange Disciplines	(33-21 31 00) Engineering (33-25 41 11 11) Building Product Manufacturing
Description	The design load model is based on architect's construction model and defines the structural requirements of the building. It may include load calculations, precast connection designs, precast-to-structural steel connection design, foundation design and connection element capacities.
Related Exchange Models	A_EM.6, P_EM.6, P_EM.7

[A_EM.7] Fabrication Model

Project Stage	31-25-00-00 Procurement
Exchange Disciplines	(33-21-11-00) Architecture (33-21 31 00) Engineering (33-25 41 11 11) Building Product Manufacturing
Description	The precast fabrication model is developed by the precaster and includes high-level description of precast piece detailing, descriptions of all connection details, finishes, joints, embeds, reinforcing, tensioning cable layout and blockouts, pre-tensioned pieces, and lifting hooks for lifting and transporting. It is sent for review to the architect and engineer.
Related Exchange Models	A_EM.7, S_EM.8

[A_EM.8] Architectural Review Model

Project Stage	31-25-00-00 Procurement
Exchange Disciplines	(33-21-11-00) Architecture (33-25 41 11 11) Building Product Manufacturing
Description	The architectural review model is the architect's response from design intent review of the precast fabrication model. It identifies those aspects of the design where design intent has not been met. It may contain mark-ups of detailing, finishes, reveals and other decorative aspects; It is being developed by the architect to ensure consistency between the architectural design and precast detailing models.
Related Exchange Models	

[A_EM.9] Precast Contract Model

Project Stage	31-25-00-00 Construction Documentation
Exchange Disciplines	(33-21-11-00) Architecture (33-41 11 11) General Contracting
Description	Precast contract model consist of the total building cost estimate based

	on the early schematic design models. The bid estimate may include schematic architectural/structural models and drawings, specifications, and subcontractor information.
Related Exchange Models	

[A_EM.10] Coordination Model

Project Stage	31-25-00-00 Procurement
Exchange Disciplines	(33-25 41 11 11) Building Product Manufacturing (33-41 11 11) General Contracting
Description	The precast detail model is used by the GC for coordination, merged with other trade models. It is high-level description of precast piece detailing and includes descriptions of all connection details, finishes, joints, embeds, reinforcing, tensioning cable layout and blockouts, pre-tensioned pieces, and lifting hooks for lifting and transporting.
Related Exchange Models	A_EM.10, P_EM.12, S_EM.9

[A_EM.11] Arch/Structural Contract Model

Project Stage	31-25-00-00 Construction Documentation
Exchange Disciplines	(33-25 41 11 11) Building Product Manufacturing (33-41 11 11) General Contracting
Description	The architectural/structural contract model is being assembled by the GC and delivered to the precaster for bid preparation. It integrates information from the architect and engineer about the building layout, surface finishes, molding, reveals, decorative features. The structural portion is focused on the structural design and layout, structural elements, connections and details. The exchange is prepared as a construction drawing set or construction-level model.
Related Exchange Models	

Exchange Model Specifications for Architectural Precast

The exchange model specification tables are completed in accordance with the details provided in this use case and the IDM overview section. The exchange model specification tables are provided in the Consolidated EM Table starting on Page 58. All of the architectural precast exchange models are designated with the prefix "A_EM".

PRECASTER LEAD PROJECT

Specification of Precast Lead Project Process

The following tasks and sub-processes refer to the process diagram shown on the following page. The process diagram, in Business Process Modeling Notation, describes a precaster-lead design and construction process flow in a negotiated bid environment.

[1.1] Schematic Design

Type	Task
Name	Schematic Design
Omniclass Code	31-20-10-00 Preliminary Project Description
Documentation	Architects create schematic design models of the building. They might include massing model studies, building program analysis, circulation analysis and elevation studies. It might involve specifying major architectural finishes, structural system selection, structural grid and site analysis.

[1.2] Schematic Design of Precast System

Type	Task
Name	Schematic Design of Precast System
Omniclass Code	31-20-10-00 Preliminary Project Description
Documentation	Precaster uses schematic design model from architect to propose major architectural/structural precast components. This may deal with precast structural system, panelization, architectural panel finishes, and site logistics. Precaster prepares a total building cost estimate based on the early schematic design. The bid estimate may include schematic architectural/structural drawings, specifications, and subcontractor information.

[1.3] Design Development

Type	Task
Name	Design Development
Omniclass Code	31-20-20-00 Design Development
Documentation	Architects continue building design by reviewing models or documentation provided by fabricators or installers regarding precast design intent. This may deal with incorporating precasters' proposals for structural system and panelization in architects'' models. Precast finishes are reviewed and further specified. Architect specifies doors, windows, interior wall partitions, curtain wall systems.

[1.4] Structural Requirements

Type	Task
Name	Structural Requirements
Omniclass Code	31-20-20-00 Design Development
Documentation	Structural engineers review architects' models and define the structural requirements on the building. This may include load calculations, precast connection design, precast-to-structural steel connection design, foundation design. Engineers work with precasters to determine precast and connection element capacities.

[1.5] Precast System Design Development

Type	Task
Name	Precast System Design Development
Omniclass Code	31-20-20-00 Design Development
Documentation	After the bid has been awarded the precasters continue to design the building based on architects' designs. Precast slabs, beams, columns, and connections are designed. Models, drawings and specifications are exchanged for review with architects and engineers to ensure the building design intent and the structural adequacy are preserved.

[1.6] GMP Preparation

Type	Task
Name	GMP Preparation
Omniclass Code	31-20-20-00 Design Development
Documentation	General contractor received the bid for the entire building from several precasters or other subcontractors. The GC reviews the budget, schedule, models, drawings and specifications. The information is passed to the owner/architect group to make a go/no-go decision about the building.

[1.7] Construction Documentation

Type	Task
Name	Construction Documentation
Omniclass Code	31-25-00-00 Construction Documentation
Documentation	The architects refine the architectural design and integrate the layout with other building systems. Surface finishes, molding, reveals and other decorative features are defined. The information is prepared as a construction drawing set, or optionally, a construction-level model.

[1.8] Construction Detailing

Type	Task
Name	Construction Detailing
Omniclass Code	31-25-00-00 Construction Documentation
Documentation	The engineers refine the structural design and integrate their layout with other building systems. Structural elements, connections and details are described. Both the precast and the other structural systems are fully designed. The information is prepared as a construction drawing set, or optionally, a construction-level model.

[1.9] Design Intent Validation

Type	Task
Name	Design Intent Validation
Omniclass Code	31-30-00-00 Procurement
Documentation	The architects or designers review precast fabricator detailed model with corrections as required.

[1.10] Structural Design Review

Type	Task
Name	Structural Design Review
Omniclass Code	31-30-00-00 Procurement
Documentation	Structural engineers review the models and drawings prepared by the

	precaster. Structural integrity of the building is evaluated in cases where structural design changes are needed due to building trade coordination.

[1.11] Precast Detailing

Type	Task
Name	Structural Design Review
Omniclass Code	31-25-00-00 Construction Documentation
Documentation	High-level description of precast piece detailing. Includes detailing of all details, finishes, joints and connections. Includes all embeds, reinforcing, tensioning cable layout and blockouts. Precast pieces adjusted for fabrication, including dimensional corrections for pre-tensioning, raking of vertical mold surfaces to facilitate release and lifting hooks for lifting and transporting.

[1.12] Precast Procurement

Type	Sub-process
Name	Task
Omniclass Code	31-30-00-00 Procurement
Documentation	The precaster buys the necessary materials, forms, reinforcement, connection plates and other components needed to procure the project. The building model, drawings and specifications are used in the buyout process.

