

**Bridge Data File Protocols
for Interoperability and Life Cycle Management**

**Volume II:
Information Delivery Manual Elements for Highway
Bridge Interoperable Data Protocols**

FHWA Cooperative Agreement DTFH61-11-H-0027

*Advancing Steel and Concrete Bridge Technology
to Improve Infrastructure Performance*

August 2013

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16. Abstract The research resulting in this report and its companion report ("Model View Definition Elements for Highway Bridge Interoperable Data Protocols") develops, implements and demonstrates an efficient and robust digital data protocol that could be used to automate the exchange of bridge information in the various activities of design, detailing, fabrication, construction, inspection, and evaluation involved in the bridge lifecycle. This data protocol is intended for public domain use and provides the relevant information that requires exchange regarding the bridge from "cradle to grave." This data exchange protocol, dubbed "openBrIM," is developed and presented in a manner that is software neutral (a.k.a. "vendor agnostic"), but is developed with consideration of relevant software vendors to facilitate their development of conforming translators to automate the transfer of data among software applications. Focus is placed on common "workhorse" steel and concrete girder bridge structures.					
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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
AREA				
in ²	square inches	645.2	square millimeters	mm ²
ft ²	square feet	0.093	square meters	m ²
yd ²	square yard	0.836	square meters	m ²
ac	acres	0.405	hectares	ha
mi ²	square miles	2.59	square kilometers	km ²
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft ³	cubic feet	0.028	cubic meters	m ³
yd ³	cubic yards	0.765	cubic meters	m ³
NOTE: volumes greater than 1000 L shall be shown in m ³				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact degrees)				
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m ²	cd/m ²
FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	newtons	N
lbf/in ²	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
AREA				
mm ²	square millimeters	0.0016	square inches	in ²
m ²	square meters	10.764	square feet	ft ²
m ²	square meters	1.195	square yards	yd ²
ha	hectares	2.47	acres	ac
km ²	square kilometers	0.386	square miles	mi ²
VOLUME				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m ³	cubic meters	35.314	cubic feet	ft ³
m ³	cubic meters	1.307	cubic yards	yd ³
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
TEMPERATURE (exact degrees)				
°C	Celsius	1.8C+32	Fahrenheit	°F
ILLUMINATION				
lx	lux	0.0929	foot-candles	fc
cd/m ²	candela/m ²	0.2919	foot-Lamberts	fl
FORCE and PRESSURE or STRESS				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in ²

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

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SECTION 1 EXECUTIVE SUMMARY

1. Executive Summary

1.1 Objectives

The research resulting in this report and its companion report (“Model View Definition Elements for Highway Bridge Interoperable Data Protocols”) develops, implements and demonstrates an efficient and robust digital data protocol that could be used to automate the exchange of bridge information in the various activities of design, detailing, fabrication, construction, inspection, and evaluation involved in the bridge lifecycle.

This data protocol is intended for public domain use and provides the relevant information that requires exchange regarding the bridge from “cradle to grave.” This data exchange protocol, dubbed “openBrIM,” is developed and presented in a manner that is software neutral (a.k.a. “vendor agnostic”), but is developed with consideration of relevant software vendors to facilitate their development of conforming translators to automate the transfer of data among software applications. Focus is placed on common “workhorse” steel and concrete girder bridge structures.

1.2 Developing Process

A diverse set of information resources has been investigated in the openBrIM development process. These resources have included the following:

- Data schemas explicitly oriented to bridges,
- Data schemas in various aspects of the transportation industry,
- Data schemas in various segments of the vertical construction (e.g., building) industry:
 - Regarding steel structures,
 - Regarding concrete structures,
- Data schemas in the Geo-Spatial arena,
- Data schemas in the geotechnical arena,
- Other data schemas,
- Bridge project delivery procedures used by several owners,
- Bridge Industry manuals and guidelines of various kinds,
- Bridge Contract plans, shop drawings, erection procedures, etc,
- BIM and Bridge Software applications,
- Interactions with various professionals involved in the key stakeholder roles (design, analysis, detailing, fabrication and construction, and operations) arising through the bridge lifecycle,
- Etc.

The bridge lifecycle was characterized in terms of a process mapping notation utilized by other related data exchange standard development efforts including those of the buildingSMART Alliance. This process map, described herein, identifies the activities and data exchanges involved in the bridge lifecycle. It, in effect, provides a grid for identifying the various pieces of the overall process and where they fit together. These activities and the data exchanges that occur between them are described herein. Five of the key exchanges are singled out for further in-depth development based on industry stakeholder opinions of higher payoff potential. The data Exchange Models (EMs) corresponding to these and the Data Dictionaries (DDs) associated with these are included in this report, while the computer-implementable schema descriptions of these are in the companion (MVD Elements) report.

These reports are intended to provide a platform suited to further openBrIM development shepherding by a suitable standards body (e.g., buildingSMART or AASHTO).

The authors thank colleagues involved in the AASHTO/NSBA Steel Bridge Collaboration and the National Concrete Bridge Council and the buildingSMART Alliance along with the NYSDOT and other DOTs for their review comments on earlier portions of this report contents and access to information about their bridge design and construction process, bridge data, and construction sites. In addition, support and assistance of the following are gratefully acknowledged: NWFU University of Engineering and Technology, the University at Buffalo, Bentley Systems, Red Equation Corp. and other software solution providers, the Association for Bridge Construction and Design-Western NY Chapter, and the Federal Highway Administration under Cooperative Agreement No. DTFH61-11-RA-00010 administered by ATLSS (Advanced Technology for Large Structural Systems) at Lehigh University. Any opinions, findings, and conclusions or recommendations expressed in this paper are those of the author(s) and do not necessarily reflect the views of the Federal Highway Administration.

SECTION 2 BACKGROUND

2. Background

2.1 Context and Needs

Within the bridge industry, what is rapidly becoming arguably the single most important need in our information technology enabled era must be the advancement of communication (interoperability) among various stakeholders in the still-all-too-fragmented industry. In our increasingly resource-constrained era, building bridges will require closer collaboration among planners, engineers, fabricators, constructors, and owners. The mere “electronifying” of conventional written documents and engineering drawings will not suffice to bring effective data re-use and information integration to streamline the process with maximal efficiency.

Previous and ongoing applied research increasingly indicates that streamlining of data exchange intensive processes involved in project delivery and asset management are possible and beneficial. But without industry standards for BrIM (Bridge Information Modeling) data exchange, there is no common tool to coordinate the various phases of a bridge design and construction project and on into the ongoing maintenance and operation associated with its asset management. What is needed is cradle-to-grave data sharing via such data exchange. Accordingly, proposed OpenBrIM standards for electronic exchange of steel and concrete bridge data are developed in Task 12 of the Federal Highway Administration’s Cooperative Agreement No. DTFH61-11-RA-00010 and presented herein.

2.2 Subtasks

To successfully achieve the objectives of this task, the research plan is broken down into subtasks. A brief summary of the subtasks is provided below.

Subtask 12.1 – Literature and Practice Review. This research includes an extensive literature search and targeted information collection to acquire various stakeholders’ (Owners, Engineers, Fabricators, AASHTO, TRB, ASCE, etc.) practices & opinions regarding modeling of workhorse bridge data focusing mainly on shared (vs. private) uses; and technical development in data models/standards and bridge information technologies. We identify critical data exchange needs and document these using BPMN (Business Process Modeling Notation) identifying high priority use cases.

Subtask 12.2 – Development of Multi-Year Implementation Roadmap. A national level, multi-year implementation roadmap for moving the industry towards bridge information modeling (BrIM) - based project delivery and life cycle management is proposed in a separate report. Both top-down (e.g., policy/program-driven) and bottom-up (e.g., authorizing environment / stakeholder influenced) aspects are addressed. The bottom-up aspects are intended to recognize and define inclusion of specific data exchange needs at operational/ practitioner levels. The top-down aspects are intended to recognize and encourage economies of scale resulting from widespread adoption and the policy/standards mechanisms that may be applicable. Organizational capacity constrains both top-down and bottom-up aspects to varying extents; a Task Force is proposed to generate recommendations regarding openBrIM standards deployment. This roadmap identifies and recommends steps and procedures deemed necessary to facilitate the adoption and use of the developed bridge data exchange protocols. The roadmap is intended to define a strategic plan for establishment and deployment of these protocols as a national standard for data exchange in the bridge industry.

The objective of this roadmap is to identify specific steps and corresponding timetables for further developing, educating, implementing, and deploying bridge data exchange protocols. Ultimately, what is affected is how an entire industry conducts business. Real - world industry transformation does not

simply happen with the flip of a switch, especially when public agencies shielded from competitive pressures are involved. Thus, an evolutionary rather than revolutionary change process is proposed. The planning horizon for such an evolutionary change is presented in three consequent phases: shorter-term (approx. the next 12 months), intermediate-term (approx. 12 mos – 5 years), and longer-term (5+ years). The conceptual framework used in the development of this roadmap is based on the proven Roberts Leadership and Management Model (Larson 2004) named after its creator, Professor Marc Roberts of Kennedy School of Government at Harvard University.

Subtask 12.3 – Analysis of Bridge Activities. The proposed bridge data file protocols should provide systematic, efficient, accurate data exchange between software applications used in various stages of bridge project delivery and asset management. Therefore, it is crucial to understand and characterize at which points the data exchanges of interest occur in order to develop a correct blueprint. In the development of data file protocols, not only such data items but also bridge activities should be identified and described. Process mapping methodologies have been employed accordingly in this subtask.

Section 4 of this (IDM Elements) report contains a description of results of this subtask.

Subtask 12.4 – Identifying Information Items. We have collected data items used in well-established models such as TransXML, ISM, IFC, and CIS/2 to describe geometrics, sections, materials, cambers, etc. Focused gap-analysis and data-integrity analysis have been employed to identify, classify, revise, and add required information items in each high-priority “use case” data exchange identified from analysis of bridge activities (SubTask 12.3). Finally, bridge activities and data items have been combined together, so that the activities can provide a structured context for how data items should be organized. This task includes evaluation of potentially applicable digital file formats and selection of the optimal baseline digital file format (considering, e.g., XML, CIS/2, IFC, etc.) for expansion and/or modification to accommodate exchangeable bridge information.

Section 5 (EM Specifications) and Section 6 (Data Dictionary) of this (IDM Elements) report contains a description of results of this subtask expressed intentionally in plain or stylized English that non-programmer industry stakeholders would use. The companion (MVD Elements) report contains more formal schema descriptions, specifications, and examples intended for the distinct audience of software implementers.

Subtask 12.5 – Development of a Prototype 3D Viewer/Modeler. The envisioned 3D Viewer/Modeler is for the visualization of bridges described with the proposed bridge data file protocols. This 3D Viewer/Modeler is intended to be open software shared in the public domain in order to encourage wide deployment of the developed data file protocols and to provide tangible indicators of progress during their development. It will also facilitate importing/exporting data based on the digital file format proposed. This 3D Viewer/Modeler will be a crucial tool to raise the awareness of bridge data file protocols and data exchange requirement and to provide a means of checking test files developed according to those protocols. Renderings in Section 7 of this report and in the companion (MVD Elements) report are generated from the Viewer/Modeler.

