Information Delivery Manual (IDM) for Cast-in-place Concrete

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CHARLES PANKOW FOUNDATION
Building Innovation through Research

Information Delivery Manual (IDM) for Cast-in-place Concrete (ACI 131.1 Version 1.0)

An ACI Report
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ACI 131.1 provides a framework for enabling efficient interdisciplinary coordination and collaboration for exchanging information in both model and nonmodel forms. This report develops a process model that identifies the typical workflows during engineering design, planning, and site production of cast-in-place (CIP) reinforced concrete. It identifies when information is shared between disciplines at different stages of CIP concrete projects. The process model relates the different disciplines that deliver the project, the different phases of the project, and the information exchanges that take place. This report will be used by building information modeling (BIM) users and software developers as a framework for developing shareable model views for visualization and coordination of production and placement of reinforced concrete.

Keywords: building information modeling; exchange descriptions; information delivery manual; task descriptions; work process flow chart.

CHAPTER 1—INTRODUCTION AND SCOPE

1.1—Introduction

The National Institute of Building Sciences (2007) defines standard and efficient terminology and semantics to be exchanged in building information models to support various business use cases throughout architecture, engineering, construction and operations projects. The project committee responsible for developing the NIBS standard is a committee of the buildingSMART (2013) alliance, a council of the National Institute of Building Sciences (NIBS).

The National Institute of Building Sciences (2007) establishes the standard process to develop the NIBS standard. The process includes four phases:

(1) Program—defines standard information exchange requirements through developing process models and defining specifications and business rules for each exchange. In this phase, a process model that identifies where the exchanges take place in the project lifecycle, as well as the actors and applications that are the senders and recipients of these exchanges, is developed. The information exchanges are defined by exchange models, which specify the functional requirements of data exchanges to be implemented. When the process models and exchange models are combined, they form an information delivery manual (IDM). This IDM serves as the overall functional requirements specification for one or more exchanges.

(2) Design—develops exchange requirement models and generic model view definition (MVD).

(3) Construct—develops implementation specifications for MVD and facilitates product testing and certification.

(4) Deploy—provides generic and product-specific building information modeling (BIM) guide, validates data exchange, and extends BIM data.

1.2—Scope

This report is intended to enable accurate and efficient creation, sharing, modification, and reuse of cast-in-place (CIP) concrete model information among various project entities throughout a project lifecycle. Specifically, a process model that identifies the typical workflows during engineering design, planning, and site production of concrete is developed. It identifies when information is shared between disciplines at different stages of projects. The tasks and information exchanges that make up the process model are clearly defined.

CHAPTER 2—DEFINITIONS

2.1—Definitions

building information modeling—processes and technology that use a digital representation of the physical and functional characteristics of a project.

exchange models—description of the information exchanged and the typical producer and receiver of that information.

information delivery manual—report identifying user requirements for one or more information exchanges.

model view definition—software specification of exchange requirements for one or more data exchanges.

CHAPTER 3—INFORMATION DELIVERY MANUAL OVERVIEW

3.1 —Background

An information delivery manual (IDM) defines exchange requirements in the context of reference industry processes. IDMs are defined by end users and practicing professionals to support the process in which they are expert. The resulting IDM serves to define the exchange requirements for one or more building information modeling (BIM) transactions.

The IDM is focused on end-user exchange requirements supporting a given set of workflows. The exchange requirements are captured by developing a process model that defines the context of the workflows of interest. The process model identifies the sets of use case exchanges being addressed; the tasks involved in each phase of the project, and, most importantly, the exchange requirements that will enhance the workflow. The various components of the IDM capture the user needs and specification of the exchanges in a form that can serve as the functional requirements for the technical exchange specification, called a model view definition (MVD). Thus the IDM is developed by users to specify what they need for a target workflow, to be translated later by the MVD into computer-implementable code.

This report defines the functional data exchange requirements and workflow scenarios for exchanges among all the entities involved in the cast-in-place (CIP) concrete supply chain during each phase of a project. There are a wide variety of CIP concrete elements used in construction projects including different types of footings, beams, columns, walls, slabs, ramps, corbels, piles, and piers. These are mostly used as part of the structural system of facilities. The different elements are often designed and produced by separate business entities that include formwork design and erection, reinforcement detailing, fabrication and placement, design of concrete mixture proportions, placing, testing and curing, and concrete finishing. Moreover, CIP concrete, as a fundamental building system, interacts with many other aspects of a building in the following ways:

(a) Concrete walls might be connected to steel or precast concrete beams and precast concrete or composite slabs, and sometimes to concrete columns.

(b) Concrete may encase or otherwise be connected to steel, creating composite members including composite beams, columns, shear walls, slabs, and braces.

(c) Mechanical electrical and plumbing (MEP) products cross CIP concrete elements.

(d) The site excavation plan and execution schedule are important for design and execution of concrete foundations.

Table 3.1a—Omniclass designation for project disciplines

Architecture	33-21-11-00	**Structural engineer**	33-21-31-14
Civil engineer	33-21 31 11	**Mechanical engineer**	33-21 31 17
Reinforcing detailer	33-41-11-14	**Reinforcing fabricator**	33-41-11-14
Batch plant	33-41 21 24	**Testing agency**	33-25 54 00
Concrete contractor	33-41 11 14	**Reinforcing contractor**	33-41 11 14 17
Formwork contractor	33-41 11 14	**Finish contractor**	33-41 11 14
General contractor	33-41 11 11	**Site contractor**	33-41 11 14
Reinforcement distributor	33-25 41 11	**Owner/client**	33-55 21 00

Notes: Omniclass is part of the ISO 12006-2 standard. ISO 12006-2 defines methods of organizing the information associated with construction and affiliated industries, and also promote a standard object-modeling definition for concepts addressed.

There are 16 different disciplines identified in the process model developed in this report (Table 3.1a). Exchanges are defined for six different phases of a project (Table 3.1b). To accommodate the diversity and variety of disciplines involved, efficient communication and collaboration of the different disciplines during each project phase is required. Different entities involved in design and production of CIP concrete elements use different software tools to generate information. Hence, enabling efficient interdisciplinary coordination and collaboration requires exchange of information between different software platforms in model and nonmodel forms. This report identifies and documents the information items that each discipline involved in design, planning, production, and site construction of CIP concrete needs to share with other disciplines at different stages of the projects.

Table 3.1b—Omniclass designation for project phases

Design development	31-20-20-00
Construction documentation	31-25-00-00
Concrete resource and placement planning	31-40-30-31
Concrete execution	31-40 40 24
Erection phase	31-40-40-14-11
Turnover	31-40-40-91-31

Workflows within the CIP concrete supply chain are not standardized, but are tuned dynamically to reflect what is most appropriate for a given project and stage. Some processes might vary based on the selected delivery method and specific contract terms designated for a project. The definitions of workflows in this report are tied into an overall process and a typical illustrative schedule, not as a prescriptive process. The process model is laid out to provide a structure for addressing different use cases of information exchange; they are not intended to be used as a prescriptive process.

3.2 —Information delivery manual hierarchy

Figure 3.2 illustrates the hierarchical structure used to develop an information delivery manual (IDM), which includes the following.

a) Process models (Appendixes A through D): this is defined for the general processes identified for cast-in-place (CIP) concrete construction projects. The process models identify the tasks carried out and the typical phase of design in which they are carried out. They also define the exchanges required to support the flow of information needed to accomplish those tasks; these are called exchange models. The full process models (Appendix A) have been filtered to show only those tasks and information exchanges

related to a certain portion of the CIP supply chain. Appendixes B through D show submodels for supply of concrete material such as shoring and formwork, and design, detailing, supply, and installation of reinforcing.

b) Tasks and model and nonmodel information exchange descriptions (Appendix E): the tasks, exchange models, and nonmodel exchanges identified in the process model throughout the lifecycle of the CIP concrete are described in short paragraphs, allowing cross-referencing back to the process model.

c) The detailed exchange models are fully reported in the consolidated exchange model tables in Appendix E. This provides a structure and definition of the exchange functionality for future implementation.

d) An exchange requirement report is part of the process for developing a model view definition (MVD). This report provides detailed functional requirements for the contents of each exchange. The functional requirements are being developed for the MVD for concrete and are not included in this report.

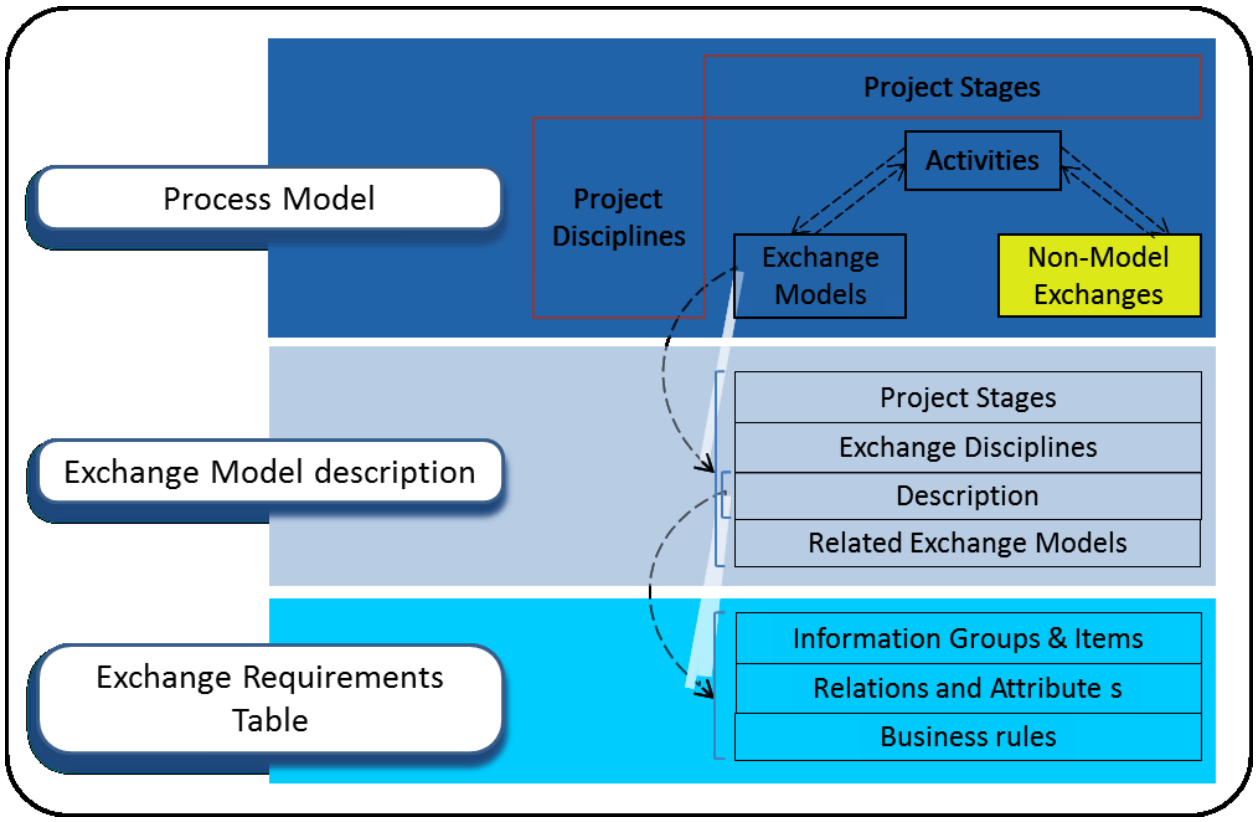

Fig. 3.2—IDM hierarchical structure.

CHAPTER 4—PROCESS MODEL

4.1 —Protocol for process model

One or more process models identify the tasks, actors, and information flow throughout the lifecycle of a project that are to be supported by building information modeling (BIM) tools. These models identify the relationship of tasks and information that are either used as an input to perform tasks or are outputs as a result of performing tasks. They help determine the information value chain throughout projects, identify the inefficiencies of current practice, and assist in eliminating the nonvalue-adding or lesser-value-adding information-based activities.

Business process modeling notation (BPMN), developed by Object Management Group (2013), is a standard for expressing process models that are flow-oriented representations of business

operations. Models represented by BPMN have been used to facilitate information exchange and communication between project participants and to aid with decision making based on various analysis techniques. Detailed BPMN models are, however, increasingly used to identify the information packages exchanged in business processes and to define required software features for vendors.

The main components of process models developed using BPMN are illustrated in Fig. 4.1 and include flow objects and connecting objects. Flow objects represent tasks or decision-making gateways. Connecting objects capture either the information flow between tasks that are carried out as a result of tasks or the logical sequence of tasks. The information flows are of two types: model data and nonmodel data.