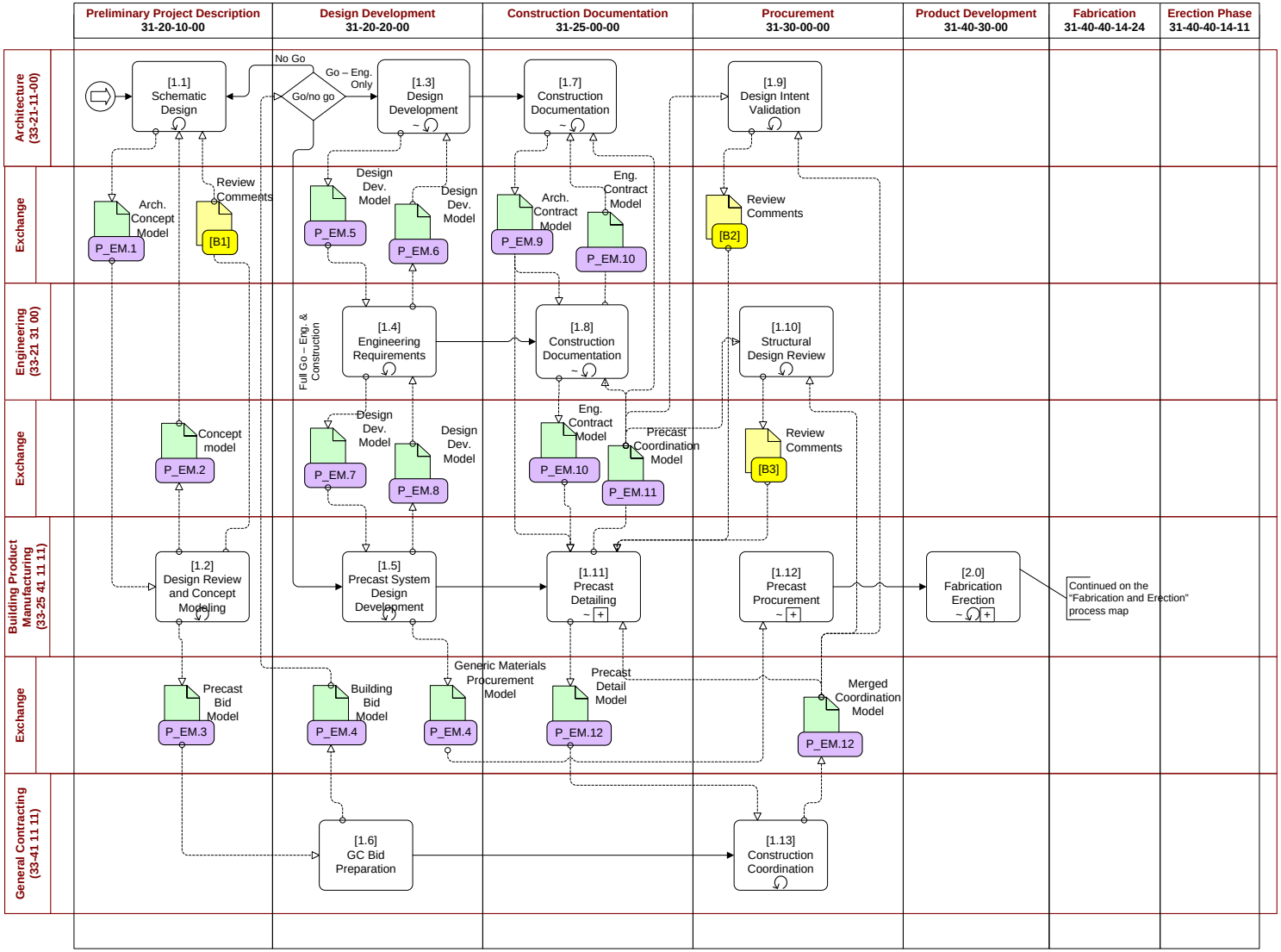
[1.13] Construction Coordination

Type	Task
Name	Construction Coordination
Omniclass Code	31-30-00-00 Procurement
Documentation	The General contractor coordinates with all subcontractors regarding the sequence of construction and there for delivery and erection sequences. Initially these are at a high level. The models are used to review complex conditions needed special attention.

[2.0] Fabrication and Erection

Type	Task
Name	Fabrication and Erection
Omniclass Code	31-40-30-00 Product Development
Documentation	The General contractor coordinates with all subcontractors regarding the sequence of construction and there for delivery and erection sequences. Initially these are at a high level. The models are used to review complex conditions needed special attention.

Process Map: Precaster Lead Project



Specification of Exchange Models for Precaster Lead Projects

This section defines the contents required for each exchange model in terms of functional exchange objects. The exchange objects are specified in the following section.

Change Log		
25-Nov-08	Version 1.0 created, based on Pankow project documents developed by Chuck Eastman and Ivan Panushev of Georgia Tech and Rafael Sacks at Technion	chuck.eastman@coa.gatech.edu cvsacks@techunix.technion.ac.il ivan.panushev@gatech.edu

Exchange Model Definitions

			Architectural Concept Model	Precast Concept Model	Precast Bid/Material Procurement Model	Building Bid Model	Arch. Design Development Model	Str. Design Development Model	Str. Design Development Model	Precast Design Development Model	Arch. Contract Model	Engineering Contract Model	Precast Coordination Model	Precast Detail/Merged Coordination Model
	Omniclass		P_EM.1	P_EM.2	P_EM.3	P_EM.4	P_EM.5	P_EM.6	P_EM.7	P_EM.8	P_EM.9	P_EM.10	P_EM.11	P_EM.12
Project Stage	31-20-10-00	Preliminary Project Description	✓	✓	✓									
	31-20-20-00	Design Development				✓	✓	✓	✓	✓				
	31-25-00-00	Construction Documentation									✓	✓	✓	✓
	31-25-00-00	Procurement												✓
	31-40-30-00	Product Development												
	31-40-40-14-24	Fabrication												
	31-40-40-14-11	Erection Phase												
Discipline	(33-21-11-00)	Architecture	✓			✓	✓	✓			✓		✓	
	(33-21 31 00)	Engineering		✓			✓	✓	✓	✓	✓	✓	✓	
	(33-25 41 11 11)	Building Product Manufacturing	✓	✓	✓				✓	✓	✓	✓	✓	✓
	(33-41 11 11)	General Contracting			✓	✓								✓

Exchange Model Descriptions for Precaster Lead Projects

The following descriptions refer to the process diagram shown on the following page. The process diagram uses Business Process Modeling Notation.

[P_EM.1] Architectural Concept Model

Project Stage	31-20-10-00 Preliminary Project Description
Exchange Disciplines	(33-21-11-00) Architecture (33-25 41 11 11) Building Product Manufacturing
Description	Architectural concept model consists of concept layout of precast pieces into simple assemblies, without surface or structural detailing. Building model includes massing models, structural and other grid controls, building program and space layout and use, expected thermal and acoustic functions, if known, It might involve major architectural finishes, structural system selection, structural grid and site analysis. With precaster as lead, these models are likely to be more developed than those in other business cases.
Related Exchange Models	A_EM.1, P_EM.1, S_EM.1

[P_EM.2] Precast Concept Model

Project Stage	31-20-10-00 Preliminary Project Description
Exchange Disciplines	(33-21 31 00) Engineering (33-25 41 11 11) Building Product Manufacturing
Description	Precast concept model is based on architectural concept models from architects and specifies major architectural/structural precast components. This may deal with precast structural system, panelization, architectural panel finishes, and site logistics.
Related Exchange Models	A_EM.2, P_EM.2, S_EM.2

[P_EM.3] Precast Bid/Material Procurement Model

Project Stage	31-20-10-00 Preliminary Project Description
Exchange Disciplines	(33-25 41 11 11) Building Product Manufacturing (33-41 11 11) General Contracting
Description	Precast bid model consist of the total building cost estimate based on the early schematic design models. The bid estimate may include schematic architectural/structural models and drawings, specifications, and subcontractor information. It is also used to procure materials that have been agreed upon with the owner or architect requiring long lead times.
Related Exchange Models	

[P_EM.4] Building Bid Model

Project Stage	31-20-20-00 Design Development
Exchange Disciplines	(33-21-11-00) Architecture (33-41 11 11) General Contracting
Description	The building bid model by the general contractor includes budget, schedule, concept design models, drawings and specifications for the entire building received from several precasters or other subcontractors. The model and bid package is passed to the owner/architect group to make a go/no-go decision about the building.
Related Exchange Models	

[P_EM.5] Arch. Design Development Model

Project Stage	31-20-20-00 Design Development
Exchange Disciplines	(33-21-11-00) Architecture (33-21 31 00) Engineering
Description	The architectural design development model reflects the detailed design intent of precast concrete as integrated with all other systems The building information model and documentation provides fabricators and installers the framework regarding precast design intent. It may incorporate precasters' proposals for structural systems and panelization. Precast finishes are defined together with doors, windows, interior wall partitions, and curtain wall systems embedded in or related to the precast.
Related Exchange Models	A_EM.6, P_EM.5, S_EM.3

[P_EM.6] Str. Design Development Model

Project Stage	31-20-20-00 Design Development
Exchange Disciplines	(33-21-11-00) Architecture (33-21 31 00) Engineering
Description	The structural design development model is based on architect's design development model and defines the structural requirements of the building. It may include load calculations, precast connection designs, precast-to-structural steel connection design, foundation design and connection element capacities.
Related Exchange Models	P_EM.6, P_EM.7

[P_EM.7] Str. Design Development Model

Project Stage	31-20-20-00 Design Development
Exchange Disciplines	(33-21 31 00) Engineering (33-25 41 11 11) Building Product Manufacturing
Description	The structural design development model is based on architect's design development model and defines the structural requirements of the building. It is passed to the precaster for review and may include load calculations, precast connection designs, precast-to-structural steel connection design, foundation design and connection element capacities.
Related Exchange Models	P_EM.6, P_EM.7

[P_EM.8] Precast Design Development Model

Project Stage	31-20-20-00 Design Development
Exchange Disciplines	(33-21 31 00) Engineering (33-25 41 11 11) Building Product Manufacturing
Description	The precast design development model is a continuation of the building design based on architects' designs. It includes precast slabs, beams, columns, and connections. Models, drawings and specifications are exchanged for review with architects and engineers to ensure the building design intent and the structural adequacy are preserved.
Related Exchange Models	

[P_EM.9] Arch. Contract Model

Project Stage	31-25-00-00 Construction Documentation
Exchange Disciplines	(33-21-11-00) Architecture (33-21 31 00) Engineering

	(33-25 41 11 11) Building Product Manufacturing
Description	The architectural contract model integrates the building layout of all precast pieces with all other building systems. It identifies the shape and logical connectivity of all precast pieces. It includes layout of surface finishes, molding, reveals and other decorative features. Other system interacting with precast are also passed. The pass-off exchange is prepared to support production of a construction drawing set.
Related Exchange Models	A_EM.4, P_EM.9, S_EM.4