Subtask 12.6 – Development of “Manual of Translator Development.” This subtask is to provide guidance to software developers writing translators to utilize the data file protocols to implement data exchange. This manual/guidelines document will be used to provide technical guidance facilitating interoperability with commercial software and in-house programs developed by stakeholders involved in data exchange use cases. The companion report, “Model View Definition Elements for Highway Bridge Interoperable Data Protocols,” contains draft content for this manual along with online documentation associated with the Viewer/Modeler software.

Subtask 12.7 – Demonstration Project. The developed data exchange digital file protocols, 3D Viewer/Modeler, and translators should be demonstrated for a typical workhorse steel bridge and a typical workhorse concrete bridge to illustrate usage of the developed data exchange protocols in the processes of project delivery and asset management. In this demonstration project, typical software programs used in various stages will be engaged. Data exchanges in support of the following aspects are the main interests in this task.

- Bridge roadway geometry
- Preliminary bridge design
- Bridge structural analysis
- Asset Management concerns such as load rating/permitting
- Bridge geometry modeling
- Contract drawing generation

2.3 Overview of Existing Schemas and Standards

There have been various efforts, made by individual software vendors, commercial software companies and public domain organizations, to develop, certify, and implement data schemas with varying degrees of relevance to bridges. However, while considerable progress has been made, especially in building and geographic fields, development and implementation of bridge-oriented data schemas are still at a relatively early stage.

Bridge data standards are also within the scope of investigation for this research, because they can be incorporated into the proposed openBrIM IDM and schema. Some data standards are being used throughout the bridge industry. For example, Opis/Virtis Data Structure is used by a number of the State Departments of Transportation (DOT) in the U.S. Although these data standards cannot be directly implemented into bridge software for data exchange, they provide a good starting point for identifying and organizing a large amount of bridge data (albeit not in the detailing arena).

2.3.1 Bridge Related Data Schemas and Standards

The IFC-Bridge Data Model [1] tends to extend the Industry Foundation Classes (IFC) [2] to capture information related to the whole bridge life cycle. It not only covers conventional highway bridges, but also includes cable stayed bridge and suspension bridge. It could be used as an important reference.

The Steel Bridge Construction Data Model (SBCDM) [3] extended TransXML [4] for steel bridge construction and fabrication. It could serve as the basis for developing the proposed BrIM schema.

The AASHTO Opis/Virtis (BrD/BrR) Data Structure [5] addresses analysis, design and load rating of superstructures of concrete and steel bridges. It could serve as the basis for developing the proposed BrIM schema.

The AASHTO Pontis (BrM) Data Structure [6] addresses inspection, management and maintenance areas in the bridge structure. It could serve as the basis for developing operations and maintenance aspects of the proposed BrIM schema.

The SteelBridge XML Data Model (NCHRP 20-7/Task 149) [7] extended the AASHTO Opis/Virtis Data Structure for steel bridge fabrication and construction. It was the predecessor of SBCDM.

2.3.2 Transportation Related Data Schemas and Standards

TransXML Data Model (NCHRP 20-64) [4] is a family of transportation data exchange formats using eXtensible Markup Language (XML) [8]. It addresses four major business areas: survey/roadway design, transportation construction/materials, highway bridge structures, and transportation safety. Its bridge related schema, Bridge Design and Analysis (BDA), was developed based on the Opis/Virtis Data Structure.

The AASHTOWare Trns*port Data Standard [9] is composed of 12 modules which cover cost estimate, bidding, letting and management of bridge projects. This data standard could be used as an important reference, and be incorporated into future schema development.

In addition, 8 transportation-related languages, standards, data dictionaries and data formats that address areas of highway, traveler, signal control, etc. were studied. Because they are not directly relevant to the objective of this research, they are not further evaluated herein. Looking forward, however, their potential relevance under a possible eventual AASHTO “big data” shepherding remains to be seen.

2.3.3 Building Related Data Schemas and Standards

The Industry Foundation Classes (IFC) [2] is an open source and international standard for exchanging BIM data. It is supported by about 150 software products. The specification of the IFC is composed of four components: the IFC specification HTML documentation, IFC EXPRESS schema, ifcXML XSD Schema, and the property set and base quantity library.

CIMsteel Integration Standard (CIS/2) [10] is an electronic file format for exchange of structural steel project data. It is endorsed by AISC as the format for data exchange between steel related CAD software programs.

Construction Operations Building Information Exchange (COBie) [11] was created for project handover. It is a standard denotes how information may be captured during design and construction stages and provided to facility operators.

Integrated Structural Modeling (ISM) [12] is a technology for sharing structural engineering project information among structural modeling, analysis, design, drafting and detailing applications. ISM was developed by a commercial software company, Bentley Systems, Inc. It can work with major Bentley software products.

BIM Collaboration Format (BCF) [13] is an open XML schema proposed by Tekla Corporation and Solibri, Inc. to enable communication between different BIM tools. BCF is currently a prerelease. It will not be further evaluated since it is not stable.

agcXML [14] was developed by Associated General Contractors (AGC) as a set of XML schemas designed to enable the exchange of electronic construction project information among all building design and construction professionals. agcXML is currently inactive. Its maintainer, AGC, is now concentrated on restarting the schema development and adoption stage. It will not be further evaluated since it is inactive.

aecXML Common Object Schema [15] is an architecture, engineering and construction industry schema. It provides a content format for specifying building, plant, infrastructure, and facility information. aecXML will not be further evaluated because it is inactive.

2.3.4 Geospatial Related Data Schemas and Standards

LandXML [16] is an XML schema designed for exchange of civil design information, including raw and reduced surveying data, surface data, parcel data and 3D road model. LandXML is implemented in more than 20 software products but is in need of overhaul expected to be addressed by the Open Geospatial Consortium.

Geography Markup Language (GML) [17] is an open XML schema developed by Open Geospatial Consortium (OGC) for encoding both spatial and non-spatial geographic information. Although its implementations are mainly in the geospatial area, it has been adopted as the basis for developing a bridge-related schema under the TransXML umbrella.

In addition, OGC developed other geospatial related schemas and standards, e.g. OpenGIS [18], CityGML [19], Geospatial One-Stop (GOS) [20], etc. Since they are not directly related to this research, these schemas will not be further investigated.

2.3.5 Geotechnical Related Data Schemas and Standards

Geotech-XML [21] is a geotechnical engineering application of XML. A sample example of Geotech-XML is shown in Code 2-1. The drawback of this XML schema is that one node contains too much information. For example, in Code 2-1, node layer contains values for topelev, bottom and soil. It will be difficult for software developers to program queries. This schema can be improved in two ways.

```

1  <profile>
2    <layer>
3      topelev=-12 m
4      bottom=-14 m
5      soil="clay A"
6    </layer>
7    <layer>
8      topelev=-14 m
9      bottom=-18 m
10     soil="silty sand X"
11   </layer>
12   <soil name="clay A">
13     w="38%"
14     gamma-tot="17.8 kN/m3"
15   </soil>
16 </profile>

```

Code 2-1 Sample Geotech-XML Code

The first improvement is to convert the contents of an element (e.g. topelev) to attributes of that element, as shown in Code 2-2.

```

1  <profile>
2    <layer topelev="-12m" bottom="-14m" soil="clay A"/>
3    <layer topelev="-14m" bottom="-18m" soil="silty sand X"/>
4    <soil name="clay A" w="38%" gamma-tot="17.8 kN/m3"/>
5  </profile>

```

Code 2-2 Improvement 1 to the Geotech-XML

The second improvement is to convert the contents of an element to children elements of that element, as shown in Code 2-3.

```

1  <profile>
2  <layer>
3      <topelev>-12m<topelev/>
4      <bottom>-14m<bottom/>
5      <soil>clay A<soil/>
6  </layer/>
7  <layer>
8      <topelev>-14m<topelev/>
9      <bottom>-18m<bottom/>
10     <soil>silty sand X<soil/>
11 </layer/>
12 <soil name="clay A">
13     <w>38%<w/>
14     <gamma-tot>17.8 kN/m3<gamma-tot/>
15 </soil/>
16 </profile>

```

Code 2-3 Improvement 2 to the Geotech-XML

However, there is another problem regarding these two improvements. The value of topelev, -12m is hard to be mapped to any primitive data type, e.g. int or string. Therefore, it is still hard for software programmer to parse this XML. One solution to this problem is to set up a unit system at the beginning and remove the units in the contents.

The Geotech-XML is not directly relevant to the bridge structures portion of this openBrIM research. However, it is considered as a relevant reference for further schema expansion.

COSMOS/PEER-LL Geotechnical Data XML Schema [22] was developed by Caltrans Geo-Research Group as a pilot data system. This schema will not be further reviewed because 1) it is not directly relevant to this research and 2) lacking of detailed information.

Data Interchange for Geotechnical and Geoenvironmental Specialists (DIGGS) [23, 24] was developed as an international data exchange standard for Geotechnical and Geoenvironmental data. The effort is a collaboration between Construction Industry Research and Information Association (CIRIA), Federal Highway Administration (FHWA), UK Highways Agency (UK-HA), United States Environmental Protection Agency (US EPA), US Army Corps of Engineers, US Geological Survey (USGS), FHWA-Eastern Federal Lands Highway Division (EFLHD) and the following state DOT's: California, Connecticut, Florida, Georgia, Indiana, Kentucky, Minnesota, Missouri, North Carolina, Ohio, Tennessee. The standards includes a data dictionary and an XML schema which are GML compliant. This schema will not be further reviewed because it is not directly relevant to the bridge structures portion of this research. However, it will be of use as an important reference for the future expansion of the OpenBrIM schema.

2.3.6 Safety Related Data Schemas and Standards

Multiple data schemas have been developed to address transportation safety. In this research, five efforts selected for initial screening are listed below.

- Transportation Safety Information Management System (TSIMS) [25]

- Crash Records Markup Language (CRML) [26]
- Fatal Accident Reporting System (FARS) [27]
- The Global Justice XML Data Model (Global JXDM) [28]
- IEEE P1512 [29]

Introduction to these schemas are shown in the Appendix A. Because they are not directly relevant to the BrIM research, the schemas will not be further evaluated herein.

2.3.7 Other Data Schemas and Standards

Other data schemas that are related to asset management, e-commerce, recreation elements, radio communication and Information Technology (IT) [30-33] are also introduced in the Appendix A. Among them, BLIS-XML [34] is a methodology for converting EXPRESS based information to XML format. It will be used as a reference in developing Model View Definitions (MVD). Other schemas will not be further investigated.

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SECTION 3 INTRODUCTION TO INFORMATION DELIVERY MANUAL (IDM)

3. Introduction to Information Delivery Manual (IDM)

3.1 IDM Components

Intentionally just one Process Map is provided intending to characterize the lifecycle and associated information exchanges for typical “workhorse” steel and concrete bridge projects. “Plain English” descriptions in the language of the (bridge) domain is used intentionally for these characterizations in order to engage various bridge lifecycle stakeholders (most of whom are not software developers) in vetting the exchange data sets. The Process Map (Section 4 of this IDM Elements report) provides the setting for describing and contextualizing the data exchanges (Sections 5 and 6 and the companions MVD Elements report) that are the heart of openBrIM.