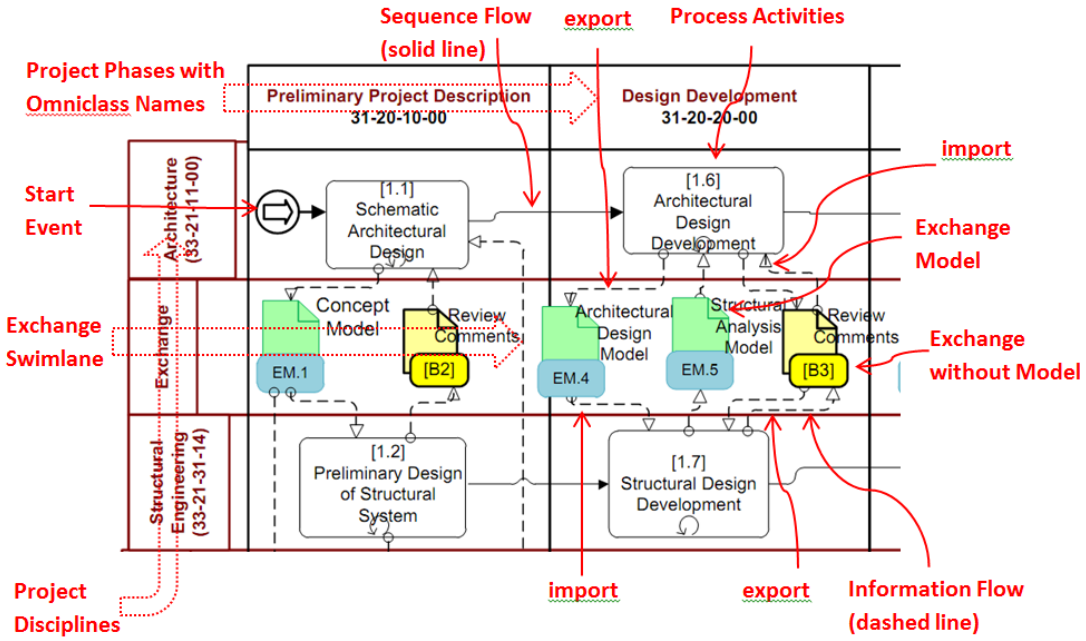

Fig. 4.1—BPMN notation guide.

BPMN uses swimlanes to categorize tasks with different functional objectives or capabilities. Some swimlanes contain the exchange requirements of a data source that may be carried either

by a BIM tool in the form of a model, referred to as exchange models, or other nonBIM forms of information exchange; for example, informal comments on the architectural design by the structural engineer. Exchange models are used to provide the content of information exchanges between users, software applications, or both. Further, to provide appropriate levels of development, tasks may be broken down into subprocesses that may be executed multiple times concurrently.

BPMN models are useful for identifying the exchange models in cast-in-place (CIP) concrete construction projects and provide a base to later identify the content of each information exchange package in the information delivery manual (IDM). In the BPMN model (ISO 12006-2), designations for project phases and project disciplines that are actors that participate in the use cases and workflows of projects are used (Table 3.1a and 3.1b).

Major process phases are identified in the context of their relation to CIP concrete construction. Omniclass classification is used to identify their relation to the overall construction process. In addition to the standard BPMN notation, the IDM uses notation for information exchanges between exchange models. Information exchanges in nonmodel forms such as text and tables are also identified and described.

4.2—Rules for formatting process model

Process models using business process modeling notation (BPMN) can be large and complex. They also have to have logic to be respected. The protocol used to make the process models more readable and logically correct are given in the following. There are two primary considerations: 1) formatting to facilitate readability; and 2) ensuring a logical information flow. These are described more fully as follows.

4.2.1 *Methods for formatting to facilitate readability*

4.2.1.1 *Aggregating information flows*

Multiple information flows leaving a model or nonmodel exchange are aggregated into a single pipe flow with branches, with a triangle identifying the number of flows in the pipe (Fig. 4.2.1.1).

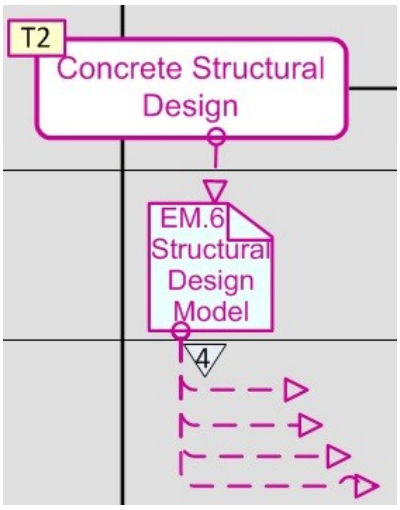

Fig. 4.2.1.1—Notation consolidation.

4.2.1.2 *Connection of all links*

For traceability and reading, all information flows are fully connected (Fig. 4.2.1.2).

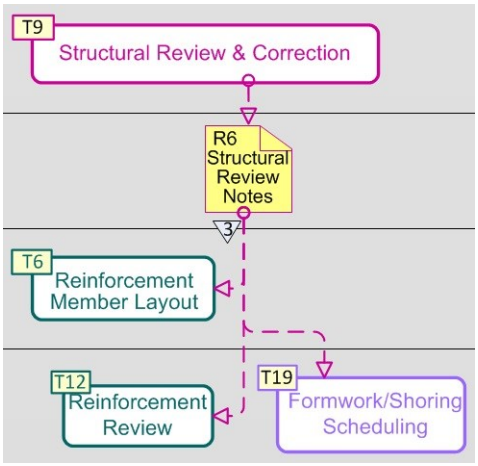

Fig. 4.2.1.2—BPMN notation guide: color coding of information flows.

4.2.1.3 *Coding of discipline information flows*

To facilitate visual tracking of information flows, each discipline should contain the tasks performed by the discipline; all the information generated by those tasks; and information flows from those tasks to generated models and, ultimately, to receiving tasks; each discipline is distinguished by a specific color (Table 4.2.1.3 and Fig. 4.2.1.3).

Table 4.2.1.3—Color codes for task boxes

Architect	Structural Engineering
Civil Engineering	Mechanical Engineering
Reinforcing Detailer	Reinforcing Fabricator
Batch Plant	Testing Agency
Concrete Contractor	Reinforcing Contractor
Formwork Contractor	Finish Contractor
General Contractor	Site Contractor

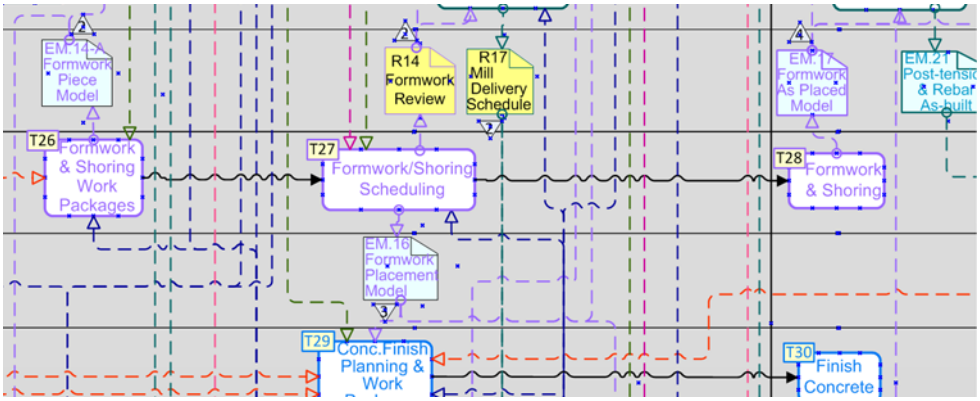

Fig. 4.2.1.3—BPMN notation guide: information flows from a source are coded to be same color as source.

The only exception for this rule is reinforcement related disciplines. To decrease the variety of colors used and make the tasks easier to trace, information models and connection links of four disciplines of reinforcing detailer, reinforcing fabricator, reinforcing contractor and reinforcement distributor are designated the same color.

4.2.1.4 *Hidden loop markers of tasks*

Usually several rounds of design, review, and modification goes into producing each exchange model and nonmodel information produced by each activity. In BPMN models, this repetition of tasks are normally illustrated by loop markers. Due to the complexity of the CIP concrete process model, the fact that planning of one placement cycle is proceeding at the same time as the execution of others, and to improve readability, these loop markers are removed (Fig. 4.2.1.4). It should be noted that the nature of most tasks in the CIP concrete design and production lead to several rounds of review and modification.

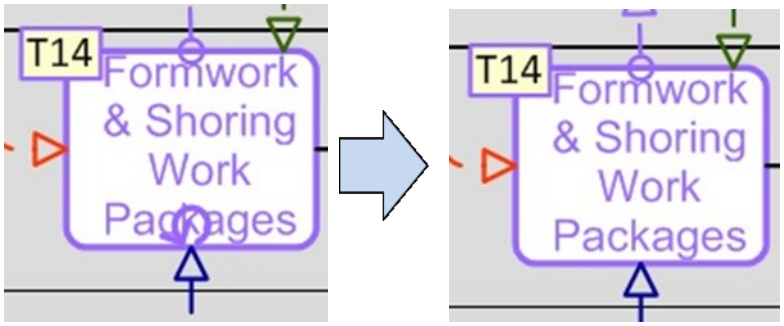

Fig. 4.2.1.4—BPMN uses a loop symbol to indicate iterated tasks. We assume all tasks can be iterated and removed the loop to enhance readability.

4.2.1.5 *Ensuring logical information flow*

A later activity or exchange model cannot inform an earlier activity. As it can be seen in Fig. 4.2.1.5a, EM.13 is generated in the Concrete Resource Planning phase and T16 happened in the Construction Documentation phase. Therefore, when T16 happens, EM.13 has not yet been generated and cannot be used as an input for T16. In these cases, some tasks are iterated across multiple project stages or they can happen in different stages of a project, depending on selected project delivery method and contract terms. In such cases, the tasks are extended to both reflect this iteration and cover different situations and also solve this logical issue rather than making separate tasks for each stage. In some cases, these links are corrected by routing them to corresponding tasks that happen in the same project phase.

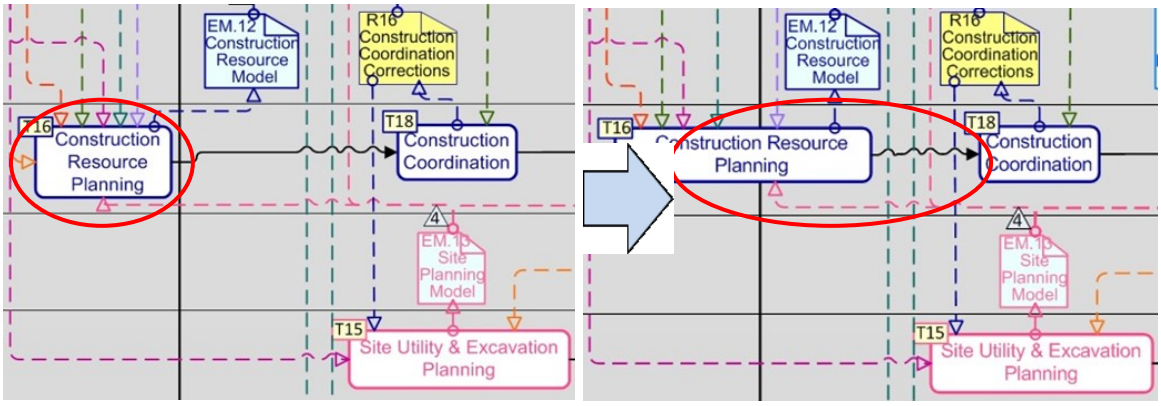

Fig. 4.2.1.5a—Adjustment of column alignment for flow direction consistency.

Tasks within a row receive all the information in the tasks to the left in the row because they are received by the same discipline. They need not be explicitly linked (Fig. 4.2.1.5b).

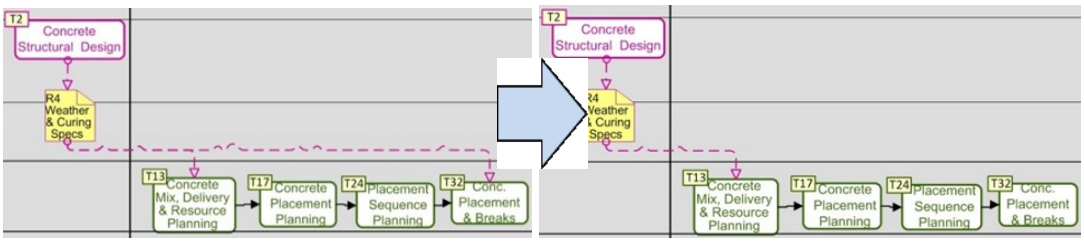

Fig. 4.2.1.5b—Implicit information flows within a task row.

4.2.1.6 *Single application*

Exchange models are the product of a single application. As an exchange between applications, only one application can generate the data for a model or nonmodel view (Fig. 4.2.1.6).