[P_EM.10] Engineering Contract Model

Project Stage	31-25-00-00 Construction Documentation
Exchange Disciplines	(33-21 31 00) Engineering (33-25 41 11 11) Building Product Manufacturing
Description	The engineering contract model is focused on the structural design and integrates the structural layout with other building systems. It includes structural elements, connections and details. Both the precast and other structural systems are fully designed. The exchange is prepared as a construction drawing set or construction-level model.
Related Exchange Models	A_EM.11, P_EM.10, S_EM.5

[P_EM.11] Precast Coordination Model

Project Stage	31-25-00-00 Construction Documentation
Exchange Disciplines	(33-21-11-00) Architecture (33-21 31 00) Engineering (33-25 41 11 11) Building Product Manufacturing
Description	The precast coordination model is an early stage of the precast detail model and is used for coordination of all precast components. It includes detailed model descriptions of all precast structural elements. It is being reviewed by the engineer for structural and logistical consistency.
Related Exchange Models	A_EM.10, P_EM.12, S_EM.9

[P_EM.12] Precast Detail/Merged Coordination Model

Project Stage	31-25-00-00 Construction Documentation / 31-25-00-00 Procurement
Exchange Disciplines	(33-25 41 11 11) Building Product Manufacturing (33-41 11 11) General Contracting
Description	The precast detail model is used by the GC for coordination, merged with other trade models. It is high-level description of precast piece detailing and includes descriptions of all connection details, finishes, joints, embeds, reinforcing, tensioning cable layout and blockouts, pre-tensioned pieces, and lifting hooks for lifting and transporting.
Related Exchange Models	

Exchange Model Specifications for Precaster Lead Projects

The exchange model specification tables are completed in accordance with the details provided in this use case and the IDM overview section. The exchange model specification tables are provided in the Consolidated EM Table starting on Page 58. All of the precaster lead exchange models are designated with the prefix "P_EM".

PRECASTER AS SUBCONTRACTOR

Specification of the Precaster as Subcontractor Process

The following tasks and sub-processes refer to the process diagram shown on the following page. The process diagram uses Business Process Modeling Notation.

[1.1] Schematic Design

Type	Task
Name	Schematic Design
Omniclass Code	31-20-10-00 Preliminary Project Description
Documentation	Architects create schematic design models of the building. They might include massing model studies, building program analysis, circulation analysis and elevation studies. It might involve specifying major architectural finishes, structural system selection, structural grid and site analysis.

[1.2] Engineering Concept

Type	Task
Name	Specify Structural System
Omniclass Code	31-20-10-00 Preliminary Project Description
Documentation	Engineer uses concept model from architect to provide feedback on the structural grid, structural system, major precast connections issues, interfaces between precast and other structural and curtain wall system.

[1.3] Design Review and Concept Modeling

Type	Task
Name	Design Review and Concept Modeling
Omniclass Code	31-20-10-00 Preliminary Project Description
Documentation	Precaster uses schematic design model from architect to propose major architectural/structural precast components. This may deal with precast structural system, panelization, architectural panel finishes, and site logistics.

[1.4] Design Development

Type	Task
Name	Design Development
Omniclass Code	31-20-20-00 Design Development
Documentation	Architects continue building design by reviewing models or documentation provided by fabricators or installers regarding precast design intent. This may deal with incorporating precasters' proposals for structural system and penalization in architects'' models. Precast finishes are reviewed and further specified. Architect specifies doors, windows, interior wall partitions, curtain wall systems.

[1.5] Engineering Requirements

Type	Task
Name	Structural Requirements
Omniclass Code	31-20-20-00 Design Development
Documentation	Structural engineers review architects' models and define the structural requirements on the building. This may include load calculations,

	precast connection design, precast-to-structural steel connection design, and foundation design. Engineers work with precasters to determine precast and connection element capacities.

[1.6] Development Review

Type	Task
Name	Development Review
Omniclass Code	31-20-20-00 Design Development
Documentation	The precast manufacturer reviews design development model from the architect and creates preliminary project plan. The precaster provides feedback on floor spans, floor to ceiling clearances, major structural elements sizes, etc.

[1.7] Construction Documentation

Type	Task
Name	Construction Documentation
Omniclass Code	31-25-00-00 Construction Documentation
Documentation	The architect refines the structural design and integrates their layout with other building systems. Structural elements, connections and details are described. Both the precast and the other structural systems are fully designed. The information is prepared as a construction drawing set, or optionally, a construction-level model.

[1.8] Construction Documentation

Type	Task
Name	Construction Documentation
Omniclass Code	31-25-00-00 Construction Documentation
Documentation	The engineer refines the structural design and integrates their layout with other building systems. Structural elements, connections and details are described. Both the precast and the other structural systems are fully designed. The information is prepared as a construction drawing set, or optionally, a construction-level model.

[1.9] Precast Bid Preparation

Type	Task
Name	Precast Bid Preparation
Omniclass Code	31-25-00-00 Construction Documentation
Documentation	Precaster prepares precast cost estimate based on the architectural and structural construction documents. The bid estimate may include schematic fabrication drawings, specifications, and subcontractor procurement information.

[1.10] GC Bid Preparation

Type	Task
Name	GC Bid Preparation
Omniclass Code	31-25-00-00 Construction Documentation
Documentation	General contractor receives the bid for the entire building from several precasters or other subcontractors. The GC reviews the budget, schedule, models, drawings and specifications. The GC makes the

	precaster selection decision.

[1.11] Design Intent Validation

Type	Task
Name	Design Intent Validation
Omniclass Code	31-30-00-00 Procurement
Documentation	The architects or designers review precast fabricator detailed model with corrections as required.

[1.12] Design Review Structural System Integration

Type	Task
Name	Structural Design & Reinforcement Review
Omniclass Code	31-30-00-00 Procurement
Documentation	Structural engineers review the models and drawings prepared by the precaster. Structural integrity of the building is evaluated in cases where structural design changes are needed due to building trade coordination.

[1.13] Precast Detailing

Type	Task
Name	Structural Design Review
Omniclass Code	31-30-00-00 Procurement
Documentation	High-level description of precast piece detailing. Includes detailing of all details, finishes, joints and connections. Includes all embeds, reinforcing, tensioning cable layout and block outs. Precast pieces adjusted for fabrication, including dimensional corrections for pre-tensioning, raking of vertical mold surfaces to facilitate release and lifting hooks for lifting and transporting.

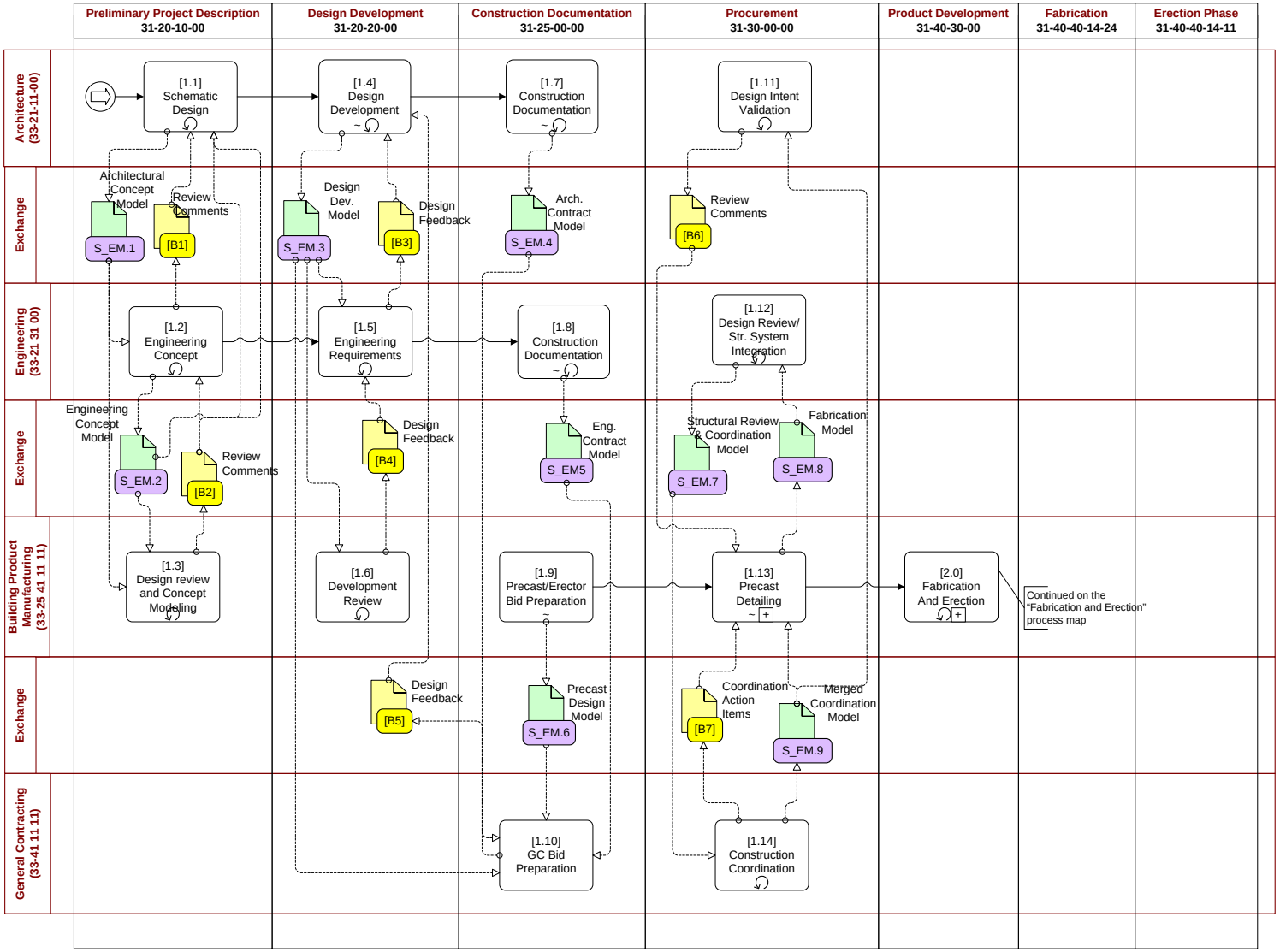
[1.14] Construction Coordination

Type	Task
Name	Construction Coordination
Omniclass Code	31-30-00-00 Procurement
Documentation	The General contractor coordinates with all subcontractors regarding the sequence of construction and there for delivery and erection sequences. Initially these are at a high level. The models are used to review complex conditions needed special attention.