It would be very easy to proliferate multiple versions of the Bridge Lifecycle Process Map. Alternative project delivery mechanisms (e.g., Design/Build vs. Design/Bid/Build, or vs. CMGC) would be one possible justification for multiple versions. Another reason could be differences (e.g., in terminology) between the concrete bridge world and the steel bridge world, particularly regarding the detailing, fabrication, and construction stages. This proliferation of multiple versions of the process map is intentionally avoided in characterizations formalized herein.

3.2 IDM Structure

IDM components, as presented in the remainder of this report, include Process Map, Activity Definitions, Activity Descriptions, Exchange Model Definitions, Exchange Model Descriptions, Non-Model Exchange Definitions, Non-Model Exchange Descriptions, Exchange Model Specifications, Data Dictionary, Data Examples, and References.

High-priority data exchanges are identified for more detailed development in the Data Dictionary and Examples. Just which exchanges are so identified are based on bridge industry stakeholder opinion (sometimes these are also called “pain points” in current practice). These high-priority exchanges also closely correspond to the high-priority exchanges in related industries.

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SECTION 4 USE CASE DESCRIPTIONS

4. Use Case Descriptions

4.1 Process Map

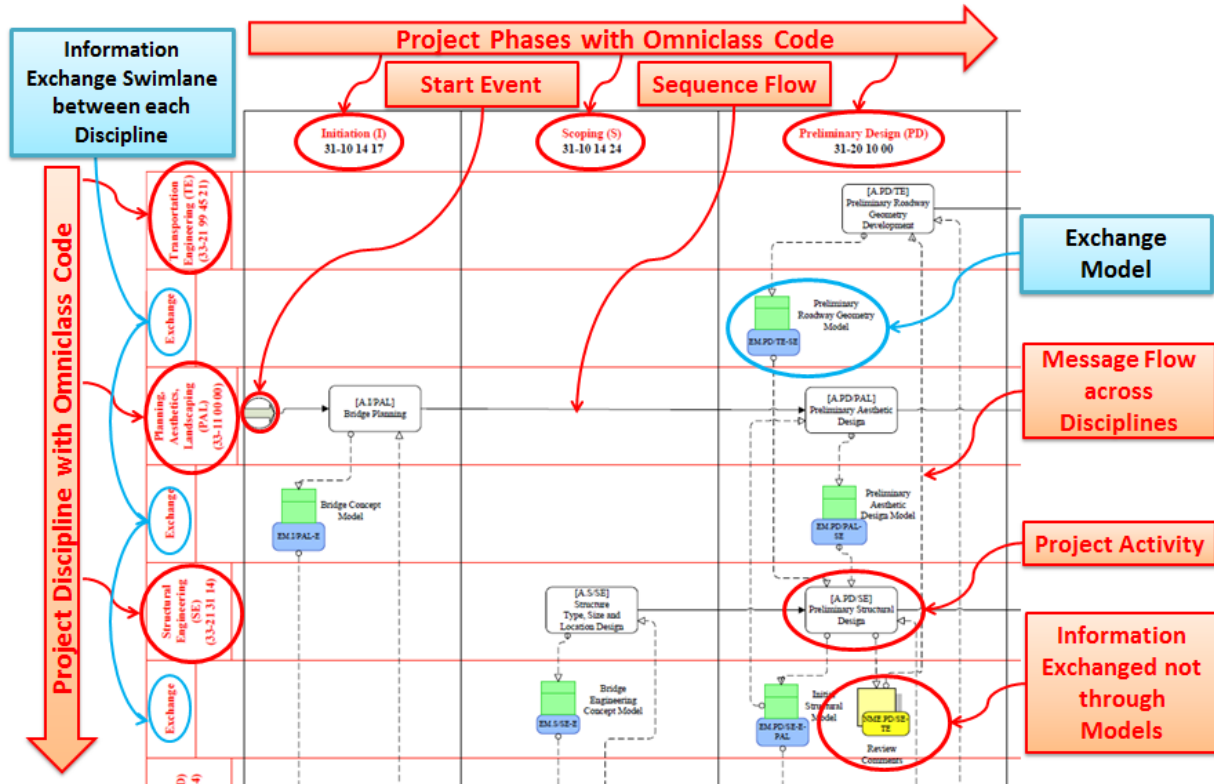


Figure 4-1. General Description

Process Map: The process map [35-38] identifies when in the bridge life cycle information exchange takes place between the various disciplines/actors involved. Information exchange between different activities across disciplines is identified by standardized “exchange models” referenced by unique IDs.

Description: Figure 4-1 describes the general layout of the process map.

- The vertical columns describe the various project phases with their Omniclass code throughout the bridge project life-cycle.
- The horizontal rows are used to categorize the various disciplines with their Omniclass code involved in the bridge life-cycle. Information exchange “swim-lanes” between any two disciplines are utilized to organize and group information exchanges between different disciplines [39-43].
- Project activities are denoted by white rectangles with rounded corners located on the process map based on the respective discipline (row) and project phase (column) they belong to [39-43].
- The solid lines show flow-of-control between activities within the same discipline during the various project phases throughout the bridge life-cycle. These solid lines never cross different disciplines.

- The dotted lines denote information flow between activities belonging to different disciplines via exchange models. Most of this information exchange is facilitated by means of digital bridge information models depicted in the process map by a green-blue block in the exchange swim-lane. Some of the information flow (such as reports, verbal communication, etc.) that does not require formal exchange of bridge information models is represented by a yellow block in the process map.
- Naming convention for activities and exchange models is based on cross referencing to disciplines and project phases. Activities are named as [A. Project phase/Discipline] and exchange models as [EM. Project phase/ Discipline1-Discipline2].

Process Map Walk-through Example: For this example consider the region marked up in **Figure 4-2. Process Map** [44-54]. Refer to **Figure 4-3. Walk-through** and **Figure 4-4. Walk-through Zoomed-in** for the following walk-through example of information/sequence flow from activity-1 to activity-3 as marked up.

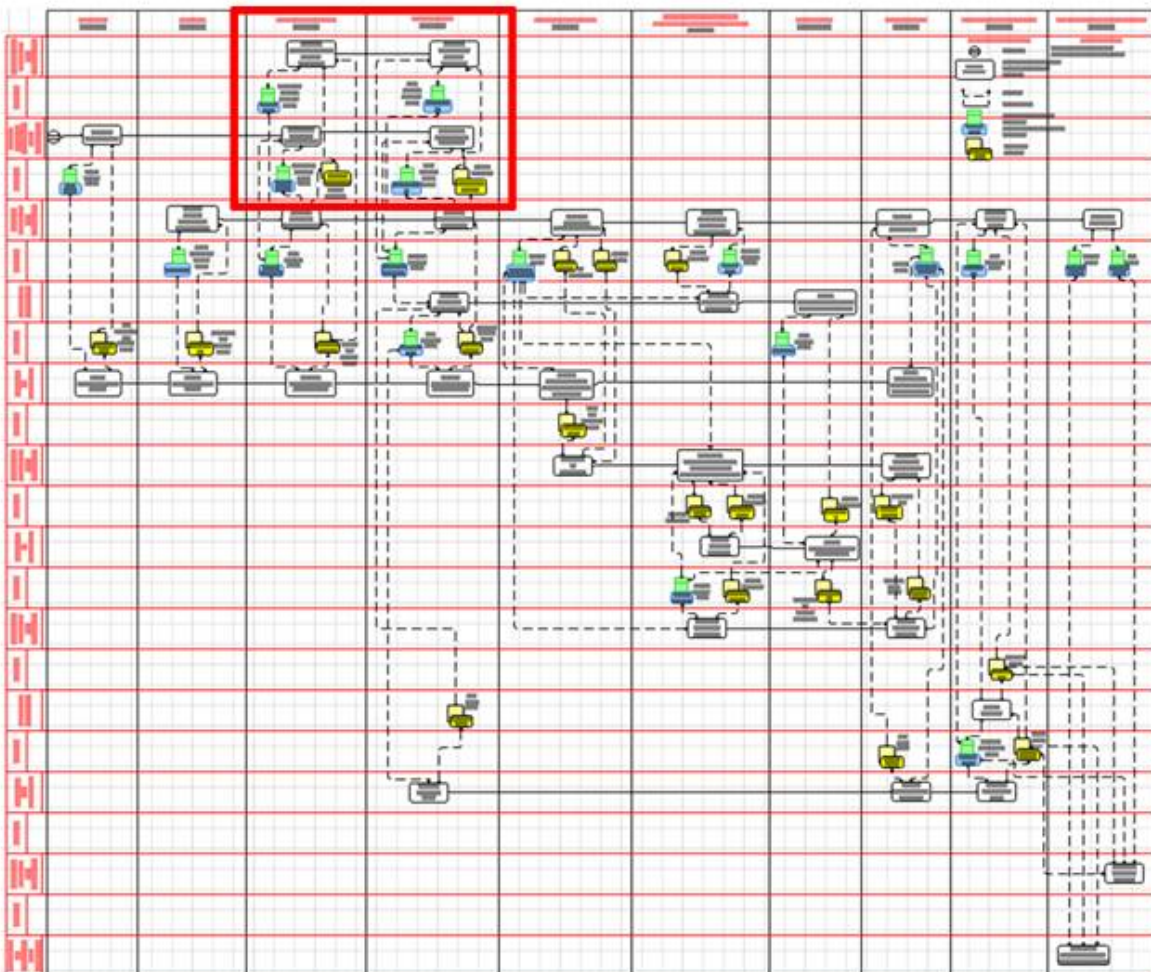


Figure 4-2. Process Map

Activity-1, Preliminary Roadway Geometry Development is named as [A.PD/TE] cross referencing to the project phase “Preliminary Design (PD)” and discipline “Transportation Engineering (TE)” it belongs to in the process map. Similarly activity-2 [A.FD/TE] and activity-3 [A.FD/SE] are placed on the process map according to the project phase and discipline they belong to.