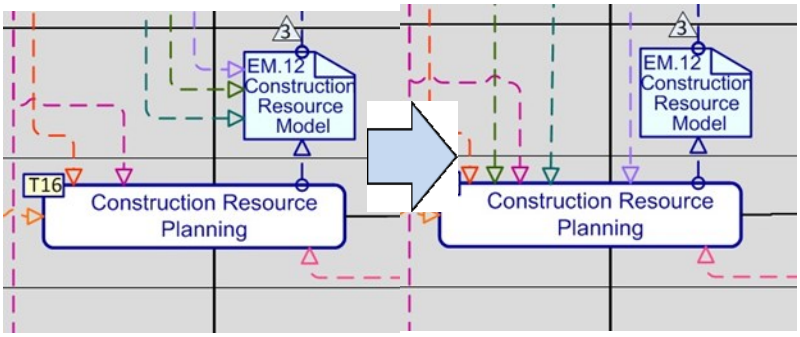

Fig. 4.2.1.6—IDM for reinforced concrete supports application to application exchange.

CHAPTER 5—TASK, EXCHANGE MODEL, AND NONMODEL INFORMATION DESCRIPTIONS

Written documentation is required to describe the intent of the tasks and exchanges identified in the process models. These descriptions are linked by identifiers to the process model. All

exchange models in the process models 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 tasks. They identify which objects, processes properties, relations, and classifications are both relevant to the receiving (importing) application and available in the sending (exporting) application (Table 5a through 5c).

Table 5a—Task description template

Project phase	Omniclass project stage
Discipline	Name and Omniclass discipline number of the activity performer
Information obtained from	Name and Omniclass discipline number of the disciplines who send their generated model information, nonmodel information, or both, as an input to enable execution of this activity.
Task description	Verbal description of: 1. The purpose of the activity 2. Task execution process

Table 5b—Nonmodel exchange description template

Project phase	Omniclass project stage
Discipline from	Omniclass discipline number and name of the discipline generating this nonmodel information.
Discipline(s) to	Omniclass number and name of disciplines who receive the generated nonmodel information.
Information transmitted	Verbal description of: 1. The purpose of the exchange 2. The required contents of the exchange 3. The optional contents of the exchange
Typical formats	Formats in which the nonmodel information is exchanged.

Table 5c—Exchange model description template

Project stage	Omniclass project stage
Exchange disciplines	Parties to this exchange From: To:

	By Omniclass discipline number and name. (can be more than two disciplines, but using the same basic data)
Description	Verbal description of: 1. The purpose of the exchange 2. The required contents of the exchange 3. The optional contents of the exchange 4. Whether the exchanges are round trip or one-way
Related exchange models	Other exchanges this one interacts with (proceeding and succeeding exchanges)

The term information items is used to refer to items that need to transfer information. These may represent physical objects (such as gravity retaining wall or precast double tee beam) or abstract ideas (such as wind loads or surface treatment). The goal in developing the exchange descriptions is to specify these information items and their attributes in sufficient detail that the coverage of exchanges will be understood. They are initially identified contextually in the process models and are then defined in generic text in the exchange models. Nonmodel exchange descriptions are also provided.

CHAPTER 6—REFERENCES

Committee documents are listed first by document number and year of publication followed by authored documents listed alphabetically.

International Standards Organization

ISO 12006-2:2001 Building Construction—Organization of Information about Construction Works—Part 2: Framework for Classification of Information

ISO 12006-3:2007 Building Construction—Organization of Information about Construction Works—Part 3: Framework for Object-Oriented Information

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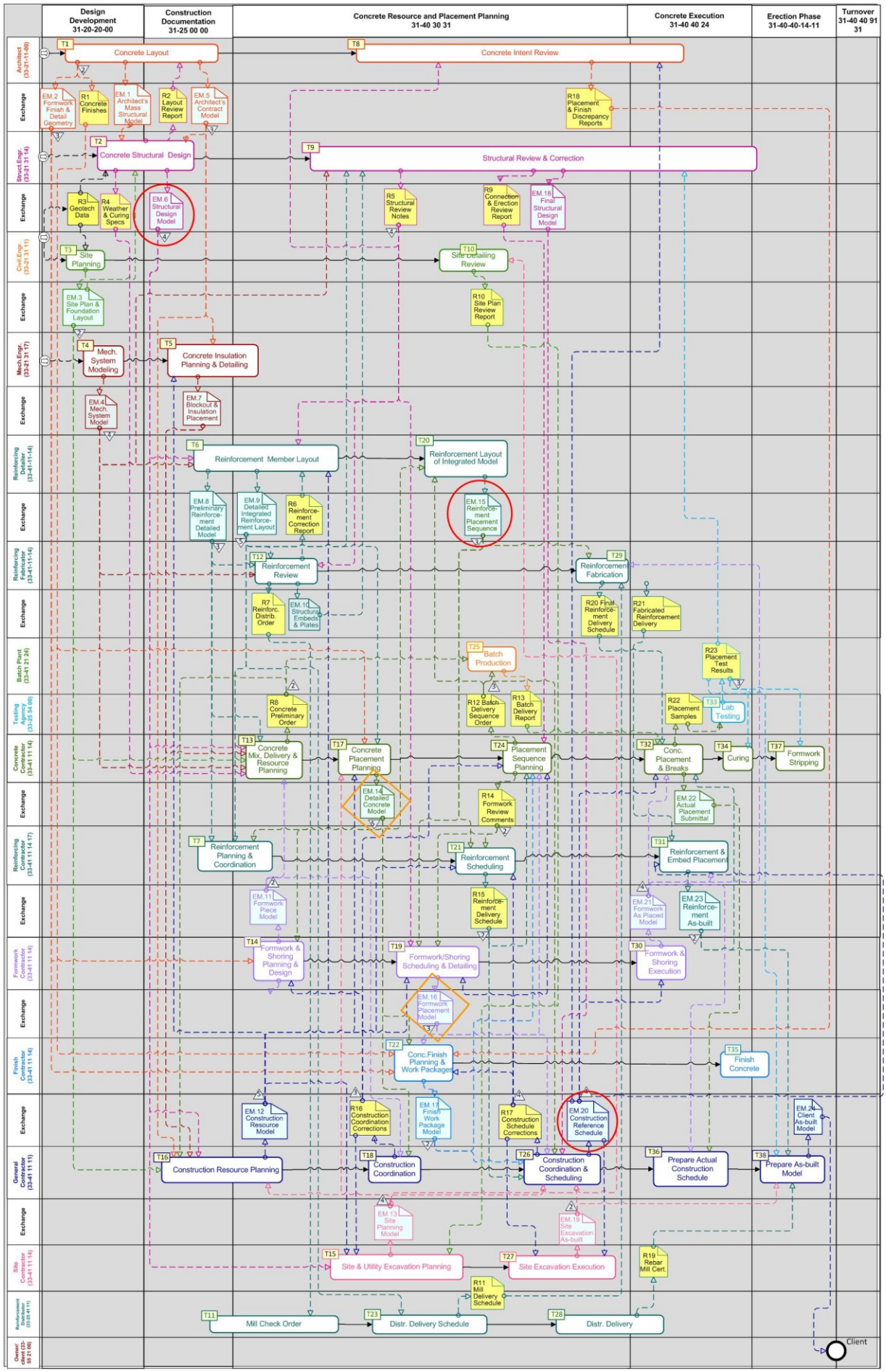
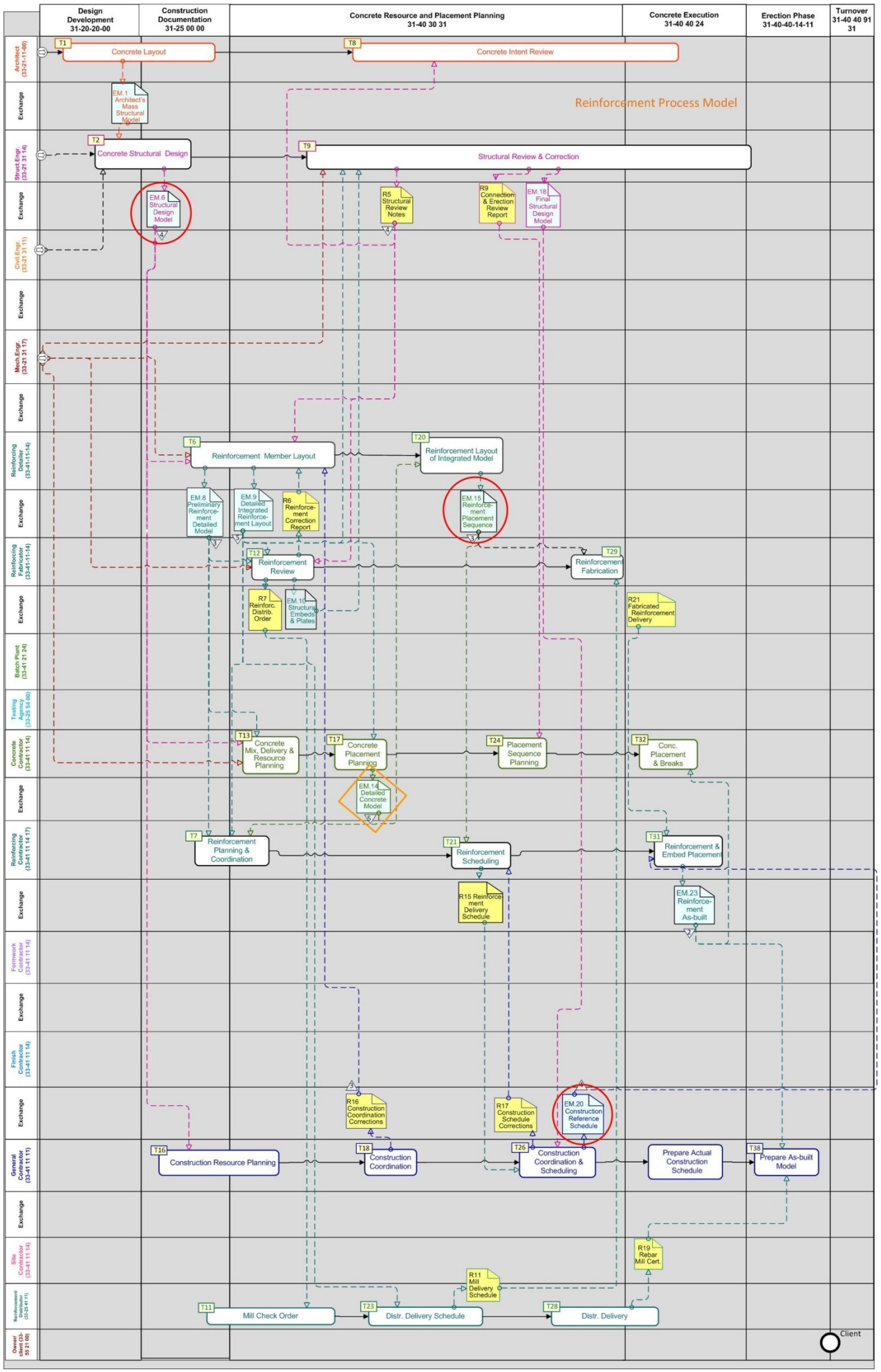
Appendix A—COMPLETE CAST-IN-PLACE CONCRETE PROCESS MODEL


Design Development 31-20-20-00
Construction Documentation 31-25 00 00
Concrete Resource and Placement Planning 31-40 30 31
Concrete Execution 31-40 40 24
Erection Phase 31-40-40-14-11
Turnover 31-40 40 91 31
Architect (33-21-11-00)
Exchange
Struct.Engr. (33-21 31 14)
Civil.Engr. (33-21 31 11)
Mech.Engr. (33-21 31 17)
Reinforcing Detailer (33-41 11 14)
Reinforcing Fabricator (33-41 11 14)
Batch Plant (33-41 21 24)
Testing Agency (33-20 34 00)
Concrete Contractor (33-41 11 14)
Reinforcing Contractor (33-41 11 14 17)
Formwork Contractor (33-41 11 14)
Finish Contractor (33-41 11 14)
General Contractor (33-41 11 11)
Site Contractor (33-41 11 14)
Reinforcement Supplier (33-41 11)
Owner/ client (33-80 00)
T1 Concrete Layout
T8 Concrete Intent Review
EM.2 Formwork Finish & Detail Geometry
R1 Concrete Finishes
EM.1 Architect's Mass Structural Model
R2 Layout Review Report
EM.5 Architect's Contract Model
R18 Placement & Finish Discrepancy Reports
T2 Concrete Structural Design
T9 Structural Review & Correction
R3 Geotech Data
R4 Weather & Curing Specs
EM.6 Structural Design Model
R5 Structural Review Notes
R9 Connection & Erection Review Report
EM.18 Final Structural Design Model
T3 Site Planning
T10 Site Detailing Review
EM.3 Site Plan & Foundation Layout
R10 Site Plan Review Report
T4 Mech. System Modeling
T5 Concrete Insulation Planning & Detailing
EM.4 Mech. System Model
EM.7 Blockout & Insulation Placement
T6 Reinforcement Member Layout
T20 Reinforcement Layout of Integrated Model
EM.8 Preliminary Reinforcement Detailed Model
EM.9 Detailed Integrated Reinforcement Layout
R6 Reinforcement Correction Report
EM.15 Reinforcement Placement Sequence
T12 Reinforcement Review
T29 Reinforcement Fabrication
R7 Reinforc. Distrib. Order
EM.10 Structural Embeds & Plates
R20 Final Reinforcement Delivery Schedule
R21 Fabricated Reinforcement Delivery
T25 Batch Production
R23 Placement Test Results
R8 Concrete Preliminary Order
R12 Batch Delivery Sequence Order
R13 Batch Delivery Report
R22 Placement Samples
T33 Lab Testing
T13 Concrete Mix, Delivery & Resource Planning
T17 Concrete Placement Planning
T24 Placement Sequence Planning
T32 Conc. Placement & Breaks
T34 Curing
T37 Formwork Stripping
EM.14 Detailed Concrete Model
R14 Formwork Review Comments
EM.22 Actual Placement Submittal
T7 Reinforcement Planning & Coordination
T21 Reinforcement Scheduling
T31 Reinforcement & Embed Placement
EM.11 Formwork Piece Model
R15 Reinforcement Delivery Schedule
EM.21 Formwork As Placed Model
EM.23 Reinforcement As-built
T14 Formwork & Shoring Planning & Design
T19 Formwork/Shoring Scheduling & Detailing
T30 Formwork & Shoring Execution
EM.16 Formwork Placement Model
T22 Conc.Finish Planning & Work Packages
T35 Finish Concrete
EM.12 Construction Resource Model
R16 Construction Coordination Corrections
EM.17 Finish Work Package Model
R17 Construction Schedule Corrections
EM.20 Construction Reference Schedule
EM.24 Client As-built Model
T16 Construction Resource Planning
T18 Construction Coordination
T26 Construction Coordination & Scheduling
T36 Prepare Actual Construction Schedule
T38 Prepare As-built Model
EM.13 Site Planning Model
EM.19 Site Excavation As-built
T15 Site & Utility Excavation Planning
T27 Site Excavation Execution
R19 Rebar Mill Cert.
R11 Mill Delivery Schedule
T11 Mill Check Order
T23 Distr. Delivery Schedule
T28 Distr. Delivery
Client