[2.0] Fabrication and Erection

Type	Task
Name	Fabrication and Erection
Omniclass Code	31-40-30-00 Product Development
Documentation	The General contractor coordinates with all subcontractors regarding the sequence of construction and there for delivery and erection sequences. Initially these are at a high level. The models are used to review complex conditions needed special attention.

Process Map: Precaster as Subcontractor Project



Specification of Exchange Models for Precaster as Subcontractor Projects

This section defines the contents required for each exchange model in terms of functional exchange objects. The exchange objects are specified in the following section.

Exchange Model Definitions

			Architectural Concept Model	Engineering Concept Model	Design Development Model	Architectural Contract Model	Engineering Contract Model	Precast Design Model	Structural Review Coordination Model	Fabrication Model	Merged Coordination Model
	Omniclass		S_EM.1	S_EM.2	S_EM.3	S_EM.4	S_EM.5	S_EM.6	S_EM.7	S_EM.8	S_EM.9
Project Stage	31-20-10-00	Preliminary Project Description	✓	✓							
	31-20-20-00	Design Development			✓						
	31-25-00-00	Construction Documentation				✓	✓	✓			
	31-25-00-00	Procurement							✓	✓	✓
	31-40-30-00	Product Development									
	31-40-40-14-24	Fabrication									
	31-40-40-14-11	Erection Phase									
Discipline	(33-21-11-00)	Architecture	✓	✓	✓	✓					✓
	(33-21 31 00)	Engineering	✓	✓			✓		✓	✓	
	(33-25 41 11 11)	Building Product Manufacturing	✓	✓	✓			✓		✓	✓
	(33-41 11 11)	General Contracting			✓	✓	✓	✓	✓		✓

Exchange Model Descriptions for Precaster as Subcontractor Projects

The following descriptions refer to the process diagram shown on the following page. The process diagram uses Business Process Modeling Notation.

[S_EM.1] Architectural Concept Model

Project Stage	31-20-10-00 Preliminary Project Description
Exchange Disciplines	(33-21-11-00) Architecture (33-21 31 00) Engineering (33-25 41 11 11) Building Product Manufacturing
Description	Architectural concept model consists of concept layout of precast pieces into simple assemblies, without surface or structural detailing. Building model includes massing models, structural and other grid controls, building program and space layout and use, expected thermal and acoustic functions, if known, It might involve major architectural finishes, structural system selection, structural grid and site analysis.
Related Exchange Models	A_EM.1, P_EM.1, S_EM.1

[S_EM.2] Engineering Concept Model

Project Stage	31-20-10-00 Preliminary Project Description
Exchange Disciplines	(33-21-11-00) Architecture (33-21 31 00) Engineering (33-25 41 11 11) Building Product Manufacturing
Description	The engineering concept model provides information about the structural grid, structural system, major precast connections and issues, interfaces between precast and other structural and curtain wall systems.
Related Exchange Models	A_EM.2, P_EM.2, S_EM.2

[S_EM.3] Design Development Model

Project Stage	31-20-20-00 Design Development
Exchange Disciplines	(33-21-11-00) Architecture (33-25 41 11 11) Building Product Manufacturing (33-41 11 11) General Contracting
Description	The architectural design development model is build to reflect the detailed design intent of precast concrete as integrated with all other systems The building information model and documentation provides fabricators and installers the framework regarding precast design intent. Precast finishes are defined and optionally doors, windows, interior wall partitions, and curtain wall systems embedded in or related to the precast.
Related Exchange Models	P_EM.5, S_EM.3

[S_EM.4] Architectural Contract Model

Project Stage	31-25-00-00 Construction Documentation
Exchange Disciplines	(33-21-11-00) Architecture (33-41 11 11) General Contracting
Description	The architectural contract model integrates the building layout of all precast pieces with all other building systems. It identifies the shape and logical connectivity of all precast pieces. It includes layout of surface finishes, molding, reveals and other decorative features. Other system interacting with precast are also passed. The pass-off exchange

	is prepared to support production of a construction drawing set.
Related Exchange Models	A_EM.4, P_EM.9, S_EM.4

[S_EM.5] Engineering Contract Model

Project Stage	31-25-00-00 Construction Documentation
Exchange Disciplines	(33-21 31 00) Engineering (33-41 11 11) General Contracting
Description	The engineering contract model is focused on the structural design and integrates the structural layout with other building systems. It includes structural elements, connections and details. Both the precast and other structural systems are fully designed. The exchange is prepared as a construction drawing set or construction-level model.
Related Exchange Models	A_EM.11, P_EM.10, S_EM.5

[S_EM.6] Precast Design Model

Project Stage	31-25-00-00 Construction Documentation
Exchange Disciplines	(33-25 41 11 11) Building Product Manufacturing (33-41 11 11) General Contracting
Description	The precast design model is based on the architectural and engineering designs. It includes precast slabs, beams, columns, and connections. Models, drawings and specifications are submitted to the general contractor for the bid preparation.
Related Exchange Models	

[S_EM.7] Structural Review Coordination Model

Project Stage	31-25-00-00 Procurement
Exchange Disciplines	(33-21 31 00) Engineering (33-41 11 11) General Contracting
Description	The structural review precast coordination model is based on early stage of precast fabrication model and is used for evaluation of all precast components. It is being developed by the engineer to ensure structural and logistical consistency.
Related Exchange Models	S_EM.7, P_EM.11

[S_EM.8] Fabrication Model

Project Stage	31-25-00-00 Procurement
Exchange Disciplines	(33-21 31 00) Engineering (33-25 41 11 11) Building Product Manufacturing
Description	The precast fabrication model is developed by the precaster and includes high-level description of precast piece detailing, descriptions of all connection details, finishes, joints, embeds, reinforcing, tensioning cable layout and blockouts, pre-tensioned pieces, and lifting hooks for lifting and transporting. It is sent for review to the engineer.
Related Exchange Models	A_EM.7, S_EM.8

[S_EM.9] Merged Coordination Model

Project Stage	31-25-00-00 Procurement
Exchange Disciplines	(33-21-11-00) Architecture (33-25 41 11 11) Building Product Manufacturing (33-41 11 11) General Contracting
Description	The reviewed fabrication model is used by the GC for coordination,

	merged with other trade models. It is high-level description of precast piece detailing and includes descriptions of all connection details, finishes, joints, embeds, reinforcing, tensioning cable layout and blockouts, pre-tensioned pieces, and lifting hooks for lifting and transporting.
Related Exchange Models	A_EM.10, P_EM.12, S_EM.9

Exchange Model Specifications for Precaster as Subcontractor Projects

The exchange model specification tables are completed in accordance with the details provided in this use case and the IDM overview section. The exchange model specification tables are provided in the Consolidated EM Table starting on Page 58. All of the precaster as subcontractor exchange models are designated with the prefix "S_EM".

FABRICATION AND ERECTION

Specification of Fabrication and Erection Precast Process

The following tasks and sub-processes refer to the process diagram shown on the following page. The process diagram uses Business Process Modeling Notation.

[1.50] Design Intent Validation

Type	Task
Name	Design Intent Validation
Omniclass Code	31-40-40-11 Construction Start-up Phase
Documentation	Architects review models or documentation provided by fabricators or installers regarding design intent. This may deal with the jointing and alignment of architectural precast panels, the treatment of joints and connection in other precast applications, review of finishes that will be visible in the project and other visual characteristics of the work. It may also involve coordination issues, for example between the different trades.

[1.51] Structural Analysis and Design

Type	Task
Name	Structural Analysis and Design
Omniclass Code	31-40-30-17 Product Evaluation Phase
Documentation	Structural engineer reviews the composition of piece definitions and sizing with regard to adequacy to carry loads, sizing, spans bearing conditions and live and dead loads and lateral forces, for efficacy of the precast piece definition. Reviews issues of erection sequencing and temporary erection loads and supports.

[1.52] Precast Piece Layout

Type	Task
Name	Precast Piece Layout
Omniclass Code	31-40-30-11 Product Prototyping Phase
Documentation	The precast designer/engineer develops the layout of precast assemblies and pieces that make up the project, dealing with architectural panel layout and joints, structural elements and their spanning and load carrying requirements, and large assemblies such as stairways and service cores.

[1.53] Construction Coordination

Type	Task
Name	Construction Coordination
Omniclass Code	31-40-40-11 Construction Start-up Phase
Documentation	The general contractor coordinates with all subcontractors regarding two interrelated issues: a) the spatial relationships between systems, to avoid clashes; b) the sequence of construction (both delivery and erection) Initially these are at a high level. The models are used to review complex conditions that need special attention.