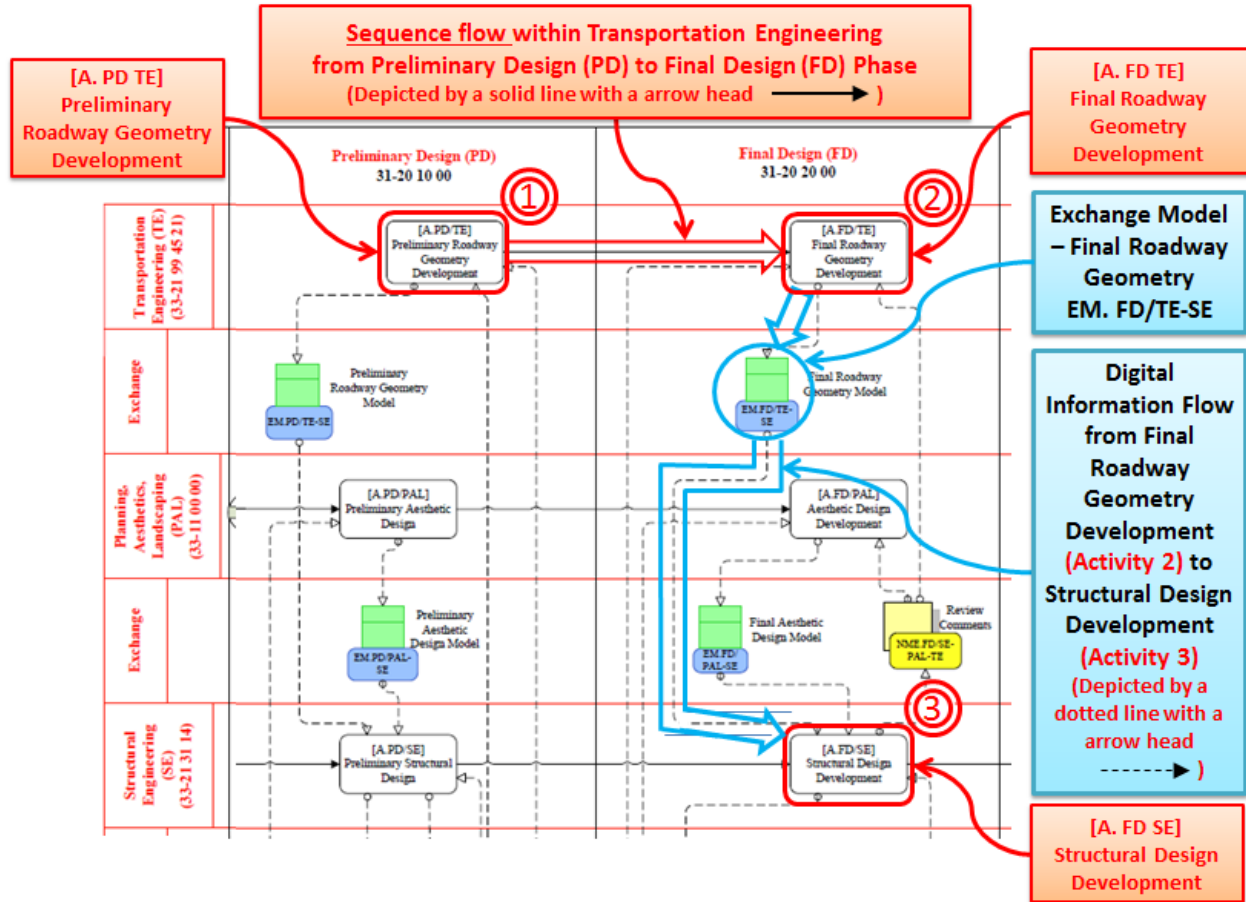


Figure 4-3. Walk-through

As the project progresses to the final design phase, the flow-of-control from activity-1 [A.PD/TE] to activity-3 [A.FD/TE] is denoted by a solid line with an arrow head. This represents the progression of roadway geometry development activity within the transportation engineering discipline from preliminary design phase to the final design phase.

Now consider the information flow during the final design phase from activity-2 (Final Roadway Geometry Development [A.FD/TE]) to activity-3 (Structural Design Development [A.FD/SE]). This information flow from activity-2 to activity-3, belonging to transportation engineering and structural engineering disciplines respectively, is facilitated by a digital bridge information exchange model named as [EM.FD/ TE-SE]. This exchange model is depicted on the process map by a green-blue block located in the exchange swim-lane below the transportation engineering row as marked up in **Figure 4-3. Walk-through**. Note that “TE” and “SE” in the name of this exchange model represent the two disciplines involved in the information exchange. Except for reports/comments/communications (e.g., as depicted in yellow blocks), all other exchange of information between different disciplines is through digital exchange models.

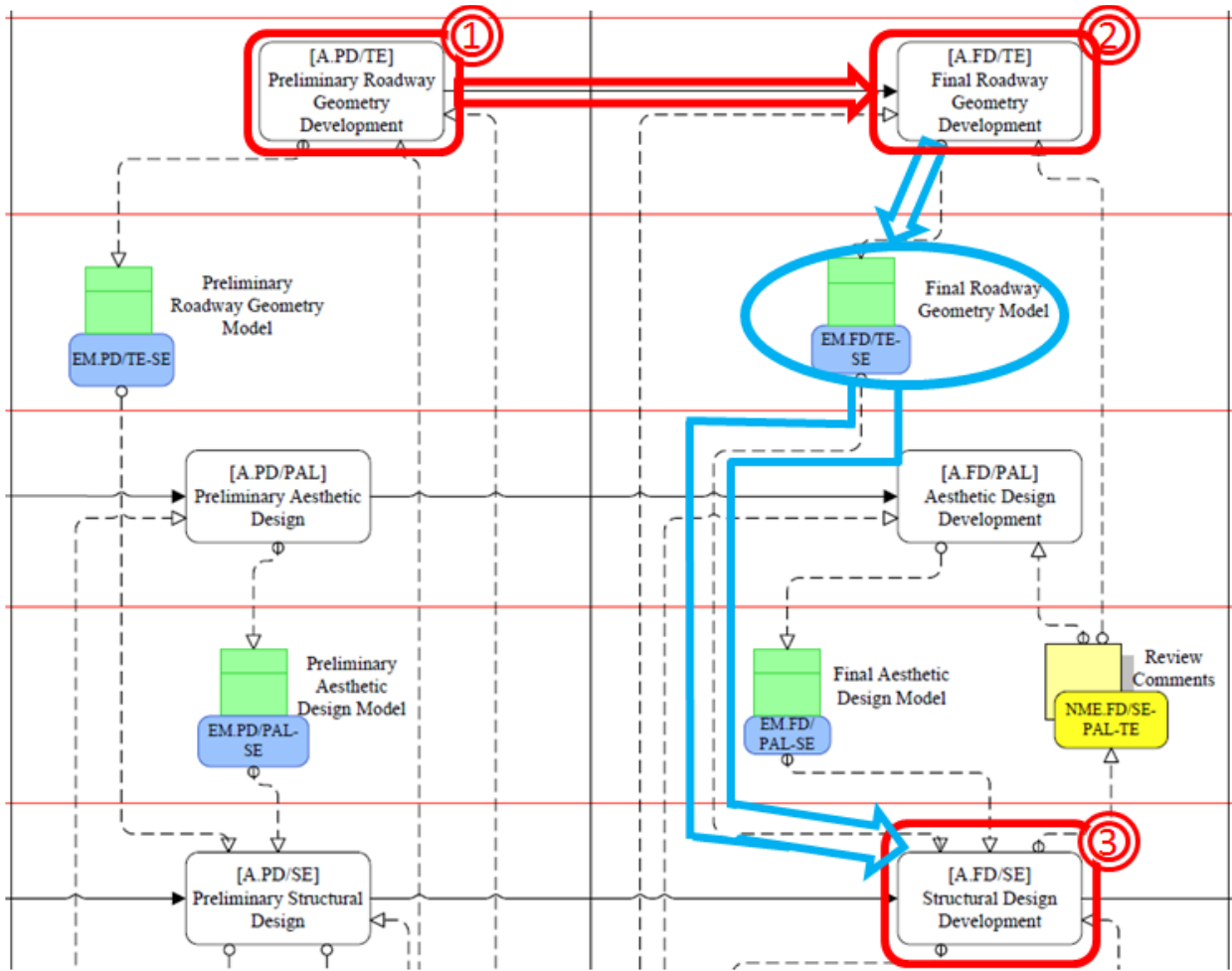


Figure 4-4. Walk-through Zoomed-in

4.1.1 Use Case Descriptions

Use Case 1 – Bridge Initial Planning. The use case presented herein is between activity A.I/PAL (bridge planning) and activity A.I/E (conceptual estimate (owner)). After a transportation problem or need from a variety of sources has been determined, engineer starts the initial planning of a bridge program by selecting candidate projects based on program goals [48, 50]. At the initiation stage, engineer describes candidate projects and how the projects address the program goals. The description of candidate projects are captured in the exchange model, EM.I/PAL-E (bridge concept model). Bridge owner uses this exchange model to accomplish a conceptual cost estimate without benefit of detailed field investigations or project design details. Rules of thumb (cost per mile, cost per square foot, etc.) based on experience can be used at this stage.

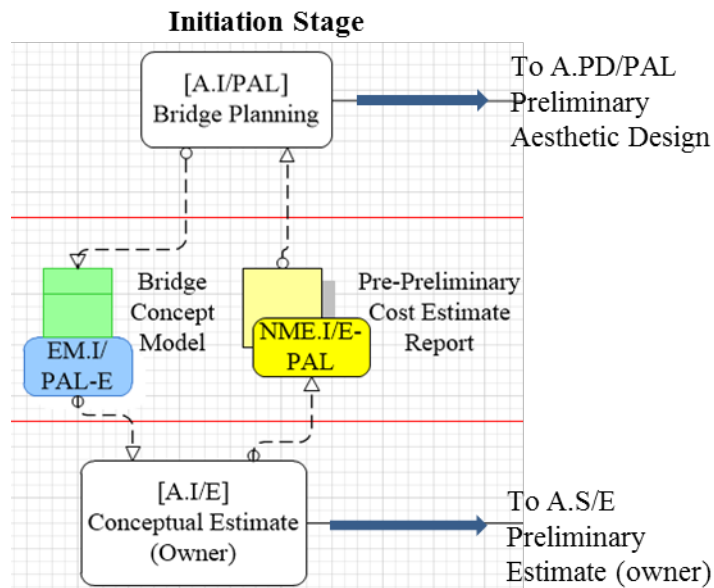


Figure 4-5. Use Case 1 – Bridge Initial Planning

Use Case 2 – Bridge Engineering Planning. This use case is between activity A.S/SE (structure type, size and location design) and activity A.S/E (preliminary estimate (owner)). After the initial planning, structural engineer considers and investigates various project issues, elements and initiatives which will have an effect on scope, cost, and schedule. At the end of the scoping stage, associated project stakeholders will have a clear understanding of the problems and needs. They will establish consensus regarding the proper scope of the project and will make informed decisions. The structural engineer will then update the initial planning to form a scoping report, whose contents are captured in the exchange model, EM.S/SE-E (bridge engineering concept model). Bridge owner updates the conceptual cost estimate according to the contents of this exchange model including field investigations, major design elements identified, and major quantities estimated. The estimate methods contain Benefit-cost (B/C) analysis and Life Cycle Cost analysis based on approximate approaches (e.g., shoulder break area).