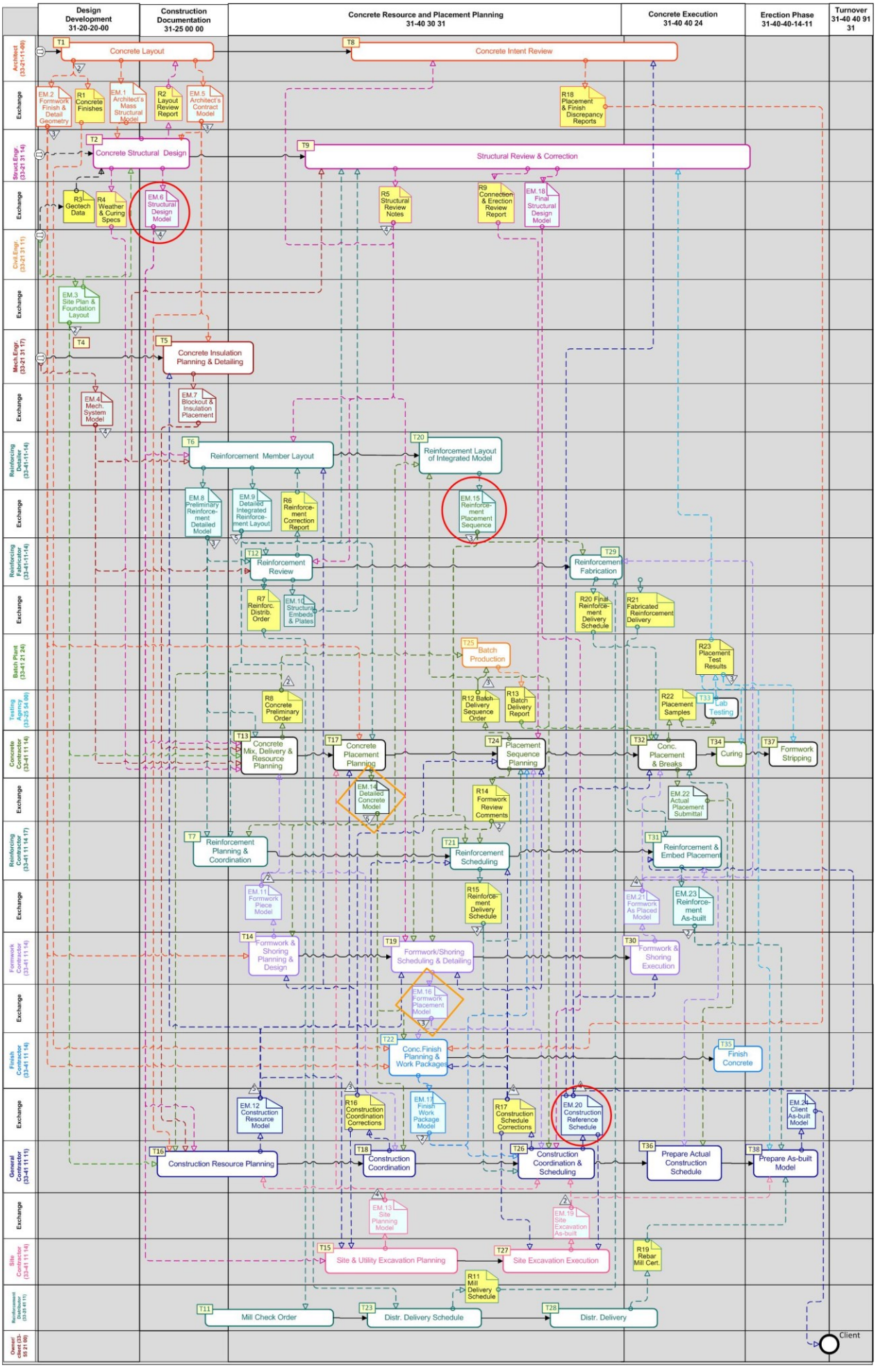
Notes: Red circle indicates primary exchange for developing MVD; yellow diamond indicates secondary exchange for developing MVD.

Appendix B —CONCRETE REINFORCEMENT SUBPROCESS MODEL

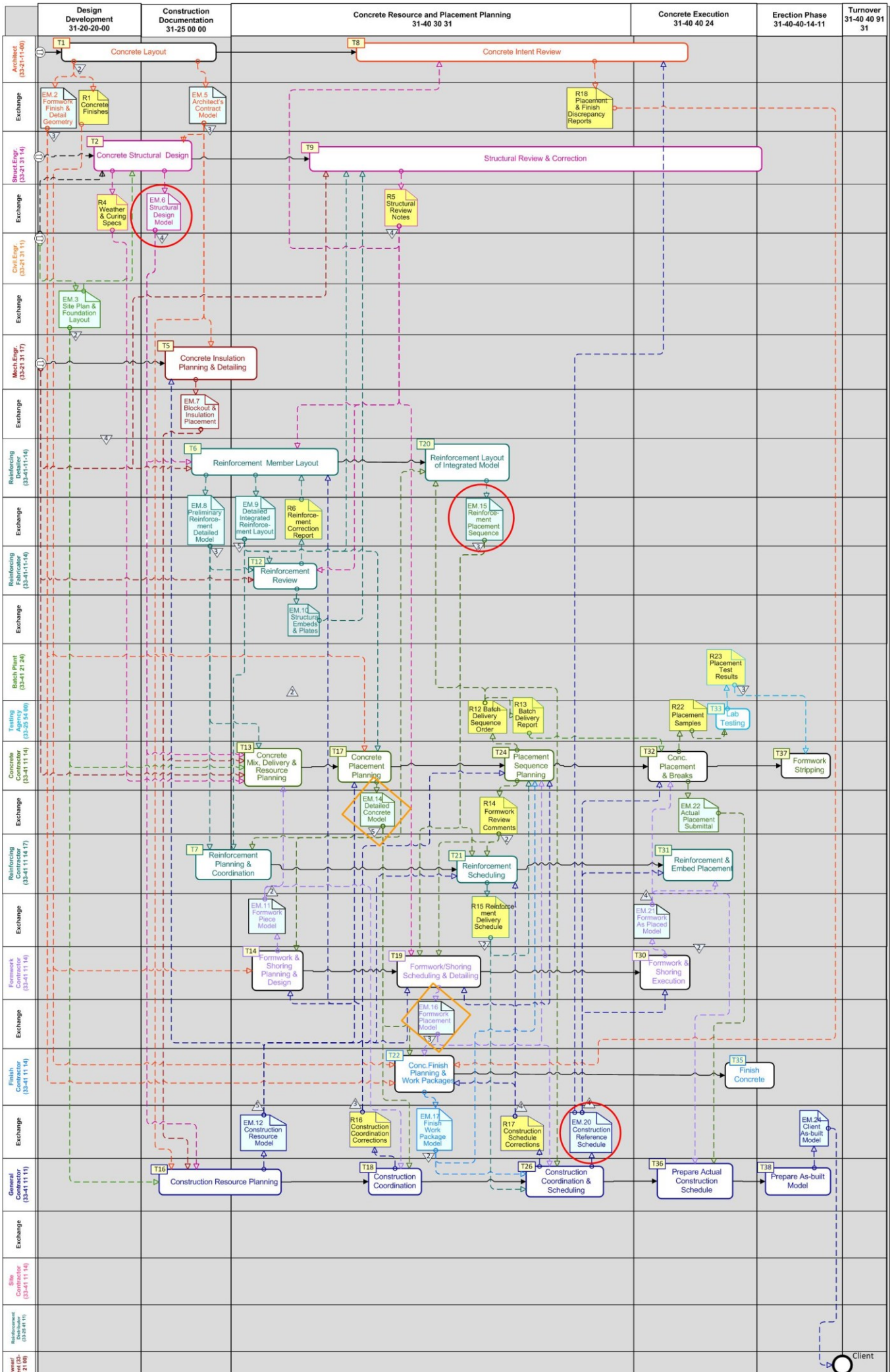

Design Development 31-20-20-00
Construction Documentation 31-25 00 00
Concrete Resource and Placement Planning 31-40 30 31
Concrete Execution 31-40 40 24
Erection Phase 31-40-40-14-11
Turnover 31-40 40 91 31
Reinforcement Process Model
Architect (33-21-11-00)
Exchange
Struct.Engr. (33-21 31 14)
Civil.Engr. (33-21 31 11)
Mech.Engr. (33-21 31 17)
Reinforcing Detailer (33-41-11-14)
Batch Plant (33-41 21 24)
Testing Agency (33-23 34 00)
Concrete Contractor (33-41 11 14)
Formwork Contractor (33-41 11 14)
Finish Contractor (33-41 11 14)
General Contractor (33-41 11 11)
Site Contractor (33-41 11 14)
Reinforcement Supplier (33-23 41 11)
Owner/ Operator (33-05 95 21 00)
T1 Concrete Layout
T8 Concrete Intent Review
EM.1 Architect's Mass Structural Model
T2 Concrete Structural Design
T9 Structural Review & Correction
EM.6 Structural Design Model
R5 Structural Review Notes
R9 Connection & Erection Review Report
EM.18 Final Structural Design Model
T6 Reinforcement Member Layout
T20 Reinforcement Layout of Integrated Model
EM.8 Preliminary Reinforce-ment Detailed Model
EM.9 Detailed Integrated Reinforce-ment Layout
R6 Reinforce-ment Correction Report
EM.15 Reinforce-ment Placement Sequence
T12 Reinforcement Review
T29 Reinforcement Fabrication
R7 Reinforc. Distrib. Order
EM.10 Structural Embeds & Plates
R21 Fabricated Reinforcement Delivery
T13 Concrete Mix, Delivery & Resource Planning
T17 Concrete Placement Planning
T24 Placement Sequence Planning
T32 Conc. Placement & Breaks
EM.14 Detailed Concrete Model
T7 Reinforcement Planning & Coordination
T21 Reinforcement Scheduling
T31 Reinforcement & Embed Placement
R15 Reinforce-ment Delivery Schedule
EM.23 Reinforce-ment As-built
R16 Construction Coordination Corrections
R17 Construction Schedule Corrections
EM.20 Construction Reference Schedule
T16 Construction Resource Planning
T18 Construction Coordination
T26 Construction Coordination & Scheduling
Prepare Actual Construction Schedule
T38 Prepare As-built Model
R19 Rebar Mill Cert.
R11 Mill Delivery Schedule
T11 Mill Check Order
T23 Distr. Delivery Schedule
T28 Distr. Delivery
Client

Note: This process model and the two following it extract out from the full model a subset to facilitate flow tracking. B-1 breaks out reinforcement based exchanges; B-2 breaks out concrete placement centered exchanges; B-3 breaks out formwork and shoring centric exchanges.