[1.54] Precast Detailing

Type	High-Level Task
Name	Precast Detailing
Omniclass Code	31-40-40-14 Project Execution Phase
Documentation	High-level description of precast piece detailing. Includes detailing of all details, finishes, joints and connections. Includes all embeds, reinforcing, tensioning cable layout and blockouts. Precast pieces are adjusted for fabrication, including dimensional corrections for pre-tensioning, raking of vertical mold surfaces to facilitate release and lifting hooks for lifting and transporting.

[1.55] Construction Management

Type	Task
Name	Construction Management
Omniclass Code	31-40-40-14 Project Execution Phase
Documentation	The construction manager first plans the overall construction sequence for the building project and communicates the sequencing and phasing to be followed by each of the construction and erection crews. These consist of sequences of activity and the precedence of activities. Calendar windows might be outlined. This constrains the production sequence of the precast. Once construction commences, the construction manager continues to coordinate activities between crews, adapting the schedule as needed. This activity involves collaboration and consultation with the precast plant and with the erection crew.

[1.56] Production Planning

Type	Task
Name	Production Planning
Omniclass Code	31-40-40-14-21Off-site fabrication Phase
Documentation	The precast plant production manager takes the project schedule and erection sequence to determine the production sequence within the precast plant. The delivery of all necessary components is scheduled and slots are allocated in casting beds in the plant. Long lead items (such as galvanized or stainless steel inserts, brick or stone facing materials and special molds) are ordered earlier in the process but also by this function; exchange EM.57 will occur multiple times, with increasingly mature information each time as the lead time reduces. Ideally, production planning also determines the sequence of fabrication detailing, pulling final design and fabrication as and when needed for erection.

[1.57] Structural Design & Reinforcement Review

Type	Task
Name	Structural Design & Reinforcement Review
Omniclass Code	31-40-40-14 Project Execution Phase
Documentation	The structural engineer reviews the reinforcement, prestress cable

	layouts and connection details for structural adequacy. These are compared with the structural requirements defined earlier, plus any changes to these conditions as the rest of the building was detailed.

[1.58] Fabrication Detailing

Type	Task
Name	Fabrication Detailing
Omniclass Code	31-40-40-14 Project Execution Phase
Documentation	The precast fabricator's engineers or drafters add the details needed for production of each piece. This includes detailing of any standard wire meshes, lifting hooks, special forms and form liners, etc. This is the last modeling and drawing production activity before production.

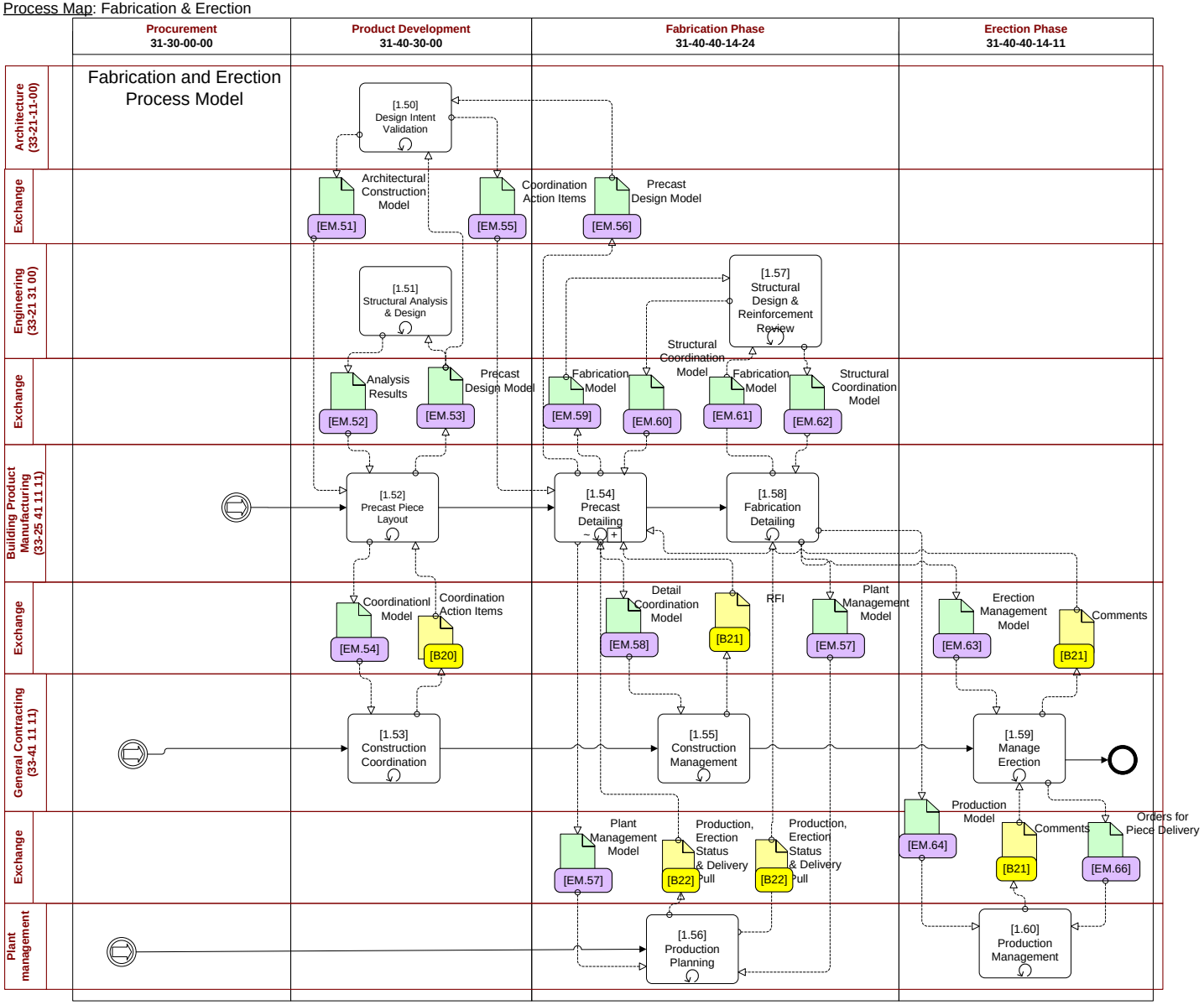
[1.59] Manage Erection

Type	Task
Name	Manage Erection
Omniclass Code	31-40-40-14 Project Execution Phase
Documentation	The site manager of the erection team coordinates the erection schedule with the construction manager, notifying the precast plant of any changes to the precast erection schedule as issues arise. The main communication from the site manager to the plant is to call for delivery of pieces as they are required.

[1.60] Production Management

Type	Task
Name	Production Management
Omniclass Code	31-40-40-14 Project Execution Phase
Documentation	The plant production manager makes adjustments to the casting schedule and to the shipping schedule as feedback is received from the construction site and schedule issues arise.

Process Map: Fabrication & Erection



Specification of Exchange Models for Fabrication and Erection

This section defines the contents required for each exchange model in terms of functional exchange objects. The exchange objects are specified in the following section.

Exchange Model Definitions

			Architectural Construction Model	Structural Analysis Results	Precast Design Model	Coordination Model	Coordination Action Items Model	Precast Design Model	Plant Management Model	Detail Coordination Model	Fabrication Model	Structural Coordination Model	Fabrication Model	Structural Coordination Model	Erection Management Model	Production Model	Orders for Piece Delivery
	Omniclass		EM.51	EM.52	EM.53	EM.54	EM.55	EM.56	EM.57	EM.58	EM.59	EM.60	EM.61	EM.62	EM.63	EM.64	EM.65
Project Stage	31-20-10-00	Preliminary Project Description															
	31-20-20-00	Design Development															
	31-25-00-00	Construction Documentation															
	31-25-00-00	Procurement															
	31-40-30-00	Product Development	✓	✓	✓	✓	✓										
	31-40-40-14-24	Fabrication						✓	✓	✓	✓	✓	✓	✓			
	31-40-40-14-11	Erection Phase													✓	✓	✓
Discipline	(33-21-11-00)	Architecture	✓				✓	✓									
	(33-21 31 00)	Engineering		✓	✓						✓	✓	✓	✓			
	(33-25 41 11 11)	Building Product Manufacturing	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	(33-41 11 11)	General Contracting				✓			✓	✓					✓		

Exchange Models Descriptions for Fabrication and Erection

The following descriptions refer to the process diagram shown on the following page. The process diagram uses Business Process Modeling Notation.