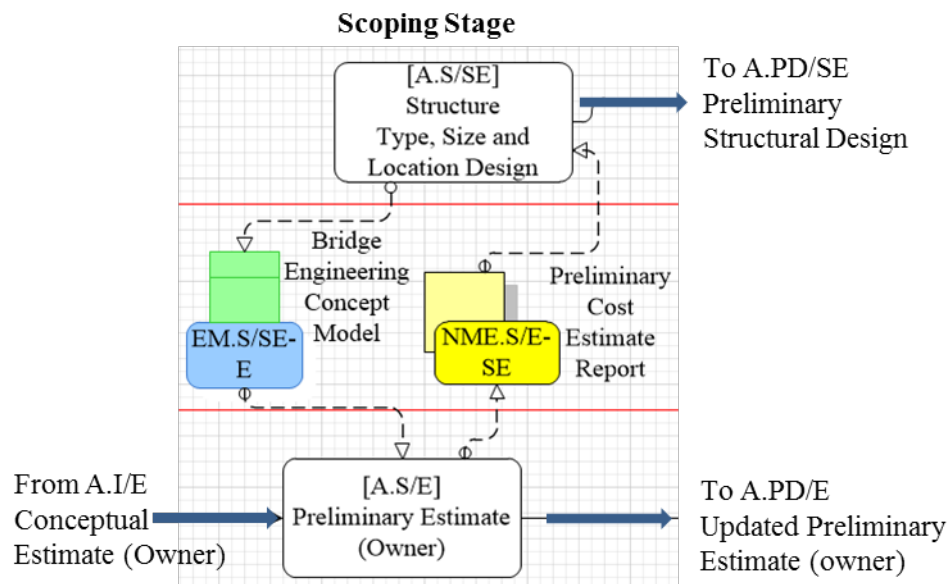
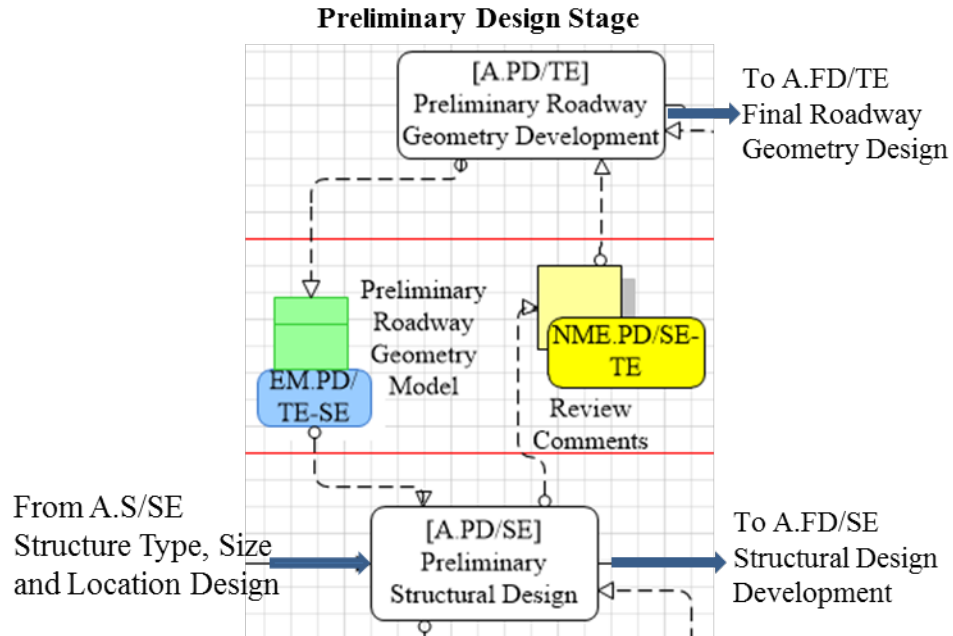


Figure 4-6. Use Case 2 – Bridge Engineering Planning

Use Case 3 – Preliminary Roadway Design. The use case presented herein is between activity A.PD/TE (preliminary roadway geometry development) and activity A.PD/SE (preliminary structural design). In the preliminary design stage, preliminary roadway design work is done primarily based on providing a level of geometric consistency between the bridge and the approach roadway, and recognizing the highway functional classification and traffic that the bridge serves. The Transportation engineer specifies the minimum requirements for bridge roadway, facility widths, and vertical under-clearances for the bridge project. These information items are captured in the exchange model, EM.PD/TE-SE (preliminary roadway geometry model). The Structural engineer then uses this exchange model to develop a preliminary bridge design. The



Use Case 4 – Preliminary Bridge Aesthetic Design. This use case is between activity A.PD/PAL (preliminary aesthetic design) and activity (preliminary structural design). The Engineer designs the appearance of the bridge structure in its surroundings in while designing the bridge’s type, size and location. This may influence the design of bridge configuration and geometry, superstructure type and shape, substructure type and shape, and appearance of appurtenances, etc. The results of the aesthetic design are included in the exchange model, EM.PD/PAL-SE (preliminary aesthetic design model).

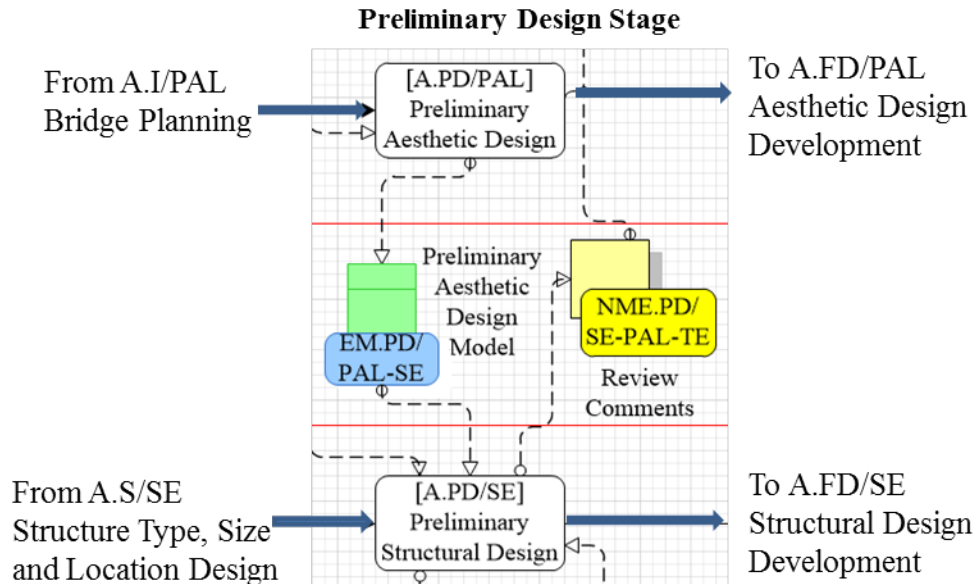


Figure 4-8. Use Case 4 – Preliminary Bridge Aesthetic Design

Use Case 5 – Preliminary Bridge Analysis and Design. The use case presented herein is between activity A.PD/SE (preliminary structural design) and activity A.PD/E (updated preliminary estimate (owner)). At the preliminary design stage, the structural engineer collects detailed structure condition data, develops feasible alternatives based on the conceptual design, studies social, economic and environmental impacts, and finally selects the most appropriate alternative to be advanced to final design. The results from preliminary bridge design are captured in the exchange model, EM.PD/SE-E-PAL (initial structure model). By using it, the bridge owner updates the preliminary cost estimate [55, 56].

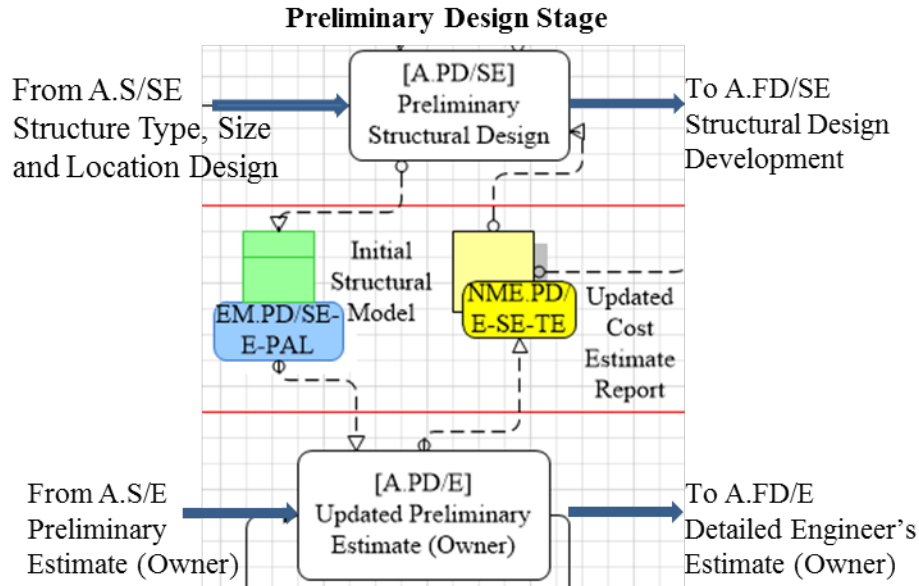


Figure 4-9. Use Case 5 – Preliminary Bridge Analysis and Design

Use Case 6 – Final Roadway Design. The first high-priority use case presented herein is between activity A.FD/TE (final roadway geometry development) and activity A.FD/SE (structural design development). In the final design stage, transportation engineer designs horizontal alignment, vertical profile and cross section of roadways that are on (and perhaps underneath) a bridge and then passes them to the bridge engineer [57-62]. The bridge engineer uses roadway geometry to design feasible bridge alternatives, which must comply with roadway geometry restrictions, such as vertical and/or horizontal clearances, location and skew angle of abutment and pier, etc. This exchange is excerpted from the process map as shown in Figure 4-10. In this use case, roadway geometry information exchanged between transportation engineer and structural engineer is contained in the exchange model, EM.FD/TE-SE (final roadway geometry model).

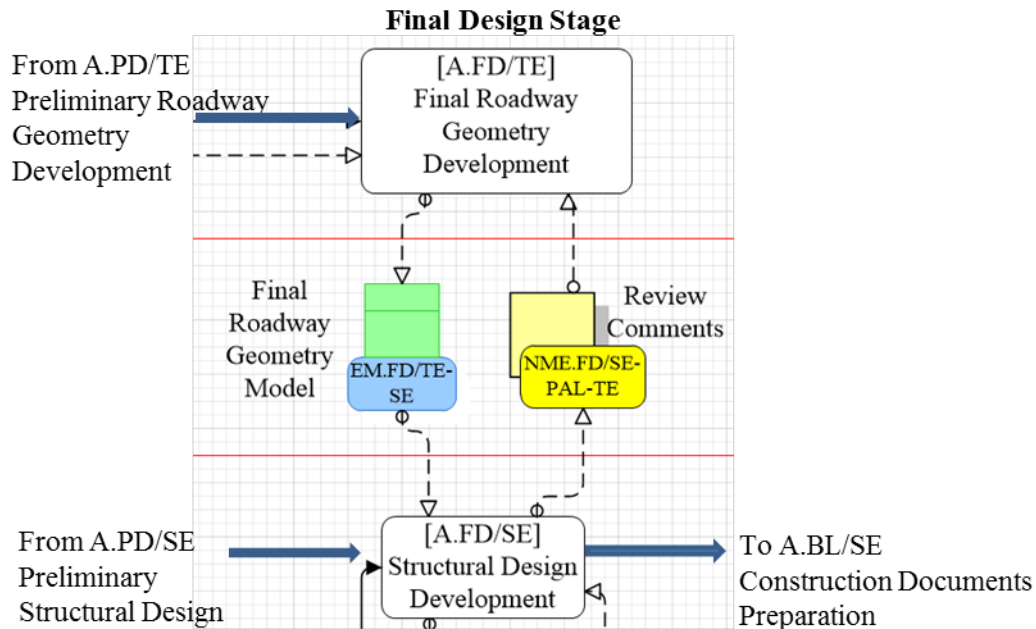


Figure 4-10. Use Case 6 – Final Roadway Design

Use Case 7 – Bridge Aesthetic Design Development. This use case is between activity A.FD/PAL (aesthetic design development) and activity A.FD/SE (structural design development). During the completion of the final design, the engineer uses the structural model to revise (if necessary) the preliminary aesthetic design to reflect any changes resulting from new information or review comments. The finalized aesthetic design is captured in the exchange model, EM.FD/PAL-SE (final aesthetic design model). The Structural engineer takes it into consideration when finalizing the bridge design.