Appendix C —Concrete Placement Subprocess Model


Design Development 31-20-20-00
Construction Documentation 31-25 00 00
Concrete Resource and Placement Planning 31-40 30 31
Concrete Execution 31-40 40 24
Erection Phase 31-40-40-14-11
Turnover 31-40 40 91 31
Architect (33-21-11-00)
Exchange
Struct.Engr. (33-21 31 14)
Exchange
Civil.Engr. (33-21 31 11)
Exchange
Mech.Engr. (33-21 31 17)
Exchange
Reinforcing Detailer (33-41-11-14)
Exchange
Reinforcing Fabricator (33-41-11-14)
Exchange
Batch Plant (33-41 21 24)
Testing Agency (33-05 54 00)
Concrete Contractor (33-41 11 14)
Exchange
Reinforcing Contractor (33-41 11 14, 17)
Exchange
Formwork Contractor (33-41 11 14)
Exchange
Finish Contractor (33-41 11 14)
Exchange
General Contractor (33-41 11 11)
Exchange
Site Contractor (33-41 11 14)
Reinforcement Supplier (33-28 41 11)
Owner (Client) (33-05 21 00)
T1 Concrete Layout
T8 Concrete Intent Review
EM.2 Formwork Finish & Detail Geometry
R1 Concrete Finishes
EM.1 Architect's Mass Structural Model
R2 Layout Review Report
EM.5 Architect's Contract Model
R18 Placement & Finish Discrepancy Reports
T2 Concrete Structural Design
T9 Structural Review & Correction
R3 Geotech Data
R4 Weather & Curing Specs
EM.6 Structural Design Model
R5 Structural Review Notes
R9 Connection & Erection Review Report
EM.18 Final Structural Design Model
EM.3 Site Plan & Foundation Layout
T4
T5 Concrete Insulation Planning & Detailing
EM.4 Mech. System Model
EM.7 Blockout & Insulation Placement
T6 Reinforcement Member Layout
T20 Reinforcement Layout of Integrated Model
EM.8 Preliminary Reinforcement Detailed Model
EM.9 Detailed Integrated Reinforcement Layout
R6 Reinforcement Correction Report
EM.15 Reinforcement Placement Sequence
T12 Reinforcement Review
T29 Reinforcement Fabrication
R7 Reinforc. Distrib. Order
EM.10 Structural Embeds & Plates
R20 Final Reinforcement Delivery Schedule
R21 Fabricated Reinforcement Delivery
T25 Batch Production
R23 Placement Test Results
R8 Concrete Preliminary Order
R12 Batch Delivery Sequence Order
R13 Batch Delivery Report
R22 Placement Samples
T33 Lab Testing
T13 Concrete Mix, Delivery & Resource Planning
T17 Concrete Placement Planning
T24 Placement Sequence Planning
T32 Conc. Placement & Breaks
T34 Curing
T37 Formwork Stripping
EM.14 Detailed Concrete Model
R14 Formwork Review Comments
EM.22 Actual Placement Submittal
T7 Reinforcement Planning & Coordination
T21 Reinforcement Scheduling
T31 Reinforcement & Embed Placement
EM.11 Formwork Piece Model
R15 Reinforcement Delivery Schedule
EM.21 Formwork As Placed Model
EM.23 Reinforcement As-built
T14 Formwork & Shoring Planning & Design
T19 Formwork/Shoring Scheduling & Detailing
T30 Formwork & Shoring Execution
EM.16 Formwork Placement Model
T22 Conc.Finish Planning & Work Packages
T35 Finish Concrete
EM.12 Construction Resource Model
R16 Construction Coordination Corrections
EM.17 Finish Work Package Model
R17 Construction Schedule Corrections
EM.20 Construction Reference Schedule
EM.24 Client As-built Model
T16 Construction Resource Planning
T18 Construction Coordination
T26 Construction Coordination & Scheduling
T36 Prepare Actual Construction Schedule
T38 Prepare As-built Model
EM.13 Site Planning Model
EM.19 Site Excavation As-built
T15 Site & Utility Excavation Planning
T27 Site Excavation Execution
R19 Rebar Mill Cert.
R11 Mill Delivery Schedule
T11 Mill Check Order
T23 Distr. Delivery Schedule
T28 Distr. Delivery
Client

Appendix D—Concrete Formwork and Shoring Subprocess Model


Design Development 31-20-20-00
Construction Documentation 31-25 00 00
Concrete Resource and Placement Planning 31-40 30 31
Concrete Execution 31-40 40 24
Erection Phase 31-40-40-14-11
Turnover 31-40 40 91 31
Architect (33-21-11-00)
Exchange
Struct.Engr. (33-21 31 14)
Civil Engr. (33-21 31 11)
Mech.Engr. (33-21 31 17)
Reinforcing Detailer (33-41 11 14)
Reinforcing Contractor (33-41 11 14)
Batch Plant (33-41 21 24)
Testing Agency (33-29 54 00)
Concrete Contractor (33-41 11 14)
Formwork Contractor (33-41 11 14)
Finish Contractor (33-41 11 14)
General Contractor (33-41 11 11)
Site Contractor (33-41 11 14)
T1 Concrete Layout
T2 Concrete Structural Design
T5 Concrete Insulation Planning & Detailing
T6 Reinforcement Member Layout
T7 Reinforcement Planning & Coordination
T8 Concrete Intent Review
T9 Structural Review & Correction
T12 Reinforcement Review
T13 Concrete Mix, Delivery & Resource Planning
T14 Formwork & Shoring Planning & Design
T16 Construction Resource Planning
T17 Concrete Placement Planning
T18 Construction Coordination
T19 Formwork/Shoring Scheduling & Detailing
T20 Reinforcement Layout of Integrated Model
T21 Reinforcement Scheduling
T22 Conc.Finish Planning & Work Packages
T24 Placement Sequence Planning
T26 Construction Coordination & Scheduling
T30 Formwork & Shoring Execution
T31 Reinforcement & Embed Placement
T32 Conc. Placement & Breaks
T33 Lab Testing
T35 Finish Concrete
T36 Prepare Actual Construction Schedule
T37 Formwork Stripping
T38 Prepare As-built Model
EM.2 Formwork Finish & Detail Geometry
R1 Concrete Finishes
EM.5 Architect's Contract Model
R18 Placement & Finish Discrepancy Reports
R4 Weather & Curing Specs
EM.6 Structural Design Model
R5 Structural Review Notes
EM.3 Site Plan & Foundation Layout
EM.7 Blockout & Insulation Placement
EM.8 Preliminary Reinforcement Detailed Model
EM.9 Detailed Integrated Reinforcement Layout
R6 Reinforcement Correction Report
EM.15 Reinforcement Placement Sequence
EM.10 Structural Embeds & Plates
R12 Batch Delivery Sequence Order
R13 Batch Delivery Report
R23 Placement Test Results
R22 Placement Samples
EM.14 Detailed Concrete Model
R14 Formwork Review Comments
EM.22 Actual Placement Submittal
EM.11 Formwork Piece Model
R15 Reinforcement Delivery Schedule
EM.21 Formwork As Placed Model
EM.16 Formwork Placement Model
EM.12 Construction Resource Model
R16 Construction Coordination Corrections
EM.13 Finish Work Package Model
R17 Construction Schedule Corrections
EM.20 Construction Reference Schedule
EM.24 Client As-built Model
Client

Appendix E—DESCRIPTIONS OF CAST-IN-PLACE REINFORCED CONCRETE TASKS AND MODEL AND NONMODEL EXCHANGE DESCRIPTIONS

(I) Task Descriptions

The following tasks and sub-processes define the tasks (T), the exchange models, and the nonmodel exchanges (R) that relate to the process. Disciplines and project stages are noted using Omniclass, Tables 33 (Disciplines) and 31 (Project Phases).

T1—Concrete layout

Design phase	Design development 31-20-20-00 Construction documentation 31-25 00 00
Discipline	Architect 33-21-11-00
Information obtained from	This task elaborates a concept model, complete to level of architect's design development; information is obtained from all facility type consultants, mechanical and equipment engineers, landscape and site consultants, and preliminary review of structural engineers.
Task description	The architects or designers produce the reinforced concrete aspects of a construction project, in terms of spatial layout, shapes, and approximate dimensions. This design includes foundations, site development and retaining walls, and concrete roads and paths. Surface finishes and textures for architectural finishes are defined.

T2—Concrete structural design

Design phase	Design development 31-20-20-00 Construction documentation 31-25 00 00
Discipline	Structural engineer 33-21 31 14
Information obtained from	Receives architect's model and general facility layout and site plan. Also receives site development, including paths and roadways, retaining walls and other site improvements, and geotechnical model or data from site engineer.
Task description	Determines applicable code loading conditions and other structural requirements. Defines and analyzes structural model in sufficient detail to ensure requirements will be met. Model typically includes all member sizes and reinforcing and tendons. Also Includes foundations and retaining walls.

T3—Site planning

Design phase	Design development 31-20-20-00
Discipline	Civil engineer 33-21 31 11
Information obtained from	Architect or site planner, geotechnical consultant, surveyor, or all of these
Task description	Develops or imports already defined model of site plan with general placement of building, all site improvements including pathways and roads, steps, retaining walls or other earth

	retainers, and planting and landscape areas. Places subterranean infrastructure such as sewer lines, existing or planned cisterns, and water catchment or drainage improvements, if existing or planned. Information sufficient for contractual bidding.

T4—Mechanical system modeling

Design phase	Design development 31-20-20-00
Discipline	Mechanical engineer 33-21 31 17
Information obtained from	Prepares mechanical equipment information needed for structural engineering contract documents.
Task description	Integrates all mechanical equipment and electrical and plumbing systems into a mechanical system model appropriate for bidding. Model for concrete work includes reference models to major mechanical equipment with approximate loads, major supply lines, and other services that may affect concrete detailing, including blockouts. Also includes all mechanical equipment connection plates and hardware.

T5—Concrete insulation planning and detailing

Design phase	Construction documentation 31-25 00 00 Concrete resource and placement planning 31-40 30 31
Discipline	Mechanical engineer 33-21 31 17
Information obtained from	General contractor identifies insulation and thermal barriers to be associated with foundation or other concrete placement tasks (comes from contractor).
Task description	Mechanical engineer determines placement of insulation and thermal barriers to be associated with foundation or other concrete placement tasks (comes from contractor).

T6—Reinforcement member layout

Design phase	Construction documentation 31-25 00 00 Concrete resource and placement planning 31-40 30 31
Discipline	Reinforcing detailer 33-41-11-14
Information obtained from	Receives reinforcing requirements from structural engineer, construction coordination model from general contractor, embeds, and plates
Task description	Generates a discrete piece model with reinforcing layout, including plates and embeds. Includes design and placement of tendons

T7—Reinforcement planning and coordination

Design phase	Construction documentation 31-25 00 00 Concrete resource and placement planning 31-40 30 31
Discipline	Reinforcing contractor 33-41-11-14 17
Information obtained from	Reinforcing review by contractor, based on preliminary layout; coordination and feedback from other trades
Task description	Reviews special needs and expected schedule requirements.

T8—Concrete intent review

Design phase	Concrete resource and placement planning 31-40 30 31 Concrete execution 31-40 40 24
Discipline	Architect 33-21-11-00
Information obtained from	Reviews finish samples and finish field work, equipment, and other material placements for design intent
Task description	Reviews concrete placement, relation of equipment, and hardware placements; reviews finishes; and approves (or not)

T9—Structural review

Design phase	Concrete resource and placement planning 31-40 30 31 Concrete execution 31-40 40 24
Discipline	Structural engineer 33-21 31 14
Information obtained from	Varied sources including mechanical engineer, reinforcement detailer and fabricator, and concrete testing agency
Task description	This is an iterated activity. Structural engineer reviews all shop drawings and submittals and changes during construction planning to determine if structural intent has been violated. Proposes corrections as needed.

T10—Site detailing review

Design phase	Concrete resource and placement planning 31-40 30 31
Discipline	Civil engineer 33-21 31 11
Information obtained from	Site contractor and general contractor
Task description	Reviews relevant site conditions and maintains and coordinates site issues associated with concrete placement and footings, retaining structures, and shoring.

T11—Mill check order

Design phase	Construction documentation 31-25 00 00 Concrete resource and placement planning 31-40 30 31
Discipline	Reinforcement distributor (33-25 41 11)
Information obtained from	Reinforcing fabricator provides model of structural reinforcing.
Task description	Concrete contractor identifies all nonstock reinforcing material required for project and generates mill order for steel or composite reinforcing. Makes sure order lead times are not an issue. May include special embeds.

T12—Reinforcing bar review

Design phase	Concrete resource and placement planning 31-40 30 31
Discipline	Reinforcing fabricator 33-41-11-14
Information obtained from	Initial reinforcing bar review by fabricator, based on design requirements from structural engineer.
Task description	Based on lengths, material specifications, and bending requirements, reinforcing bar is planned and initial production schedule set.

T13—Concrete mixture, delivery, and resource planning

Design phase	Concrete resource and placement planning 31-40 30 31
Discipline	Concrete contractor 33-41 11 14
Information obtained from	Receives model data from site planning, structural engineer, mechanical engineer, formwork contractor, and reinforcement detailer including information of embeds and plates, connections, and structural building model.
Task description	Determine resource needs and schedule for execution of concrete work packages. Includes delivery and lifting needs and rough schedule. Prepares preliminary mixture proportions selection and other concrete products (vapor barriers, water stop, curing materials. Develops overall concrete and reinforcement execution plan.