[EM.51] Architectural Construction Model

Project Stage	31-40-30-00 Product Development
Exchange Disciplines	(33-21-11-00) Architecture (33-25 41 11 11) Building Product Manufacturing
Description	This exchange passes back to the precast fabricator a report of the design intent issues identified by the architect for precast assembly-level piece layout, based on information supplied by the precast fabricator. Design constraints of buildings and spaces are indicated, where relevant. Product information that raises issues about the design intent are reported, including layout, shape, material types, geometry and material of finishes of products, both in the piece and assembly level, and assembly relation of the pieces and connections. Openings and opening frames may be identified. Detailed information of different types of products may be included. Facade layout and grid geometry may be designated; slab topping thickness, material and surface treatment may be returned. For load-bearing and non-load bearing pieces, assembly and joint relations may be identified as problems. Characteristics of thermal and acoustic insulation may be referenced Nested relations and details of joints specifications may be referenced. Finally, other building parts affecting precast pieces specifications and systems may be indicated.
Related Exchange Models	

[EM.52] Analysis Results

Project Stage	31-21-31-00 Product Development
Exchange Disciplines	(33-21-11-00) Engineering (33-25 41 11 11) Building Product Manufacturing
Description	This exchange model conveys the structural analysis result of engineer of record to the precast fabricator for precast assembly-level layout. So in the high level, site information and the design constraints and structural loads of buildings and spaces are specified. The same as EM.51, common categories of information for different types of products like layout, shape, material types, and geometry of product finishes, both in the piece and assembly level, and assembly relations of the pieces and connections are defined. However here, all of the structural loads and analysis results are also provided, Openings and their frames are defined. The specific information for each type of products is provided. Layout and grid geometry of facades are designated. For load-bearing pieces, assembly and joint relations are specified. Thermal and acoustic insulation characteristics are defined. Structural design of logical connections is specified. Finally, the relevant specifications of other building parts and systems are indicated.
Related Exchange Models	

[EM.53] Precast Design Model

Project Stage	31-40-30-00 Product Development
Exchange Disciplines	(33-25 41 11 11) Building Product Manufacturing (33-21-11-00) Architecture (33-21-11-00) Engineering
Description	The purpose of this exchange is to provide the detailed precast design model by precast designer for review of assembly and piece layout to both the structural engineer and architect. So, the design constraints and structural loads of buildings and spaces are included. Common categories of information for various types of products like design loads, layout, shape, material types, geometry and material of product finishes, both in the piece and assembly level, connection relations of the pieces and connections are defined. Assembly and nested relations except for foundation and steel parts are included. Information needed for identification of pieces and information about concrete mixes are included. Openings and their frames are defined. The specific information for each type of product is provided. Layout and grid geometry of facades are designated. For load-bearing and non-load bearing pieces, assembly and joint relations are specified. Thermal and acoustic insulation characteristics are defined. Reinforcement specifications are included. Structural design of logical connections, both field applied and plant applied connections, and joints are specified. Specifications of lifting devices are provided. Finally, the relevant specifications of other building parts are indicated.
Related Exchange Models	

[EM.54] Coordination Model

Project Stage	31-40-30-00 Product Development
Exchange Disciplines	(33-25 41 11 11) Building Product Manufacturing (33-41 11 11) General Contracting
Description	In this exchange model the fabricator passes the coordination model of precast pieces and assemblies to the general contractor for coordination during fabrication detailing. In this exchange model, general information about project site and site buildings are included. Important common categories of information include layout, shape, material types, and information about product finishes except for the joints, both in the piece and assembly level. Also, assembly relations of products except for foundation parts are specified. The piece marks for identification are included. Openings and opening frames are defined. Detailed information for some types of products is included. Layout and grid geometry of facades are designated and slab topping thickness, material and surface treatment are defined. For load-bearing and non-load bearing pieces, assembly, nested, joint and connection relations are specified. Relevant information about reinforcement is included. Nested and assembly relations of both field applied and plant applied connections are specified. Affecting specifications of other building parts and systems like lifting devices are indicated.
Related Exchange Models	

[EM.55] Coordination Action Items

Project Stage	31-40-30-00 Product Development
Exchange Disciplines	(33-21-11-00) Architecture

	(33-25 41 11 11) Building Product Manufacturing
Description	The purpose of this exchange is to transfer coordination action items to the fabricator from the architect for piece detailing. So, just a few categories of information are covered. Those include the geometric information of different products and necessary meta data for each category. Connection and joint information may be returned. Also, finish material types are specified.
Related Exchange Models	

[EM.56] Precast Design Model

Project Stage	31-40-40-14-24 Fabrication Phase
Exchange Disciplines	(33-25 41 11 11) Building Product Manufacturing (33-21-11-00) Architecture
Description	Following EM55, the precast fabricator sends the precast design model to the architect for further review/approval. So in the high level, general information about project site and site buildings are included. Important common categories of information include layout, shape, material types, and information about geometry and materials of finishes, that are covered both in the piece and assembly level. Plus assembly and connection relations of pieces and connections are specified. The piece marks for identification are included. Openings and opening frames are defined. Also, detailed information for some types of products is included. Layout and grid geometry of facades are designated and slab topping thickness, material and surface treatment are determined. The specifications of joints are defined. Nested and assembly relations of both field applied and plant applied connections are specified. Related specifications of other building parts and systems are indicated.
Related Exchange Models	

[EM.57] Plant Management Model

Project Stage	31-40-40-14-24 Fabrication Phase
Exchange Disciplines	(33-25 41 11 11) Building Product Manufacturing (33-41 14 00) Plant Management
Description	The purpose of this exchange is to send the plant management model to the plant manager, which is prepared by precast fabricator during the fabrication phase. So, more low level, detailed information about products is included. Important product information categories are layout, shape, material types, and geometry and material of finishes of products –except for steel assemblies and joints, both in the piece and assembly level. Assembly relations of the pieces and connections are specified. Openings and opening frames are defined. Identification and related production information for different pieces are included. Reinforcement specifications are defined. Relevant information for different types of products is provided. Facade layout and grid geometry are designated. For load-bearing and non-load bearing and voided pieces, nested, connection and joint relations are specified. Characteristics of thermal and acoustic insulation are defined. Nested relations of both field applied and plant applied connections are specified. Finally, related specifications of other building parts and systems are included.
Related Exchange Models	

[EM.58] Detailed Coordination Model

Project Stage	31-40-40-14-24 Fabrication Phase
Exchange Disciplines	(33-25 41 11 11) Building Product Manufacturing (33-41 11 11) General Contracting
Description	In this exchange model the fabricator passes the detailed coordination model of precast pieces and assemblies to the general contractor during the fabrication phase. So, comparing to EM54, which is "Coordination Model", it includes more details about the pieces and assemblies. Important addition to this model comparing to EM54 is information about connection relations of products. Also, for load-bearing and non-load bearing and voided pieces, joint relations are specified. Finally, surface treatment information is included.
Related Exchange Models	

[EM.59] Fabrication Model

Project Stage	31-40-40-14-24 Fabrication Phase
Exchange Disciplines	(33-25 41 11 11) Building Product Manufacturing (33-21-11-00) Engineering
Description	In this exchange model the fabricator passes the fabrication model of precast pieces and assemblies to the engineer of record for structural design and reinforcement review during the fabrication phase. Geometry and assembly relations of buildings and spaces are included. Common categories of information for various types of products like layout, related shape and material information; both in the piece and assembly level are included. Connection relations of the pieces except for non-load bearing pieces are specified. Assembly and nested relations except for connections, and non-load bearing pieces are included. Related identification information and concrete mixes are included. Layout and grid geometry of facades, slab toppings, and reinforcement specifications are designated. Logical connections are defined.
Related Exchange Models	

[EM.60] Structural Coordination Model

Project Stage	31-40-40-14-24 Fabrication Phase
Exchange Disciplines	(33-21-11-00) Engineering (33-25 41 11 11) Building Product Manufacturing
Description	Following the EM.59, this exchange model conveys the results of structural design and reinforcement review of the engineer of record to the precast fabricator during the fabrication phase. So, this model and EM59 include pretty much the same information. There are some addendum to EM.59 including information about design constraints, design loads and structural design.
Related Exchange Models	

[EM.61] Detailed Fabrication Model

Project Stage	31-40-40-14-24 Fabrication Phase
Exchange Disciplines	(33-25 41 11 11) Building Product Manufacturing (33-21-11-00) Engineering
Description	The purpose of this exchange model is for the fabricator to send the detailed fabrication model of precast pieces and assemblies to the engineer of record for structural design and reinforcement review during the fabrication phase. Related material information is defined. Slab layout and topping are defined. Assembly, nested and connection relations of load bearing and voided pieces are specified. Assembly and nested relations of logical connections and both field and plant applied connections are defined. Related identification information and concrete mixes are included. And, reinforcement specifications are designated.
Related Exchange Models	

[EM.62] Detailed Structural Coordination Model

Project Stage	31-40-40-14-24 Fabrication Phase
Exchange Disciplines	(33-21-11-00) Engineering (33-25 41 11 11) Building Product Manufacturing
Description	Following the EM.61, this exchange model conveys the results of structural design and reinforcement review of the engineer of record to the precast fabricator during the fabrication phase. So, this model and EM.61 include almost the same information. The only difference is that in this exchange structural design for load-bearing pieces and design loads for slabs are specified.
Related Exchange Models	

[EM.63] Erection Management Model

Project Stage	31-40-40-14-11 Erection Phase
Exchange Disciplines	(33-25 41 11 11) Building Product Manufacturing (33-41 11 11) General Contracting
Description	In this exchange model the fabricator passes the erection management model of precast pieces and assemblies to the plant manager to manage the erection during the erection phase. In this exchange, general information about project site, site buildings and spaces are included. Important common categories of information include layout, shape, and material types, both in the piece and assembly level. Also, assembly and nested relations of products are specified. Complete identification and production information are included. Openings and opening frames are defined. Detailed information for some types of products is included. Layout and grid geometry of facades are designated and slab topping thickness, material and surface treatment are defined. For load-bearing, non-load bearing and voided pieces, joint and connection relations are specified too. Logical and physical connections are defined. Finally, lifting devices are indicated.
Related Exchange Models	

[EM.64] Production Model

Project Stage	31-40-40-14-11 Erection Phase
Exchange Disciplines	(33-25 41 11 11) Building Product Manufacturing (33-41 14 00) Plant Management
Description	The purpose of this exchange is to send the production model, which is prepared by precast fabricator, to the plant manager during the erection phase. So, more low level, detailed information about production of products is included. Important product information categories are layout, shape, and material types, both in the piece and assembly level. Complete identification and production information for different pieces are included. Reinforcement specifications are defined. Specific information for different types of products is provided. Assembly and nested relations of different types of connections, and, load-bearing and non-load bearing pieces are specified. Concrete mixes and finish material types are defined. Finally, lifting devices are included.
Related Exchange Models	

[EM.65] (empty)

[EM.66] Orders For Piece delivery

Project Stage	31-40-40-14-11 Erection Phase
Exchange Disciplines	(33-41 11 11) General Contracting (33-41 14 00) Plant Management
Description	In this exchange model the general contractor sends the orders for piece delivery to plant manager during the erection phase. General information about project site and buildings is included. Also, there are some common categories of information for different types of products including layout, shape and material types. Finally, the identification information is provided.
Related Exchange Models	

Exchange Model Specifications for Fabrication and Erection

The exchange model specification tables are completed in accordance with the details provided in this use case and the IDM overview section. The exchange model specification tables are provided in the Consolidated EM Table starting on Page 58. All of the fabrication and erection exchange models are designated with the prefix "EM".