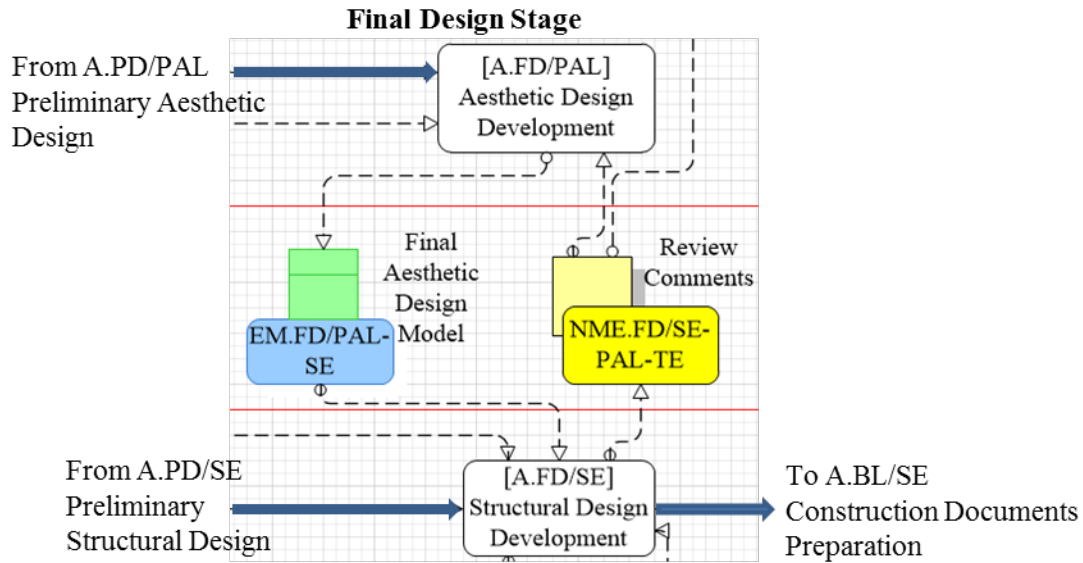


Figure 4-11. Use Case 7 – Bridge Aesthetic Design Development

Use Case 8 – Final Bridge Analysis and Design. The use case presented herein is between activity A.FD/SE (structural design development) and activity A.FD/D (preliminary detailing design). At the final design stage, the structural engineer reviews and completes the preliminary structural package, and then adds necessary detailing to the design alternative based on roadway geometry and aesthetic considerations. The outcomes, advance detailing plans (model) are captured in the exchange model, EM.FD/SE-D-TE-PAL (advance structural model). The plans (model) are submitted for review. Based on the review comments, the structural engineer modifies and details the design alternative, and finalizes the contract plans and specifications [55, 56, 63].

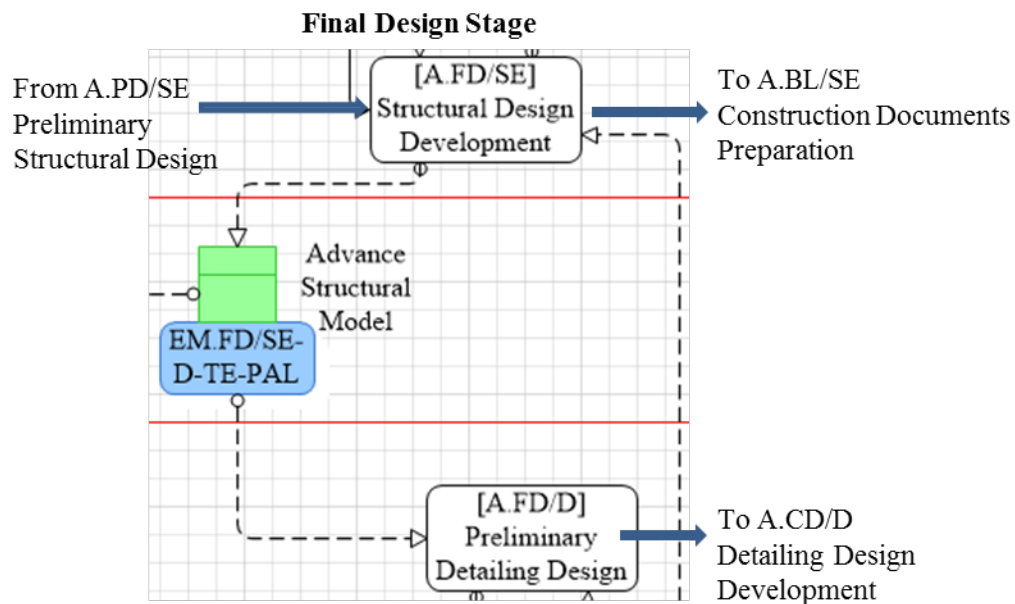
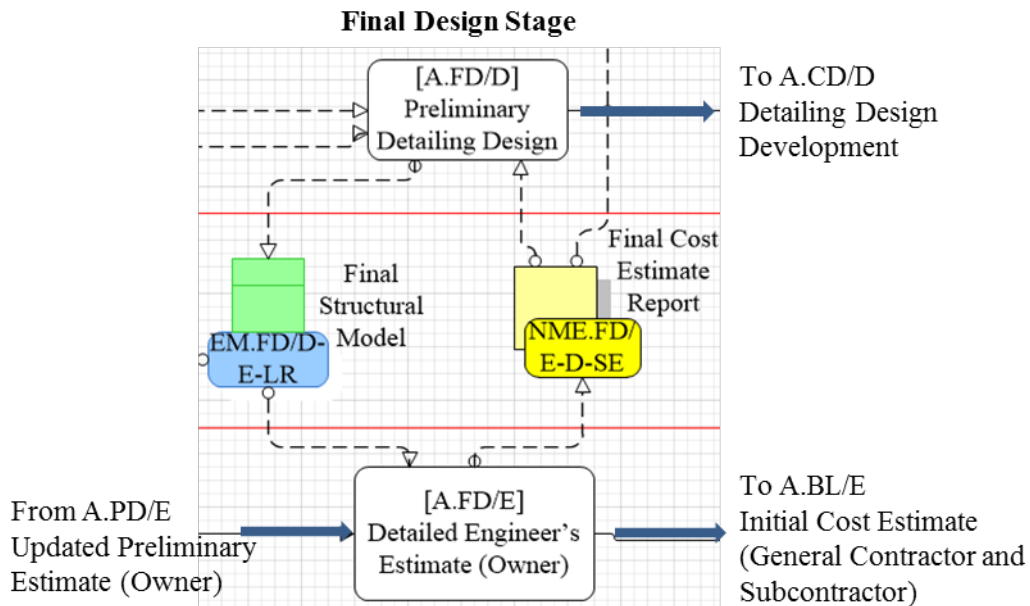


Figure 4-12. Use Case 8 – Final Bridge Analysis and Design

Use Case 9 – Preliminary Bridge Detailing. A second important high-priority use case of data exchange during bridge project life-cycle is between activity A.FD/D (preliminary detailing designs) and activity A.FD/E (detailed engineer’s estimate (owner)). At the final design stage, the bridge engineer creates, details, and finalizes the contract plans (model) and specifications. Based on this information, the engineer’s estimate is derived. Then the package of plans, specifications and estimate (PS&E) is used for project contract bidding and letting. This use case is demonstrated in the process map, as shown in Figure 9. In this data exchange, bridge analysis and design information is captured in the exchange model, EM.FD/D-E (Final Structural Model) [64, 65].



Use Case 10 – Initial Bridge Load Rating. This use case is between activity A.FD/D (preliminary detailing design) and activity A.FD/LR (initial load rating). Structural engineers make this initial load rating before the bridge is actually built based on final contract plans and specifications which are included in the exchange model, EM.FD/D-E-LR (final structural model). The initial load rating includes inventory and operating factors.

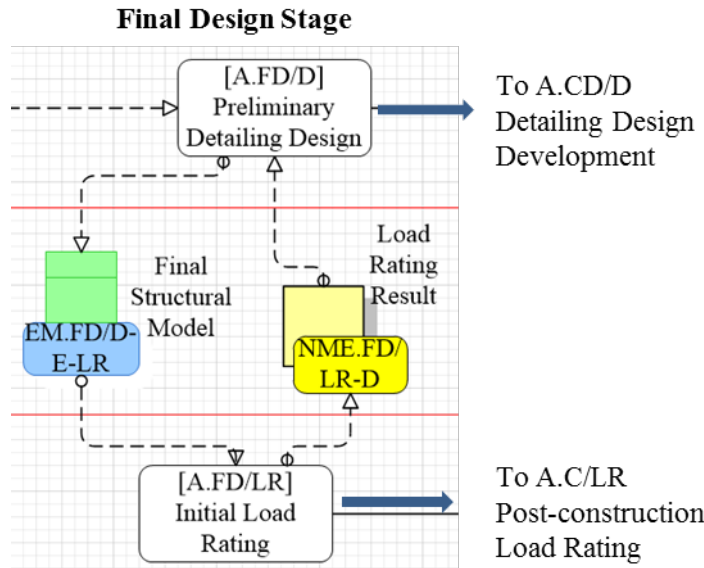


Figure 4-14. Use Case 10 – Initial Bridge Load Rating

Use Case 11 – Construction Documents Development. The use case presented herein is between activity A.BL/SE (construction documents preparation) and activity A.BL/E (initial cost estimate (general contractor and subcontractor)). In the bidding and letting stage, the bridge owner collects and produces contract documents on which various general contractors will in turn bid. Final contract package includes plans, specifications, cost estimate, and pay items regarding transportation, structural and sometimes landscaping. The contents of the package are captured in the exchange model, EM.BL/SE-D-E-CM-CE (contract model). After receiving copies of the contract documents, general contractors and subcontractors compile a complete "bid price" for submission by the closing date and time. Bid documents are produced based on the quantities of materials, devices, and labor in the completed construction [66].