T14—Formwork and shoring, planning, and design

Design phase	Concrete resource and placement planning 31-40 30 31
Discipline	Formwork contractor 33-41 11 11
Information obtained from	Receives detailed concrete model and approximate schedule and construction coordination model.
Task description	Develops general formwork and shoring plan; addresses sources of formwork and scaffolding and special shoring systems. Generates shoring work packages.

T15—Site and utility excavation planning

Design phase	Concrete resource and placement planning 31-40 30 31
Discipline	Site contractor 33-41 11 14
Information obtained from	Civil (site planning) engineer, structural engineer, reinforcement contractor, and construction coordination model
Task description	Refines site model addressing both construction use as yard for materials and supplies, and also for site improvements and infrastructure. Of particular special relevance are access and material delivery planning, safety reviews, scheduling the major site construction, and providing options for shoring and formwork.

T16—Construction resource planning

Design phase	Construction documentation 31-25 00 00 Concrete resource and placement planning 31-40 30 31
Discipline	General contractor 33-41 11 11
Information obtained from	Information from all subcontractors and fabricators, regarding their general three-dimensional layouts in the facility. Receives logistical material flow requirements.
Task description	Identifies material flows for the project, including truck deliveries; concrete deliveries; and crane, lifts, and other people and material vertical movement systems. Resolves conflicting requirements.

T17—Concrete placement planning

Design phase	Concrete resource and placement planning 31-40 30 31
Discipline	Concrete contractor 33-41 11 14
Information obtained from	Elaborates concrete model to incorporate reinforcing bar placement plans, detailed geometry, formwork placement, mechanical system model for embeds and blockouts, and structural review and construction coordination model.
Task description	Develops initial pour sequence, based on all preparatory tasks dealing with reinforcement and formwork.

T18—Construction coordination

Design phase	Concrete resource and placement planning 31-40 30 31
Discipline	General contractor 33-41 11 11
Information obtained from	Working fabrication-level models from all fabricators and subcontractors.
Task description	Coordination review by general contractor, considers all in-place systems for clashes and clearances, addresses connection alignment between systems.

T19—Formwork/shoring, scheduling and detailing

Design phase	Concrete resource and placement planning 31-40 30 31
Discipline	Formwork contractor 33-41 11 14
Information obtained from	Reinforcing bar and tendon schedule, concrete placing general plan, construction schedule correction, and structural review notes
Task description	Determines formwork and shoring schedule, synchronizing with placement schedule.

T20—Reinforcement layout of integrated model

Design phase	Concrete resource and placement planning 31-40 30 31
Discipline	Reinforcing detailer 33-41-11-14
Information obtained from	Uses reinforcing bar and tendon layout of structural members, batch delivery sequence order, and detailed concrete model

Task description	Determines revised reinforcing bar details that addresses pour sequence and breaks and continuity of reinforcing bar where advantageous. Determines reinforcing bar placement at connections and member intersections and identifies laps and reinforcing bar connectors. Considers monolithic model and resolves overlaps.

T21—Reinforcement scheduling

Design phase	Concrete resource and placement planning 31-40 30 31
Discipline	Reinforcing contractor 33-41 11 14 17
Information obtained from	Receives reinforcing placement model, formwork and shoring work package, and coordinated construction model from general contractor.
Task description	Plans reinforcing bar and tendon sequencing and schedule. Reflects pour sequencing and anticipates formwork sequencing.

T22—Concrete finish planning and work packages

Design phase	Concrete resource and placement planning 31-40 30 31
Discipline	Finish contractor 33-41 11 14
Information obtained from	Concrete finish layout model, detail concrete model, formwork placement model, and construction coordination model.
Task description	Integrate and adjust sequencing of concrete formwork and stripping plans to address finish liners or post-stripping procedures.

T23—Distributor delivery schedule

Design phase	Concrete resource and placement planning 31-40 30 31
Discipline	Reinforcement distributor 33-25 41 11
Information obtained from	Reinforcing bar and concrete placement schedule, preliminary reinforcing bar placement schedule.
Task description	Coordinate reinforcement delivery schedule with overall placement schedule.

T24—Placement sequence planning

Design phase	Concrete resource and placement planning 31-40 30 31
Discipline	Concrete contractor 33-41 11 14
Information obtained from	Receives construction coordination and schedule corrections, reinforcement delivery schedule, formwork placement model, finish work packages model and connection, and erection review report.
Task description	Works out pour sequence plan, coordinating with general contractor; includes coordination of concrete deliveries, reinforcing, formwork, concrete finishes, all embeds, and other supplies; updates placement model to reflect this information.

T25—Batch order

Design phase	Concrete resource and placement planning 31-40 30 31
Discipline	Batch plant 33-41 21 24
Information obtained from	Receives concrete batch delivery and mixture proportion requirements for project.
Task description	Determines sources and arranges for admixtures for special performance needs.

T26—Construction coordination and scheduling

Design phase	Concrete resource and placement planning 31-40 30 31
Discipline	General contractor 33-41 11 11
Information obtained from	Brings together all schedules from subcontractors for coordination
Task description	Generate construction schedule and coordination model; may relate all models together in four-dimensional simulation. Model includes all preparatory tasks, including shoring, formwork and reinforcing placement, concrete placement, and form stripping.

T27—Site excavation execution

Design phase	Concrete resource and placement planning 31-40 30 31 Concrete execution 31-40 40 24
Discipline	Site contractor 33-41-11 14
Information obtained from	General contractor 33-41 11 11
Task description	Using latest scheduling report (R17 and EM20) coordinates final site scheduling and logistics tasks for site excavation and fill work, to support concrete placement requirements.

T28—Distributor delivery

Design phase	Concrete execution 31-40 40 24 Concrete resource and placement planning 31-40 30 31
Discipline	Reinforcement distributor 33-25 41 11
Information obtained from	Mill order schedule
Task description	Mill delivery, probably staged and in batches according to fabrication order.

T29—Reinforcement fabrication

Design phase	Concrete resource and placement planning 31-40 30 31
Discipline	Reinforcing fabricator 33-41-11-14
Information obtained from	Mill delivery schedule and reinforcing bar layout and delivery sequence, detailed placement model, and mill delivery. Includes post-tensioned materials that, in some cases, may be from a separate organization.
Task description	Based on lengths, material specifications, and bending requirements, reinforcing bar is fabricated on schedule and delivered to site.

T30—Formwork and shoring execution

Design phase	Concrete execution 31-40 40 24
Discipline	Formwork contractor 33-41 11 14
Information obtained from	Formwork placement model, pour model, and construction reference sequence.
Task description	Place all shoring needed for current set of pours, place formwork, place liners if needed, and prepare forms for receiving concrete.

T31—Reinforcement and embed placement

Design phase	Concrete execution 31-40 40 24
Discipline	Reinforcing contractor 33-41 11 14 17
Information obtained from	reinforcement delivery and placement schedule and construction reference schedule
Task description	Places reinforcing, including mesh, loose bars, and reinforcing bar cages, as uniquely identified by mark identification. Inserts all embeds and dummy material for blockouts. (These may be placed by external trades (plumbing or chaises.) Places tendons prior to pours and undertakes tendon cap placement and stressing and cutoffs; undertakes patching of tendon cap embeds.

T32—Concrete placement and breaks

Design phase	Concrete execution 31-40 40 24
Discipline	Concrete contractor 33-41 11 14
Information obtained from	As-built models and schedule from subcontractors including shoring and formwork, reinforcing contractors, and construction reference schedule from general contractor.
Task description	Prepares shoring and formwork model for current placements; provides dams and edge condition, including all break and joints; carries out concrete placement per current schedule.

T33—Lab testing

Design phase	Concrete execution 31-40 40 24
Discipline	Testing agency 33-25 54 00
Information obtained from	Concrete placing casting cylinders, tendon stressing records, and slab flatness testing
Task description	Slump testing, compression tests, flexural tests, and moisture testing

T34—Curing

Design Phase	Concrete Execution 31-40 40 24

	Erection Phase 31-40-40-14-11
Discipline	Concrete Contractor 33-41 11 14
Information obtained from	Time of placing, weather conditions, testing agency
Task Description	Testing of current pours, plan for stripping

T35—Finish Concrete

Design phase	Concrete execution 31-40 40 24 Erection phase 31-40-40-14-11
Discipline	Finish contractor 33-41 11 14
Information obtained from	Concrete finish (T22) with formwork placement, formwork sequence, and contractor's construction reference model
Task description	Verify liner use during pour, carry out required finish action after form stripping (scheduled in stages).

T36—Prepare actual construction schedule

Design Phase	Concrete execution 31-40 40 24
Discipline	General contractor 33-41 11 11
Information obtained from	Actual placement schedule of formwork and reinforcement
Task description	Adjusts planned pour sequence schedule with actual batch production. Adjusts production work packets and placement breaks to reflect actions needed on the ground.

T37—Formwork stripping

Design Phase	Erection phase 31-40-40-14-11
Discipline	Concrete contractor 33-41 11 14
Information obtained from	Field, weatherman, testing results
Task description	Strip formwork at appropriate level of curing, carry out patching as needed, prepare reusable formwork for next placement

T38—Prepare as-built model

Design phase	Erection phase 31-40-40-14-11
Discipline	General contractor 33-41 11 11 (discipline may vary)
Information obtained from	Receives as-built information from all subcontractors, including concrete subcontractors
Task description	Prepares as-built model to owner specification for pass-off.

(II) Exchange model descriptions

EM.1—Architect's mass structural model

Project stage	Design development 31-20-20-00, construction documentation

	31-25 00 00, or both
Exchange disciplines	**Sender:** Architecture (33-21-11-00) **Receiver(s):** Structural engineer (33-21 31 14)
Description	**Purpose:** provides structural engineer with base layout to determine structural design. May have previously reviewed project in earlier phases. Includes major structural concrete elements, major load placements, elevators and stair shafts, concrete walls, and foundations. This exchange is iterated until all reinforced concrete aspects are identified and resolved when model is exported as EM.5. **Level of detail:** First iteration is conceptual, with approximate dimensions **Special attributes:** special loads
Software functionality: export and import	**Export:** Architectural or design intent building modeling tool **Import**: Structural analysis application typically involves nonmodel feedback
Related exchange models	Earlier exchanges between architect and structural engineering are succeeded with contract document (EM.5)for reinforced concrete design

EM.2—Formwork finishes and detail geometry

Project stage	Design development 31-20-20-00
Exchange disciplines	**Sender:** Architecture (33-21-11-00) **Receiver(s):** Concrete contractor (33-41 11 14) Concrete formwork contractor (33-41 11 14) Finish contractor (33-41 11 14)
Description	**Purpose**: To identify formwork requirements for cast-in-place work, including for concrete finishes. Associated finish specification and materials and procedures are available. **Level of detail:** Identifies all nonstandard finishes and surface areas affected. **Special attributes**: Selected colors and finish type .

Software functionality: export and import	**Export**: Architectural intent model representing concrete finishes **Import:** Reinforced concrete detailing application that supports modeling and placement of finishes.
Related exchange models	—

EM.3—Site plan and foundation layout

Project stage	Design development 31-20-20-00
Exchange disciplines	**Sender:** Civil engineer (33-21 31 11) **Receiver(s):** Structural engineer (33-21 31 14) General contractor (33-41 11 11) Concrete contractor (33-41 11 14)
Description	**Purpose:** Site, with general layout of complete facility with concrete improvements and foundation functional model. **Includes:** Base concrete model from EM.1; defines concrete site improvements: outside concrete slabs, retaining walls, and foundations. **Major elements:** All outside walls, structural elements, storm water management flows and rates, and catchments or cisterns. **Level of detail:** Sufficient for project spatial coordination
Software functionality: export and import	**Export:** Two-dimensional CAD or two-dimensional or three-dimensional building information modeling tool that deals with civil and site development. **Import:** Reinforced concrete detailing applications, contractor's site, and civil engineering applications.
Related exchange models	EM.1

EM.4—Mechanical system model

Project Stage	Design development 31-20-20-00

Exchange disciplines	**Sender:** Mechanical engineer (33-21-31-17) **Receiver(s):** Structural engineer (33-21 31 14) Concrete contractor (33-41 11 14) Reinforcing detailer (33-41 11 14) Reinforcing fabricator (33-41 11 14)
Description	**Purpose of exchange**: Provide placement of major mechanical system components sufficient to define connections, pass-throughs and other aspects requiring spatial coordination with mechanical system. Also identifies insulation needs and areas to include it. Defines connection and other embeds, pads, and curbs needed for mechanical equipment **Major elements**: Major mechanical elements, steel for connections of external systems and their connections to the structure, ducts and piping to and from mechanical equipment needed for routing. Insulation requirements. **Level of detail:** sufficient for layout.
Software functionality: export and import	**Export:** Various mechanical, electrical, and plumbing modeling applications **Import:** Reinforced concrete detailing applications
Related exchange models	—