GENERIC EXCHANGE MODEL DEFINITIONS

Consistency Check and Consolidation of Exchange Models

A rigorous analysis was performed, in which all of the exchange models were compared, in order to a) remove inconsistencies and b) identify opportunities for consolidation of exchange models to reduce their number. A Visual Basic Macro was prepared to scan each field of each EM and compare it to the parallel field of every other EM. The number of differences found was divided by the total number of fields, yielding a percentage degree of difference. The result of the scan of the initial set of exchange models is shown in the figure on the following page.

Consistency Check

The exchange models were prepared by the different members of each of four sub-committees of the PCI BIM advisory committee. As such, despite provision of guidelines, tutoring by a researcher, and use of a standard template, it was natural that there should be instances of inconsistency from EM to EM. The set of EMs was reviewed and analyzed as described above. The research team then edited the models and submitted them for review by the BIM advisory committee.

A uniform set of assumptions was adopted to guide the edit:

1) The meta-data of an object must be required in any instance where the object itself is required. Where the object is optional, the meta-data must at least be optional.
2) Generic project information (names and addresses of participants, etc.) is optional throughout.
3) The site location can be optional in all exchanges; the site does not need to be geo-located anew in every exchange.
4) Nesting relationships are only required from the design development (DD) stage on. They are optional during DD and required thereafter.
5) Areas and volumes of pieces are not required until design development (DD) stages.
6) Structural engineering information, such as live loads, analysis results (moments, shears, displacements, reactions and deformations), etc. should not appear in exchanges with the architectural function.
7) The geometry of external systems are always reference objects only, and apply in design development (DD) and subsequently.
8) Relations in non-precast objects and systems are not editable.
9) Material quantities and dimensional tolerances are optional in early exchanges, required for contract stages and at least optional after that.
10) Rebar, connection hardware, lifting equipment, etc. are not of interest at all in the concept phases, and should be blank. Similarly, they are blank through the design development phase for all exchanges with the architectural function.
11) Production information (such as production control number) can only appear after fabrication.

Consolidation of Exchange Models

Once the consistency review and edit was complete, the EM comparison macro was run once again. Wherever the degree of difference was less than 10%, the EMs were compared critically with a view to unifying them. If merging was viable, any additional changes were made and the exchange models were consolidated. The guiding principle of the merge changes was to enhance exchange capability, not to reduce it.

The following table summarizes the EMs that were merged. The details of all changes made for merging are provided in the texts describing each EM set that appear after the table.

The final resulting comparison table is provided at the end of this chapter, and the resulting Exchange Model definitions are provided in the next chapter of this document.

Percentage Degrees of Difference between Exchange Models BEFORE Correction for Consistency and Consolidation

	P_EM.1	S_EM.1	A_EM.2	P_EM.2	S_EM.2	A_EM.3	A_EM.6	P_EM.5	S_EM.3	P_EM.6	P_EM.7	S_EM.6	P_EM.3	A_EM.4	P_EM.9	S_EM.4	A_EM.11	P_EM.10	S_EM.5
A_EM.1	0%	0%	0%	0%	70%	34%	36%	58%	79%	59%	40%	75%	76%	34%	67%	80%	54%	71%	80%
P_EM.1		0%	0%	0%	70%	34%	36%	58%	79%	59%	40%	75%	76%	34%	67%	80%	54%	71%	80%
S_EM.1			0%	0%	70%	34%	36%	58%	79%	59%	40%	75%	76%	34%	67%	80%	54%	71%	80%
A_EM.2				0%	70%	34%	36%	58%	79%	59%	40%	75%	76%	34%	67%	80%	54%	71%	80%
P_EM.2					70%	34%	36%	58%	79%	59%	40%	75%	76%	34%	67%	80%	54%	71%	80%
S_EM.2						60%	62%	51%	28%	50%	68%	45%	33%	60%	49%	37%	57%	54%	30%
A_EM.3							8%	40%	77%	36%	36%	55%	71%	0%	44%	73%	23%	47%	64%
A_EM.6								35%	80%	30%	43%	50%	74%	8%	44%	67%	23%	40%	60%
P_EM.5									62%	10%	55%	34%	56%	40%	35%	50%	25%	31%	49%
S_EM.3										69%	65%	60%	29%	77%	71%	16%	78%	76%	34%
P_EM.6											58%	35%	63%	36%	28%	60%	18%	23%	47%
P_EM.7												70%	60%	36%	69%	69%	51%	73%	74%
S_EM.6													58%	55%	28%	53%	36%	22%	37%
P_EM.3														71%	67%	37%	71%	70%	43%
A_EM.4															44%	73%	23%	47%	64%
P_EM.9																66%	30%	7%	51%
S_EM.4																	67%	62%	26%
A_EM.11																		25%	51%
P_EM.10																			46%
S_EM.5																			

Merged Exchange Model	New EM Code	Original EM Codes	Summary of actions taken for merge
Building Concept Exchange Model	BC_EM	A_EM.1 P_EM.1 S_EM.1 P_EM.2	Upgrade spaces, surface treatments, finish geometry for P_EM.2 Upgrade steel structure quantities, product codes and precast piece finish information for the other three EMs.
Precast Concept	PC_EM	A_EM.5 A_EM.6	Upgrade geometric accuracy from planar to curved surfaces for A_EM.6 Upgrade frame geometry to reference for A_EM.5 Upgrade structural loads and other building parts for A_EM.5.
Architectural/ Structural Contract	ASC_EM	S_EM.4 P_EM.9	Product code and piece mark made optional for all precast pieces
Precast Detailed Coordination	PDC_EM	A_EM.7 and A_EM.10	None

A_EM.1, P_EM.1, S_EM.1 and P_EM.2

The analysis after consistency checking revealed that the first three EMs in this set were identical, while P_EM.2 differed from them by 4%. P_EM.2 was consolidated with the other three as follows:

- Position of spaces was made required for P_EM.2
- Surface treatments were made optional for P_EM.2
- Steel structure material quantity was made optional for the first three EMs.
- Foundation geometry was made optional for P_EM.2
- Product codes were made optional for the first three EMs.
- Typical finish pattern geometry was made optional for P_EM.2
- Finish information for precast pieces was made optional for the first three EMs.

A_EM.2 was very similar to this set, but was still sufficiently different to warrant remaining separate from the set.

A_EM.5 and A_EM.6

These two models differed in only 5% of their fields. They were reconciled by:

- Upgrading the geometry capability of the site for P_EM.6 to curved
- Upgrading the frame geometry for P_EM.5 to referenceable
- Making the structural load information for P_EM.5 optional, despite it being an exchange to the architectural function.
- Making the information about other building parts optional for P_EM.5

S_EM.4 and P_EM.9

Both S_EM.4 and P_EM.9 are exchanges from an architect. The pair was just 1% different. They were consolidated by making product code and piece mark optional for all precast pieces for both exchanges.

A_EM.7 and A_EM.10

These two exchange models were identical. They were consolidated as is.