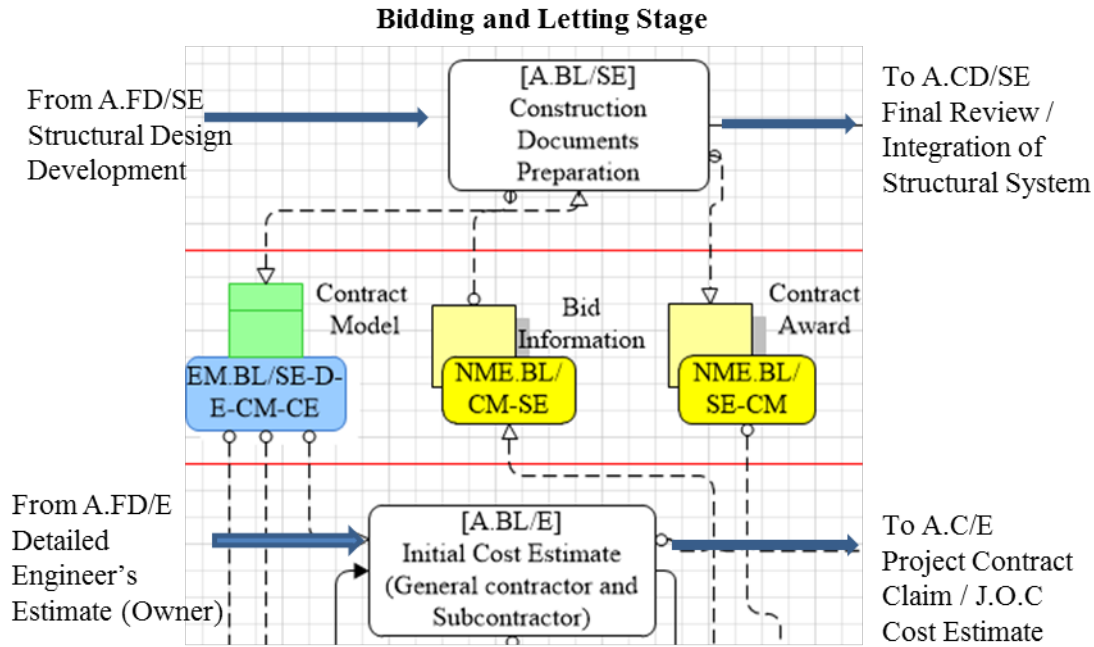


Figure 4-15. Use Case 11 – Construction Documents Development

Use Case 12 – Bridge Detailing Development. The use case presented herein is between activity A.CD/SE (final review / integration of structural system) and activity A.CD/D (detailing design development). After the project is awarded, the general contractor who receives the contract starts (or asks subcontractors) to develop bridge detailing calculations and drawings (model) for fabrication, installation, and erection. Bridge owner reviews the preliminary bridge detailing calculations and shop drawings (model) submitted from contractor for conformance with the contract documents. In this data exchange, bridge detailing information is captured in the exchange model, EM.CD/D-SE (advance detailing model).

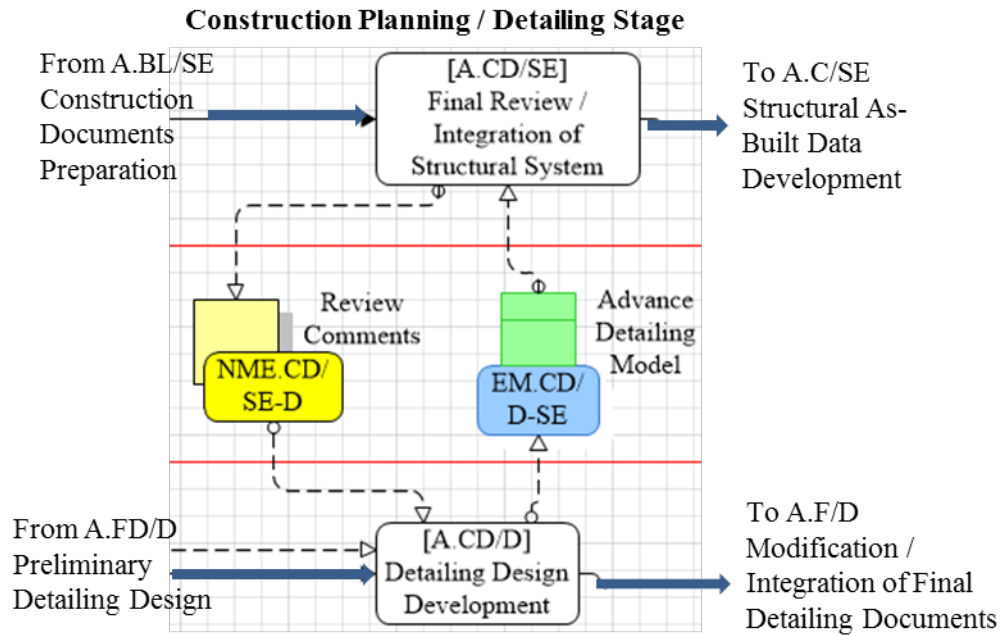


Figure 4-16. Use Case 12 – Bridge Detailing Development

Use Case 13 – Construction/Erection Planning. The use case presented herein is between activity A.CD/CM (construction planning and scheduling (general contractor and subcontractor)) and activity A.CD/CE (erection plan and analysis). The Contractor prepares (asks erector to prepare) and submits a detailed erection procedure to bridge owner for each structure in the contract. The procedure shall be conformance with the contract documents. Contractor plans and schedules construction work properly to minimize construction time and cost based on the submitted documents. The exchange model, EM.CD/CE-F-CM (erection analysis model) captures the information exchanged between these two activities.

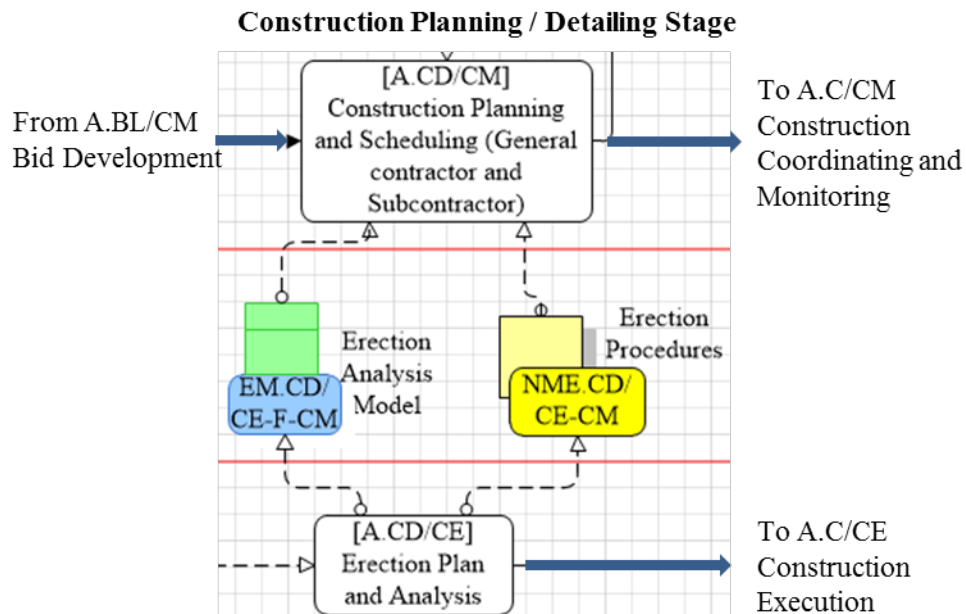


Figure 4-17. Use Case 13 – Construction/Erection Planning

Use Case 14 – Bridge Detailing and Fabrication. Another high-priority use case of data exchange during bridge project life-cycle is between activity A.F/D (modification and integration of final detailing documents), and activity A.F/F (product manufacturing, i.e., fabrication). The conventional practice is that after receiving comments on preliminary shop model / drawings from bridge owner, the detailer modifies and finalizes the shop model / drawings, then passes them to fabricator (or to CNC machine directly in some cases). The fabricator will then manufacture bridge members according to the model/drawings, and ship them to the construction site for erection and installation. This exchange is excerpted from the process map as shown in Figure 14. In the electronic data exchange, the detailing information of bridge members is captured in the exchange model, EM.F/D-F (Final Detailing Model) [67, 68].

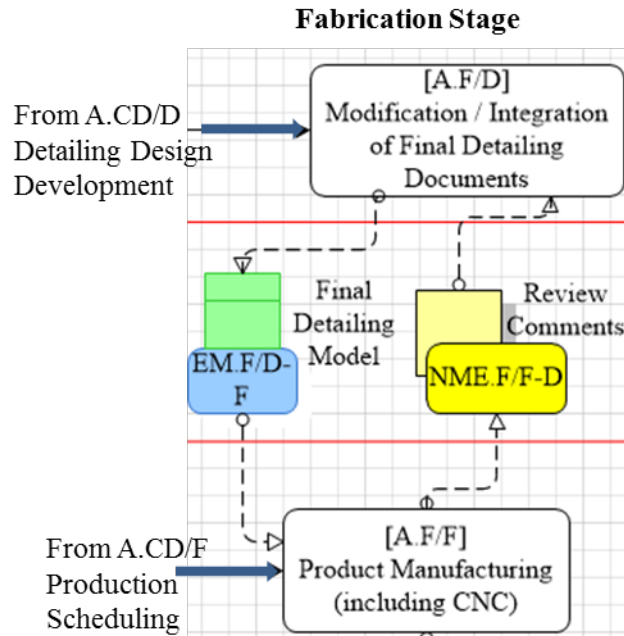


Figure 4-18. Use Case 14 – Bridge Detailing and Fabrication

Use Case 15 – As-Built Bridge Data Development. The use case presented herein is between activity A.C/SE (structural as-built data development) and activity A.C/LR (initial load rating). After completion of bridge construction, structural engineer modifies contract plans and specifications based on the revisions provided by contractor to reflect changes in construction. The information in the as-built plans which reflects the existing bridge condition is captured in the exchange model, EM.C/CE-SE-E-LR (as-built model). The Structural engineer updates the initial load rating based on the as-built bridge model.

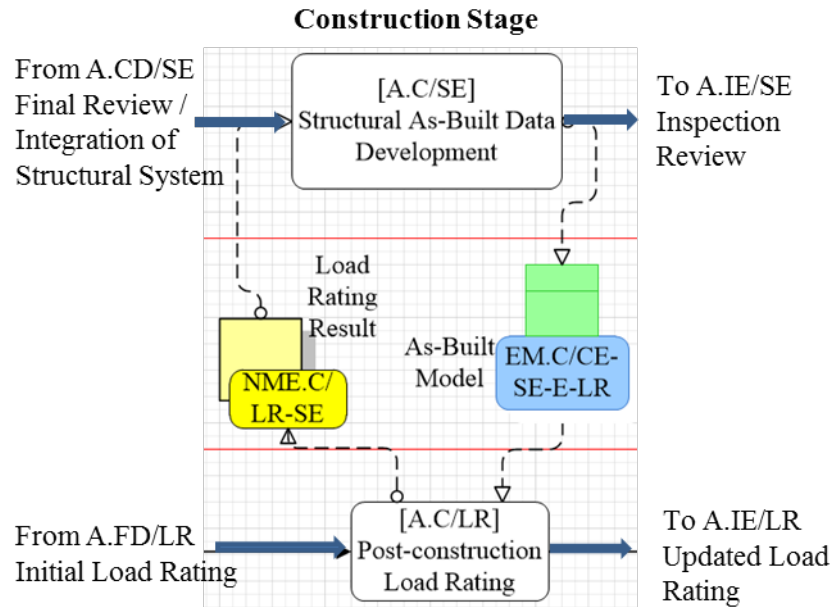


Figure 4-19. Use Case 15 – As-Built Bridge Data Development

Use Case 16 – Bridge Inspection Review. The use case presented herein is between activity A.IE/SE (inspection review) and activity A.IE/I (inspection). Bridge inspectors use a systematic method to observe the bridge, to ensure that the entire bridge inspected. The exact order of the inspection will vary depending on the type of bridge being inspected. The bridge inspectors document their findings in the bridge inspection report. The Structural engineer and bridge inspectors review the as-built data and/or the previous bridge inspection report. The inspectors identify areas where defects were found in previous inspections. This allows them to determine if the defects previously identified have been repaired or have increased in size and severity. In this data exchange, information is captured in the exchange model, EM.IE/I-SE (prior inspection model).