EM.5—Architect's contract model

Project stage	Construction documentation 31-25 00 00
Exchange disciplines	**Sender:** Architecture (33-21-11-00) **Receiver(s):** Structural engineer (33-21 31 14) General contractor (33-41 11 11) Mechanical engineer (33-21 31 17)

Description	**Purpose:** Provide a variety of users with concrete layout, as iterated and approved by structural engineer as construction document model. Includes all structural concrete elements, load placements, elevators and stair shafts concrete walls, foundations identified in contract documents. **Level of detail:** Concrete is accurately dimensioned, but not detailed, lacking embeds and reinforcing, finishes not addressed. **Special attributes:** Retaining walls, foundations, pilings, and special loads
Software functionality: export and import	**Export:** Architectural or design intent building modeling tool **Import**: Structural analysis application
Related exchange models	Earlier exchanges (EM.1) between architect and structural engineer

EM.6—Structural design model

Project stage	Construction documentation 31-25-00-00
Exchange disciplines	**Sender:** Structural engineer (33-21 31 14) **Receiver(s):** General contractor (33-41 11 11) Concrete contractor (33-41 11 14) Site contractor (33-41 11 14) Reinforcing detailer (33-41-11-14)
Description	**Purpose:** Report of detail structural design to determine steel reinforcing sections, lap standard details, and special connections. Optionally provide early mill order for reinforcing and early shoring needs. **Major elements**: Reinforced concrete members and reinforcing cross section layouts and spacing requirements; standard details; lap lengths; special connections; concrete strength; steel reinforcing and tendon specifications, including coatings, expansion joints, and post-tensioned tendon placement joints. Includes geophysical data and foundation spatial requirements. **Level of detail:** Sufficient for determining detailing to realize project structural requirements, as defined by structural engineer. **Special attributes:** Reinforcing bar layout for member sections,

	reinforcing lap requirements, required concrete joints, major embeds, and cutouts.
Software functionality: export and import	**Export:** Structural analysis application **Import:** Concrete detailing application
Related Exchange Models	—

EM.7—Blockout and insulation placement

Project stage	Construction documentation 31-25-00-00, concrete placement and resource planning 31-40 30 21, or both
Exchange disciplines	**Sender:** Mechanical engineering (33-21-31-17) **Receiver(s):** Concrete contractor (33-41 11 14) General contractor (33-41 11 11)
Description	**Purpose of exchange:** To identify placement of blockouts for pass-through in concrete placement. Also where thermal insulation will go over or within concrete for insulation or vibration **Major elements:** Insulation performance and type (that is, rigid or sprayed), all blockouts geometrically defined. **Level of detail:** surface areas addressed and performance criteria **Special attributes**: Insulation specifications
Software functionality: export and import	**Export:** Architectural or construction coordination model that includes concrete, mechanical equipment **Import:** concrete detailing applications
Related Exchange Models	—

EM.8—Preliminary reinforcement detailed model

Project stage	Construction documentation 31-25-00-00
Exchange disciplines	**Sender:** Reinforcing detailer (33-21-31-14) **Receiver(s):** Reinforcing fabricator (33-41-11-14) Reinforcing contractor (33-41 11 14 17)

	Concrete contractor (33-41 11 14)
Description	**Purpose of exchange**: To provide reinforcement layout to all reinforcing disciplines, with consideration to structural requirements and concrete placement. **Major elements**: All concrete sizes, all reinforcing and tendon members **Level of Detail:** Sufficient for layout
Software functionality: export and import	**Export:** Reinforced concrete detailing application **Import:** Reinforcing detailing applications
Related exchange models	EM.9

EM.9—Detailed integrated reinforcement layout

Project stage	Concrete resource and placement planning 31-40 30 31
Exchange disciplines	**Sender:** Reinforcing bar detailer (33-21-31-14) **Receiver(s):** Structural engineer (33-21 31 14) Concrete contractor (33-41 11 14) Reinforcing contractor (33-41 11 14 17) Reinforcing fabricator (33-41 11 14) Reinforcement distributor (33-25 41 11)
Description	**Purpose of exchange:** Integrates placement and reinforcement and tendon layout with both integrated structure and pour sequence (tendons may be a separate model). **Major elements:** Reinforcement and tendon items to be associated with pours, all embeds and connection plates, and with pour work packets (all concrete related placing activities in schedule). All reinforcing bar, mesh, and tendons, properly placed within concrete, with layout of ties, laps, and special connections. May be multiple models, not one. **Level of detail:** Full detail
Software functionality: export	**Export:** Reinforced concrete detailing applications, with reinforcing and tendons, plates, and embeds fully modeled.

and import	**Import:** Import reinforcing bar into all applications that need to coordinate with its placement: for formwork, concrete contractor, and general contractor. Exchange likely to be iterated to realize layout based on construction logic
Related Exchange Models	—

EM.10—Structural embeds and plates

Project stage	Concrete resource and placement planning 31-40 30 21
Exchange disciplines	**Sender:** Reinforcing fabricator (33-41 11 14) **Receiver(s):** Structural engineer (33-21 31 14)
Description	**Purpose of exchange**: To identify all plates, reinforcing, and embeds for all concrete pieces. Also identify special formwork considerations such as decking for placement and connections. Reviewed by structural engineer. Reinforcing fabricator work may be done by steel fabricator. **Major elements:** Steel for internal and external connections; blockouts required for constructability; placement stops (edge-of-slab), mechanical-generated curbs and plates, decking and other permanent formwork; composite materials, if used, are defined here **Level of detail:** Fabrication level detailing of reinforced concrete, all components included. **Special attributes:** Reinforcing and embed material specifications.
Software functionality: export and import	**Export:** Concrete detailing applications **Import:** Concrete structural analysis applications May be one-way or with nonmodel feedback
Related Exchange Models	—

EM.11—Formwork piece model

Project stage	Concrete resource and placement planning 31-40 30 31
Exchange disciplines	**Sender:** Formwork contractor (33-41 11 14) **Receiver(s):** Concrete contractor (33-41 11 14) General contractor (33-41 11 11)
Description	**Purpos**e: To identify formwork pieces, those prefabricated, those requiring fabrication, reuse schedule, associated finish specification, and materials. **Level of detail:** Identifies all concrete surfaces and their needed formwork piece assignment or finish process. **Special attributes**: Proprietary formwork piece identification
Software functionality: export and import	**Export**: Reinforced concrete detailing application that supports modeling and placement of finishes. **Import:** Concrete detailing and scheduling application
Related exchange models	R14

EM.12—Construction resource model

Project stage	31-40 30 21 Concrete placement & resource planning
Exchange disciplines	**Sender:** General contractor (33-41 11 11) **Receiver(s):** Site contractor (33-41 11 14) Mechanical engineer (33-21-31-17) Concrete contractor (33-41 11 14) Formwork contractor (33-41 11 14) Reinforcing contractor (33-41 11 14 17) Structural engineer (33-21 31 14)
Description	**Purpose of exchange**: To coordinate cast-in-place concrete with all other building systems for constructability and clash resolution; takes place multiple times throughout the project process. Relies on concrete element objects. **Major elements**: All concrete object shapes; reinforcing not included **Level of detail**: All external shape geometry, without reinforcing or other embeds **Special attributes:** Building data owner, piece identifier

Software functionality: export and import	**Export**: Concrete detailing application **Import:** Construction management application, supporting detailed spatial coordination in an integrated building model.
Related exchange models	EM.20

EM.13—Site planning model

Project stage	Concrete placement and resource planning 31-40 30 31
Exchange disciplines	**Sender:** Site contractor (33-41 11 14) **Receiver(s):** Civil engineer (33-21 31 11) General contractor (33-41 11 11) Concrete contractor (33-41 11 14)
Description	**Purpose of exchange**: To coordinate site development resources, for delivery of concrete, storage areas for reinforcing bar, formwork, other concrete related resources, as reviewed and coordinated with other subcontractors. **Major elements**: Verify and review access points; queuing areas, pumping, or lifting requirements and locations; rough schedule of project phases and logistics changes. **Level of detail**: Typically two-dimensional plan layout, possibly three-dimensional in complex site conditions. **Special attributes:** Iterated until site plan coordination issues are resolved.
Software functionality: export and import	**Export**: Contractor's site planning applications **Import:** Many applications that can edit or view site planning layouts
Related exchange models	—

EM.14—Detailed concrete model

Project stage	Concrete resource and placement planning 31-40 30 21
Exchange disciplines	**Sender:** Concrete contractor (33-41 11 14 17)

	Receiver(s): Reinforcing contractor (33-41 11 14 17) Finish contractor (33-41 11 14) Reinforcing detailer (33-41-11-14) Formwork contractor (33-41 11 14) General contractor (33-41 11 11) Structural engineer (33-21 31 14)
Description	**Purpose of exchange:** Provides reinforced concrete detail layout, with all members defined and reinforcing bar placed. Connections to nonconcrete elements: wall systems vertical circulation, mechanical equipment defined. Used for structural review, finish contractor coordination, and schedule coordination. **Major elements:** All members, with reinforcing placed for members and internal and external connections and finishes defined **Level of detail**: Fabrication-level layout, complete except for placement sequencing
Software functionality: export and import	**Export:** Reinforced concrete detailing application, able to represent reinforcing, tendons, embeds, finishes, and other details. **Import:** Applications that can import and use the aforementioned reinforced concrete data
Related Exchange Models	—

EM.15—Reinforcement placement sequence

Project stage	Concrete resource and placement planning 31-40 30 31
Exchange disciplines	**Sender:** Reinforcing detailer (33-21-31-14) **Receiver(s):** Formwork contractor (33-41 11 14) Reinforcing fabricator (33-41 11 14) Reinforcing contractor (33-41 11 14 17)
Description	**Purpose of exchange:** Coordinate reinforcement and tendon placement with placement sequence and schedule. **Major elements:** All reinforcement and tendon items, embeds, and formwork including formwork for special finishes, blockouts, insulation, to be associated with schedule and placement.

	Level of detail: Complete detail; schedule for formwork and reinforcing elements.
Software functionality: export and import	**Export:** Reinforced concrete detailed model, with definition of placement schedule related to pour sequence. **Import:** Construction coordination model applications able to show both model detailing and sequencing. May be one-way or round trip
Related exchange models	Is elaboration of EM.9

EM.16—Formwork placement model

Project stage	Concrete placement and resource planning 31-40 30 31
Exchange disciplines	**Sender:** Concrete formwork contractor (33-41 11 14) **Receiver(s):** Finish contractor (33-41 11 14) Concrete contractor (33-41 11 11)
Description	**Purpose of exchange**: Define formwork placement plan, which areas use movable formwork, which requires custom work or metal decking, and which need form inserts for patterning; also includes formwork and shoring placement planning and scheduling. **Major elements**: Concrete surface areas and their formwork requirements, defined as attributes/annotations, and decking placement. **Level of detail**: Conceptual definition of intent; includes scheduling of formwork placement
Software functionality: export and import	**Export:** Reinforced concrete detailing application, able to represent reinforcing, tendons, embeds, finishes, and other details. **Import:** Applications that can import and use the above RC data
Related exchange models	EM.11

EM.17—Finish work package model

Project stage	Concrete placement and resource planning 31-40 30 31
Exchange disciplines	**Sender:** Concrete contractor (33-41 11 14) **Receiver(s):** Finish contractor (33-41 11 14) General contractor (33-41 11 11)
Description	**Purpose:** Define finish plan based on the concrete placement and curing plan and concrete pour geometry. **Level of detail:** Shop model detail
Software functionality: export and import	**Export:** Concrete detailing and finish application
Related Exchange Models	—

EM.18—Final Structural design model

Project stage	Concrete placement and resource planning 31-40 30 31
Exchange disciplines	**Sender:** Structural engineer (33-21 31 14) **Receiver(s):** General contractor (33-41 11 11)
Description	**Purpose:** To apply the changes in the structural design based on the feedback from the general contractor and subcontractors regarding constructability and other issues and to provide the complete and final structural design.
Software functionality: export and import	**Export:** Structural design physical model, final geometry, and final stiffeners or other features
Related Exchange Models	—

EM.19—Site excavation as-built

Project stage	Concrete execution (31-40 40 24)

Exchange disciplines	**Sender:** Site contractor (33-41 11 14**)** **Receiver(s):** General contractor (33-41 11 11)
Description	**Purpose of exchange**: To document final site modifications made for concrete work, as carried out. Coordination with all reinforced concrete building information model roles for placement, queuing, access points, and temporary storage. Also, all site condition details for landscaping, walk concrete paving, and other later works. **Major elements:** Cut and fill, as-built concrete subterranean elements, walkways, and any exterior retaining walls **Level of Detail:** As-built placement and as required by owner.
Software functionality: export and import	**Export:** detailed site planning and civil works application **Import:** Coordination with all applications used by reinforced concrete building information model roles
Related exchange models	All previous site models