Once the consolidation was completed, the EM table was re-ordered to place consolidated EMs adjacent to one another. The headers of the

Percentage Degrees of Difference between Exchange Models AFTER Consistency Correction and Consolidation

	P_EM.1	S_EM.1	P_EM.2	A_EM.2	S_EM.2	A_EM.3	A_EM.5	A_EM.6	P_EM.5	S_EM.3	P_EM.6	P_EM.7	P_EM.8	S_EM.6	P_EM.3	P_EM.4	A_EM.4	P_EM.9	S_EM.4	P_EM.11	A_EM.11	P_EM.10	S_EM.5
A_EM.1	0%	0%	0%	6%	38%	42%	44%	44%	49%	60%	37%	51%	55%	80%	49%	46%	51%	51%	51%	69%	49%	52%	70%
P_EM.1		0%	0%	6%	38%	42%	44%	44%	49%	60%	37%	51%	55%	80%	49%	46%	51%	51%	51%	69%	49%	52%	70%
S_EM.1			0%	6%	38%	42%	44%	44%	49%	60%	37%	51%	55%	80%	49%	46%	51%	51%	51%	69%	49%	52%	70%
P_EM.2				6%	38%	42%	44%	44%	49%	60%	37%	51%	55%	80%	49%	46%	51%	51%	51%	69%	49%	52%	70%
A_EM.2					37%	42%	43%	43%	46%	59%	33%	49%	53%	79%	50%	45%	48%	49%	49%	67%	48%	48%	68%
S_EM.2						36%	10%	10%	47%	33%	31%	29%	37%	59%	29%	48%	45%	52%	52%	71%	55%	44%	56%
A_EM.3							27%	27%	27%	53%	29%	35%	47%	58%	43%	50%	19%	28%	28%	48%	46%	32%	49%
A_EM.5								0%	39%	32%	22%	24%	38%	52%	29%	49%	36%	45%	45%	63%	56%	35%	49%
A_EM.6									39%	32%	22%	24%	38%	52%	29%	49%	36%	45%	45%	63%	56%	35%	49%
P_EM.5										46%	28%	39%	48%	53%	44%	48%	17%	15%	15%	34%	39%	27%	47%
S_EM.3											44%	43%	55%	53%	40%	50%	52%	55%	55%	66%	63%	49%	50%
P_EM.6												24%	39%	56%	38%	43%	28%	29%	29%	47%	42%	22%	41%
P_EM.7													23%	44%	32%	57%	37%	40%	40%	59%	57%	30%	44%
P_EM.8														39%	33%	49%	49%	51%	51%	60%	52%	41%	44%
S_EM.6															50%	55%	52%	56%	56%	50%	53%	50%	40%
P_EM.3																44%	47%	48%	48%	65%	52%	43%	54%
P_EM.4																	51%	47%	47%	52%	17%	49%	52%
A_EM.4																		18%	18%	37%	43%	25%	44%
P_EM.9																			0%	25%	36%	25%	45%
S_EM.4																				25%	36%	25%	45%
P_EM.11																					36%	42%	43%
A_EM.11																						44%	47%
P_EM.10																							22%

P_EM.12	A_EM.8	A_EM.9	A_EM.10	A_EM.7	S_EM.7	S_EM.8	S_EM.9	EM.51	EM.52	EM.53	EM.54	EM.55	EM.56	EM.57	EM.58	EM.59	EM.60	EM.61	EM.62	EM.63	EM.64	EM.66	
68%	72%	77%	80%	80%	76%	72%	62%	52%	52%	72%	45%	41%	47%	62%	49%	50%	57%	59%	65%	66%	62%	38%	A_EM.1
68%	72%	77%	80%	80%	76%	72%	62%	52%	52%	72%	45%	41%	47%	62%	49%	50%	57%	59%	65%	66%	62%	38%	P_EM.1
68%	72%	77%	80%	80%	76%	72%	62%	52%	52%	72%	45%	41%	47%	62%	49%	50%	57%	59%	65%	66%	62%	38%	S_EM.1
68%	72%	77%	80%	80%	76%	72%	62%	52%	52%	72%	45%	41%	47%	62%	49%	50%	57%	59%	65%	66%	62%	38%	P_EM.2
67%	73%	78%	81%	81%	74%	72%	61%	53%	49%	73%	44%	40%	45%	61%	45%	47%	54%	56%	62%	62%	61%	35%	A_EM.2
58%	65%	61%	73%	73%	63%	66%	53%	51%	51%	73%	53%	60%	51%	71%	53%	53%	59%	68%	77%	67%	81%	62%	S_EM.2
45%	49%	59%	59%	59%	51%	47%	42%	47%	41%	63%	51%	50%	47%	56%	39%	40%	43%	62%	67%	51%	65%	54%	A_EM.3
54%	61%	60%	72%	72%	56%	60%	51%	49%	47%	71%	53%	58%	48%	65%	46%	48%	53%	67%	75%	66%	77%	64%	A_EM.5
54%	61%	60%	72%	72%	56%	60%	51%	49%	47%	71%	53%	58%	48%	65%	46%	48%	53%	67%	75%	66%	77%	64%	A_EM.6
40%	44%	56%	56%	56%	49%	47%	38%	43%	52%	56%	51%	48%	43%	54%	37%	45%	52%	68%	72%	54%	63%	54%	P_EM.5
55%	57%	56%	73%	73%	65%	68%	60%	50%	67%	72%	59%	67%	52%	75%	58%	67%	72%	77%	80%	72%	86%	72%	S_EM.3
53%	52%	64%	66%	66%	49%	56%	50%	46%	43%	64%	45%	47%	44%	56%	40%	41%	49%	63%	68%	56%	64%	52%	P_EM.6
55%	52%	55%	58%	58%	45%	49%	56%	56%	42%	59%	56%	59%	52%	64%	50%	50%	52%	66%	77%	61%	76%	64%	P_EM.7
64%	52%	49%	55%	55%	48%	53%	56%	61%	49%	53%	53%	64%	61%	64%	58%	48%	48%	64%	70%	61%	74%	68%	P_EM.8
51%	44%	42%	45%	45%	37%	44%	51%	56%	69%	44%	63%	77%	62%	63%	61%	69%	67%	75%	75%	60%	69%	82%	S_EM.6
60%	61%	57%	63%	63%	59%	58%	50%	49%	51%	64%	53%	61%	57%	67%	53%	56%	57%	72%	79%	64%	78%	65%	P_EM.3
50%	52%	56%	64%	64%	60%	60%	37%	45%	61%	60%	38%	54%	48%	57%	47%	51%	57%	61%	68%	56%	59%	51%	P_EM.4
41%	43%	56%	52%	52%	45%	42%	38%	44%	47%	55%	53%	53%	45%	55%	39%	43%	50%	67%	72%	50%	65%	56%	A_EM.4
35%	37%	51%	48%	48%	45%	43%	36%	43%	51%	53%	54%	48%	47%	49%	35%	46%	51%	66%	69%	50%	60%	52%	P_EM.9
35%	37%	51%	48%	48%	45%	43%	36%	43%	51%	53%	54%	48%	47%	49%	35%	46%	51%	66%	69%	50%	60%	52%	S_EM.4
33%	41%	51%	37%	37%	31%	32%	33%	51%	64%	43%	59%	63%	58%	45%	47%	58%	57%	64%	62%	48%	49%	67%	P_EM.11
33%	47%	53%	51%	51%	47%	47%	22%	46%	58%	51%	39%	54%	47%	49%	42%	47%	52%	56%	63%	46%	50%	50%	A_EM.11
47%	38%	52%	52%	52%	34%	44%	44%	49%	48%	54%	51%	56%	46%	55%	40%	43%	51%	68%	74%	50%	65%	57%	P_EM.10
50%	30%	40%	42%	42%	26%	39%	49%	56%	59%	44%	59%	73%	58%	58%	53%	56%	58%	68%	68%	57%	68%	74%	S_EM.5
	41%	47%	45%	45%	41%	39%	15%	52%	62%	56%	56%	63%	47%	49%	42%	55%	59%	62%	67%	49%	57%	64%	P_EM.12
		19%	27%	27%	37%	38%	44%	55%	63%	43%	64%	71%	57%	54%	53%	57%	60%	74%	74%	56%	64%	73%	A_EM.8
			22%	22%	45%	43%	50%	64%	64%	46%	68%	76%	65%	63%	63%	61%	62%	71%	74%	60%	68%	78%	A_EM.9
				0%	29%	25%	48%	67%	61%	38%	73%	79%	71%	56%	65%	61%	59%	71%	71%	48%	57%	78%	A_EM.10
					29%	25%	48%	67%	61%	38%	73%	79%	71%	56%	65%	61%	59%	71%	71%	48%	57%	78%	A_EM.7
						25%	42%	60%	49%	40%	61%	74%	62%	56%	53%	53%	48%	64%	67%	43%	64%	74%	S_EM.7
							38%	60%	53%	40%	66%	70%	58%	52%	57%	52%	49%	62%	66%	46%	56%	70%	S_EM.8
								48%	61%	51%	49%	62%	49%	47%	38%	50%	56%	60%	65%	45%	54%	60%	S_EM.9
									59%	56%	51%	44%	40%	55%	43%	60%	60%	67%	67%	57%	64%	58%	EM.51
										60%	50%	45%	54%	67%	50%	24%	17%	45%	53%	46%	66%	49%	EM.52
											61%	66%	62%	52%	60%	60%	60%	67%	69%	53%	59%	70%	EM.53
												39%	29%	51%	42%	45%	51%	49%	56%	47%	55%	43%	EM.54
													34%	49%	42%	39%	46%	44%	48%	55%	51%	30%	EM.55
														50%	34%	50%	58%	56%	62%	53%	59%	44%	EM.56
															46%	55%	62%	40%	41%	54%	23%	53%	EM.57
																40%	52%	56%	60%	42%	57%	38%	EM.58
																	19%	38%	48%	39%	54%	39%	EM.59
																		37%	42%	45%	59%	49%	EM.60
																			13%	50%	32%	34%	EM.61
																				53%	28%	41%	EM.62
																					55%	45%	EM.63
																						43%	EM.64
P_EM.12	A_EM.8	A_EM.9	A_EM.10	A_EM.7	S_EM.7	S_EM.8	S_EM.9	EM.51	EM.52	EM.53	EM.54	EM.55	EM.56	EM.57	EM.58	EM.59	EM.60	EM.61	EM.62	EM.63	EM.64	EM.66	

CONSOLIDATED EXCHANGE MODEL SPECIFICATIONS

The tables on the following pages provide the detailed specifications of the consolidated set of exchange models for precast concrete.