EM.20—Construction reference schedule

Project stage	Concrete placement and resource planning 31-40 30 31
Exchange disciplines	**Sender:** General contractor (33-41 11 11) **Receiver(s):** Concrete contractor (33-41 11 14) Finish contractor (33-41 11 14) Structural engineer (33-21 31 14) Reinforcing contractor (33-41 11 14 17) Formwork contractor (33-41 11 14) Site contractor (33-41 11 14)
Description	**Purpose of exchange**: Coordinate layout of all systems for clashes and coordinate schedule of installation, especially with formwork and finishing tasks; optionally a four-dimensional configurator, also used to verify coordination with mechanical systems and architectural intent. **Major elements:** All major systems: structure; mechanical, electrical, and plumbing; and architectural detailing interfacing with concrete work for clash detection and coordination. Concrete

	placement and discrepancy report. **Level of Detail:** Full detail for concrete finishes and formwork **Special attributes**: Concrete finishing spaces
Software functionality: export and import	**Export:** Concrete detailing application **Import:** Construction management application, supporting detailed spatial coordination and scheduling of all project systems in an integrated building model.
Related Exchange Models	—

EM.21—Formwork as placed model

Project stage	Concrete execution 31-40 40 24
Exchange disciplines	**Sender:** Formwork contractor (33-41 11 14) **Receiver(s):** General contractor (33-41 11 11) Concrete contractor (33-41 11 14) Reinforcing contractor (33-41 11 14 17) Reinforcing fabricator (33-41 11 14 17)
Description	**Purpose of exchange:** Fully coordinate formwork and shoring schedule with general contractor **Major elements**: Monolithic model of concrete; all planned pour breaks; all embeds, reinforcing, and tendons; areas used for shoring and concrete placement; all metal and other decking, updated frequently by on-the-ground status reporting. **Level of detail:** Includes all concrete tasks, pour breaks
Software functionality: export and import	**Export:** Reinforced concrete detailing application, able to represent reinforcing, tendons, embeds, finishes, and other details **Import**: Integrate with project scheduling applications
Related Exchange Models	—

EM.22—Actual placement submittals

Project stage	Concrete execution (31-40 40 24)
Exchange disciplines	**Sender:** Concrete contractor (33-41 11 14) **Receiver(s):** General contractor (33-41 11 11)
Description	**Purpose of exchange:** To record the actual pour breaksversus those planned for archival documentation and planning **Major elements**: Concrete elements, actual pour breaks, and added reinforcing **Level of detail**: Reinforcing, pour break geometry, any bonding agents, flatness tests, and stress records. Submittal records noted for cross reference to model as they are posted.
Software functionality: export and import	**Export**: Construction management applications that can track concrete placement progress, including all components of reinforced concrete and integrated with schedule information. **Import**: Scheduling or reporting application
Related Exchange Models	—

EM.23—Reinforcement as-built

Project stage	Erection phase (31-40-40-14-11)
Exchange disciplines	**Sender:** Reinforcing contractor (33-41 11 14) **Receiver(s):** Concrete contractor (33-41 11 14) General contractor (33-41 11 11)
Description	**Purpose of exchange:** Document all changes to the reinforcing bar, post-tensioning specification, placement sequence adjustments, due to installation and tensioning operations; report changes to testing agency. **Major elements**: Reinforcing, including mesh and reinforcing bar, tensioning ducts, cables and anchors, and monolithic concrete structure **Level of detail**: As required by owner **Special attributes**: Final tensions in cables, specifications on finishing, and waterproofing on tendon anchors
Software functionality: export and import	**Export:** Reinforced concrete detailing applications **Import**: Agreed to as-built delivery model to owner

Related exchange models	Uses details from EM.9

EM.24—Client as-built model

Project stage	Erection phase 31-40 40 14 11
Exchange disciplines	**Sender:** General contractor 33-41 11 11 **Receiver(s):** Owner/client (33-55 21 00)
Description	**Purpose of exchange**: To hand over as-built model of project to client for use in facility management, operations and maintenance, and for later remodeling **Major elements**: As specified in contract **Level of Detail**: As specified in contract **Special attributes:** As required
Software functionality: export and import	**Export:** The model type defined by owner for the as-built delivery requirement **Import**: Client facility management program

(III) Nonmodel information exchange descriptions

The following exchange data refers to the process model and identifies the contents of nonmodel changes and their purpose and general content.

R1—Concrete finishes

Design phase	Design development 31-20-20-00
Discipline from	Architect (33-21-11-00)
Discipline to	Finish contractor (33-41 11 14)
Information transmitted	Provide finish samples/specification for concrete finishes
Typical formats	Photos and physical samples

R2—Layout review report

Design phase	Design development 31-20-20-00
Discipline from	Structural engineer 33-21-31-14
Discipline to	Architect 33-21-11 00
Information transmitted	Provide structural consideration feedback to architect with regard to structural topology, bracing, foundations, member sizes, and other issues associated with the structural aspects of the project. Review process is iterated until an acceptable structural design and project structure is defined.
Typical formats	Marked-up drawings, freehand sketches, and possibly BIM coordination format notes

R3—Geotechnical data

Design phase	Design development 31-20-20-00
Discipline from	Geotechnical engineer 33-21-31-11-11
Discipline to	Structural engineer 33-21-31-14 Civil engineer 33-21 31 11
Information transmitted	Provide geotechnical report regarding soil mechanics, moisture flows, and bearing capacities for foundation planning.
Typical formats	Marked-up site plan showing sample test locations and data.

R4—Weather and curing specifications

Design Phase	Design development 31-20-20-00, construction documentation 31-25 00 00, or both
Discipline from	Structural engineer 33-21-31-14
Discipline to	Concrete contractor (33-41 11 14)
Information transmitted	Based on expected weather precipitation, temperature, humidity, and guidelines regarding curing times for various pours based on sample tests and weather conditions.
Typical formats	In tables or notes

R5—Structural review notes

Design phase	Concrete resource and placement planning 31-40 30 31
Discipline from	Structural engineer 33-21-31-14
Discipline(s) to	Architect 33-21-11 00 Reinforcing fabricator (33-41-11-14) Reinforcing detailer (33-41-11-14) Formwork contractor (33-41 11 14)
Information transmitted	Provide structural consideration feedback with regard to structural topology, bracing, foundations, member sizes, reinforcement covering, tendon layouts, and other aspects of overall concrete aspects of project. Reviews may be iterated until bidding
Typical formats	Marked up drawings, freehand sketches, and BIM coordination format notes

R6—Reinforcement correction report

Design phase	Concrete resource and placement planning 31-40 30 31
Discipline from	Reinforcing fabricator (33-41-11-14)
Discipline to	Reinforcement detailer (33-41-11-14)
Information transmitted	Reinforcing clash issues; cover problems on inspected pieces
Typical formats	BIM coordination format reports, screen capture, and project locations

R7—Reinforcement distributor order

Design phase	Concrete resource and placement planning 31-40 30 31

Discipline from	Reinforcing fabricator (33-41-11-14)
Discipline to	Reinforcement distributor (33-25 41 11)
Information transmitted	Bar lists, bar or strand count, lengths, and order numbers
Typical formats	Spreadsheets and notes

R8—Concrete preliminary order

Design phase	Concrete resource and placement planning 31-40 30 31
Discipline from	Concrete contractor (33-41 11 14)
Discipline to	Batch plant (33-41 21 24) General contractor (33-41 11 11)
Information transmitted	Preliminary concrete placement schedule and advance batch plant order
Typical formats	Schedule diagrams and Gantt charts

R9—Connection and erection review report

Design Phase	Concrete resource and placement planning 31-40 30 31
Discipline from	Structural engineer 33-21-31-14
Discipline to	Concrete contractor (33-41 11 14)
Information transmitted	Lists unresolved issues of connection design and reinforcing plans; considers pour sequencing and cross-break continuity. Review placement sequence for loading issues. Reviews may be iterative
Typical formats	Marked up drawings, freehand sketches, and BIM coordination format notes

R10—Site plan review report

Design Phase	Concrete resource and placement planning 31-40 30 31
Discipline from	Civil engineer (33-21 31 11)
Discipline to	Site contractor (33-41 11 14)
Information transmitted	Issues relating current site layout and intentions, dealing with all site issues
Typical formats	Annotated drawing or model

R11—Mill delivery schedule

Design phase	Concrete execution 31-40 40 24
Discipline from	Reinforcing bar mill or distributor33-25 41 11
Discipline to	Reinforcing fabricator (33-41-11-14)
Information transmitted	Physical delivery of reinforcing bar and mesh according to order
Typical formats	Schedule and material delivery

R12—Batch delivery sequence order

Design phase	Concrete resource and placement planning 31-40 30 31
Discipline from	Concrete contractor (33-41 11 14)

Discipline to	Batch plant (33-41 21 24)
Information transmitted	Concrete mixture proportions and delivery schedules, with quantities
Typical formats	Spreadsheets and files of orders, mixtures, and quantities

R13—Batch delivery report

Design phase	Concrete resource and placement planning 31-40 30 31
Discipline from	Batch plant (33-41 21 24)
Discipline to	Concrete contractor (33-41 11 14)
Information transmitted	Batch mixture proportions, delivery time, and quantity
Typical formats	Tabular schedule

R14—Formwork review comments

Design phase	Concrete resource and placement planning 31-40 30 31
Discipline from	Concrete contractor (33-41 11 14)
Discipline to	Reinforcing contractor (33-41 11 14 17) Formwork contractor (33-41 11 14)
Information transmitted	Review formwork placement plan and any required liners for finishes; schedule preparation tasks
Typical formats	Drawings or models with annotations

R15—Mill delivery schedule

Design phase	Concrete resource and placement planning 31-40 30 31
Discipline from	Reinforcing contractor (33-41 11 14 17)
Discipline to	Concrete contractor (33-41 11 14) Site contractor (33-41 11 14)
Information transmitted	Reinforcing bar delivery schedule considers whether reinforcing bar is shop- or field-assembled into cages
Typical formats	Schedule of reinforcing bar batches and data with (optionally) supporting heat information

R16—Construction coordination corrections

Design phase	Concrete resource and placement planning 31-40 30 31
Discipline from	General contractor (33-41 11 11)
Discipline to	Reinforcing detailer (33-41-11-14), Formwork contractor (33-41 11 14), Site contractor (33-41 11 14), Concrete contractor (33-41 11 14)
Information transmitted	Provide spatial coordination issues from clashes and spatial coordination (clashes and connection alignment) from EM.19
Typical formats	BIM coordination format,.pdf reports, marked up drawings

R17—Construction schedule corrections

Design phase	Concrete resource and placement planning 31-40 30 31

Discipline from	General contractor (33-41 11 11)
Discipline to	Reinforcing contractor (33-41 11 14 17), Finish contractor (33-41 11 14), Formwork contractor (33-41 11 14), Site contractor (33-41 11 14)
Information transmitted	Provide spatial coordination reported (clashes and connection alignment) with discrepancies with four-dimensional schedule considerations from EM.20.
Typical formats	Schedule markup, drawing markup, screen capture in four-dimensional simulation, BIM coordination format

R18—Placement and finish discrepancy reports

Design phase	Concrete execution 31-40 40 24
Discipline from	Architect (33-21-11-00)
Discipline to	Finish contractor (33-41 11 14)
Information transmitted	Identify from field review the finish and discrepancy issues associated with given concrete placements
Typical formats	Marked up drawings or models and photos

R19—Reinforcing bar mill certification

Design phase	Concrete execution 31-40 40 24
Discipline from	Reinforcing bar mill or distributor 33-25 41 11
Discipline to	General contractor (33-41 11 11)
Information transmitted	Reinforcing batch numbers and associated heat numbers
Typical formats	Tabular report, written or .pdf; could also be spreadsheet

R20—Final reinforcement delivery schedule

Design phase	Concrete resource and placement planning 31-40 30 31 or concrete execution 31-40 40 24
Discipline from	Reinforcing fabricator (33-41-11-14)
Discipline to	Concrete contractor (33-41 11 14)
Information transmitted	Bill of materials of reinforcing, with delivery dates and batch information,
Typical formats	Written bill of materials, spreadsheet report

R21—Fabricated reinforcement delivery

Design phase	Concrete execution 31-40 40 24
Discipline from	Reinforcing fabricator (33-41-11-14)
Discipline to	Reinforcing contractor (33-41 11 14 17)
Information transmitted	Provide reinforcing bar batches and delivery on schedule to site and time adjusted for shop or field assembly of reinforcing bar
Typical formats	Tabular schedule associated with piecemark bundles, possibly mill heats

R22—Placement (pour) samples

Design phase	Concrete execution 31-40 40 24
Discipline from	Concrete contractor (33-41 11 14)
Discipline to	Testing agency (33-25 54 00)
Information transmitted	Placing samples for slump and other forms of tests
Typical formats	Physical sample

R23—Placement test results

Design phase	Concrete execution 31-40 40 24
Discipline from	Testing agency (33-25 54 00)
Discipline to	Concrete contractor (33-41 11 14) General contractor (33-41 11 11) Structural engineer (33-21-31-14)
Information transmitted	Results from slump and other tests
Typical formats	Written report or .pdf of test results