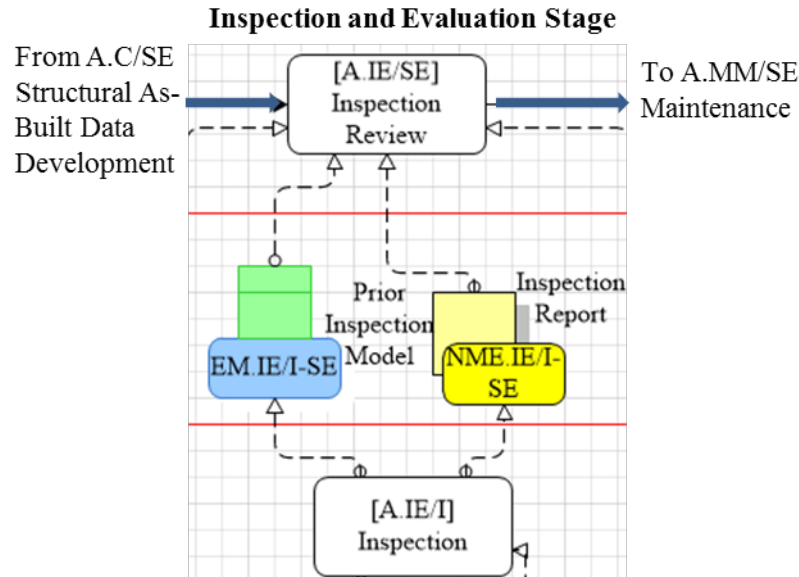


Figure 4-20. Use Case 16 – Bridge Inspection Review

Use Case 17 – Bridge Inspection and Load Rating. The use case presented herein is between activity A.IE/I (inspection) and activity A.IE/LR (updated load rating). Bridge inspectors use a systematic method to observe the bridge, to ensure that the entire bridge inspected. The exact order of the inspection will vary depending on the type of bridge being inspected. The bridge inspectors document their findings in the bridge inspection report. Structural engineers need to make an updated load rating calculation whenever the capacity of the bridge changes due to the condition of the structure, impact on the bridge due to approach roadway or deck deterioration, or if the dead load of the bridge has been increased. In this data exchange, information is captured in the exchange model, EM.IE/I-LR-SE (structural deterioration model).

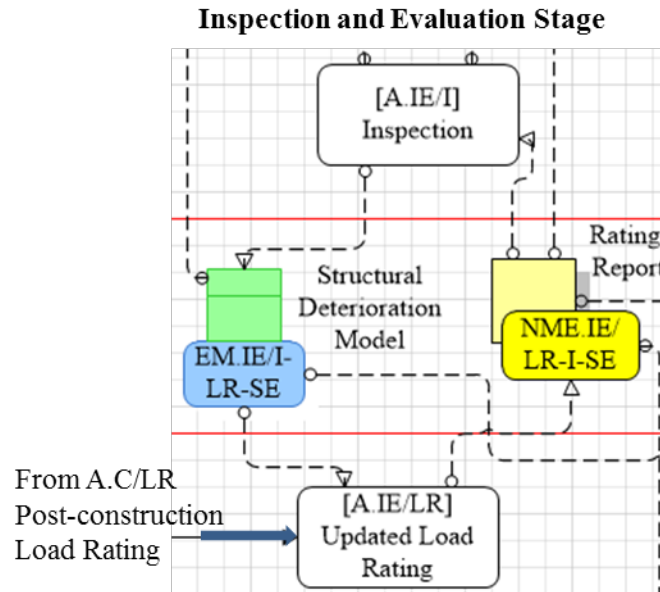


Figure 4-21. Use Case 17 – Bridge Inspection and Load Rating

Use Case 18 – Bridge Maintenance and Management. The use case presented herein is between activity A.MM/SE (maintenance), activity A.MM/MM (bridge programming / retrofit / rehabilitation) and activity A.MM/RP (routing and permitting). Cyclical maintenance activities need to be performed by bridge owner to reduce the rate of deterioration of critical bridge elements. These activities are essential for a bridge to reach its maximum useful life and maintain its designed level of service. The activities include bridge cleaning, sealing cracks in the wearing surface, etc. Based on load rating data in bridge inventory, transportation agencies permit and route oversize and overweight vehicles. When the bridge is structurally deficient or functionally obsolete, bridge engineers plan a retrofit / rehabilitation / replacement project based on bridge inspection report and load rating factors. In this data exchange, information is captured in the exchange model, EM.MM/SE-MM (retrofit model) and EM.MM/SE-RP (GIS model).

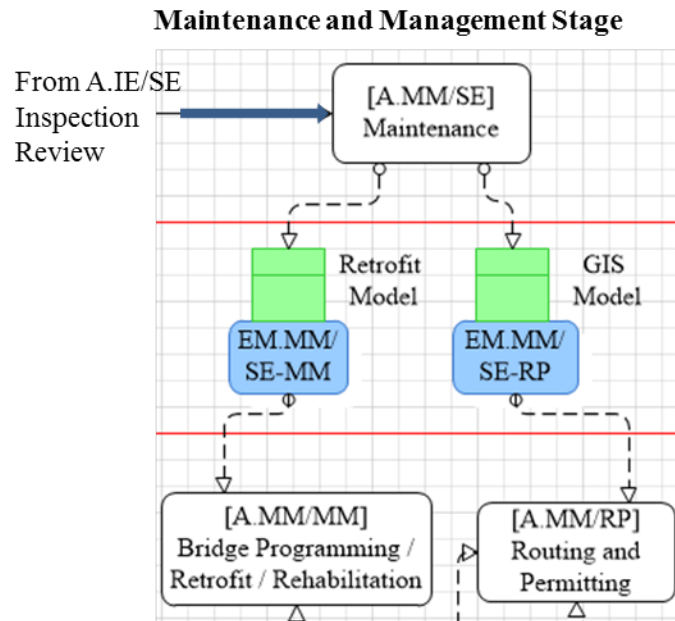


Figure 4-22. Use Case 18 – Bridge Maintenance and Management

4.2 Activity Definitions

Activity Definitions show the location of Activities in the stages labeled in the Process Map and the relations between Activities and Disciplines. The key to the following table is “x” represents an activity selected and “n” represents an activity not selected.

Project Stage / Discipline	Omniclass	Name	Bridge Planning A.I/PAL	Conceptual Estimate (Owner) A.I/E	Structure Type Size and Location Design A.S/SE	Preliminary Estimate (Owner) A.S/E
Project Stage	31-10 14 17	Initiation	x	x	n	n
Project Stage	31n10 14 24	Scoping	n	n	x	x
Project Stage	31n20 10 00	Preliminary Design	n	n	n	n
Project Stage	31-20 20 00	Final Design	n	n	n	n
Project Stage	31-30 30 00	Bidding and Letting	n	n	n	n
Project Stage	31-40 10 00	Constuction Planning/Detailing	n	n	n	n
Project Stage	31-40 40 14	Fabrication	n	n	n	n
Project Stage	31-40 40 00	Construction	n	n	n	n
Project Stage	31-50 20 21	Inspection and Evaluation	n	n	n	n
Project Stage	31-50 20 31	Maintenance and Management	n	n	n	n
Discipline	33-21 99 45 21	Transportation Engineering	n	n	n	n
Discipline	33-11 00 00	Planning, Aesthetics and Landscaping	x	n	n	n
Discipline	33-21 31 14	Structural Engineering	n	n	x	n
Discipline	33-21 31 14	Detailing	n	n	n	n
Discipline	33-25 11 00	Estimation	n	x	n	x
Discipline	33-41 14 00	Construction Management	n	n	n	n
Discipline	33-25 41 11	Fabrication	n	n	n	n
Discipline	33-41 11 11	Construction Engineering	n	n	n	n
Discipline	33-21 31 14	Inspection	n	n	n	n
Discipline	33-21 31 14	Load Rating	n	n	n	n
Discipline	33-21 31 11	Routing and Permitting	n	n	n	n
Discipline	33-55 24 00	Maintenance and Management	n	n	n	n

Project Stage / Discipline	Omniclass	Name	Preliminary Roadway Geometry Development A.PD/TE	Preliminary Aesthetic Design A.PD/PAL	Preliminary Structural Design A.PD/SE	Updated Preliminary Estimate (Owner) A.PD/E
Project Stage	31-10 14 17	Initiation	n	n	n	n
Project Stage	31-10 14 24	Scoping	n	n	n	n
Project Stage	31-20 10 00	Preliminary Design	x	x	x	x
Project Stage	31-20 20 00	Final Design	n	n	n	n
Project Stage	31-30 30 00	Bidding and Letting	n	n	n	n
Project Stage	31-40 10 00	Constuction Planning/Detailing	n	n	n	n
Project Stage	31-40 40 14	Fabrication	n	n	n	n
Project Stage	31-40 40 00	Construction	n	n	n	n
Project Stage	31-50 20 21	Inspection and Evaluation	n	n	n	n
Project Stage	31-50 20 31	Maintenance and Management	n	n	n	n
Discipline	33-21 99 45 21	Transportation Engineering	x	n	n	n
Discipline	33-11 00 00	Planning, Aesthetics and Landscaping	n	x	n	n
Discipline	33-21 31 14	Structural Engineering	n	n	x	n
Discipline	33-21 31 14	Detailing	n	n	n	n
Discipline	33-25 11 00	Estimation	n	n	n	x
Discipline	33-41 14 00	Construction Management	n	n	n	n
Discipline	33-25 41 11	Fabrication	n	n	n	n
Discipline	33-41 11 11	Construction Engineering	n	n	n	n
Discipline	33-21 31 14	Inspection	n	n	n	n
Discipline	33-21 31 14	Load Rating	n	n	n	n
Discipline	33-21 31 11	Routing and Permitting	n	n	n	n
Discipline	33-55 24 00	Maintenance and Management	n	n	n	n

Project Stage / Discipline	Omniclass	Name	Final Roadway Geometry Development A.FD/TE	Aesthetic Design Development A.FD/PAL	Structural Design Development A.FD/SE	Preliminary Detailing Design A.FD/D	Detailed Engineer's Estimate (Owner) A.FD/E
Project Stage	31-10 14 17	Initiation	n	n	n	n	n
Project Stage	31-10 14 24	Scoping	n	n	n	n	n
Project Stage	31-20 10 00	Preliminary Design	n	n	n	n	n
Project Stage	31-20 20 00	Final Design	x	x	x	x	x
Project Stage	31-30 30 00	Bidding and Letting	n	n	n	n	n
Project Stage	31-40 10 00	Construction Planning/Detailing	n	n	n	n	n
Project Stage	31-40 40 14	Fabrication	n	n	n	n	n
Project Stage	31-40 40 00	Construction	n	n	n	n	n
Project Stage	31-50 20 21	Inspection and Evaluation	n	n	n	n	n
Project Stage	31-50 20 31	Maintenance and Management	n	n	n	n	n
Discipline	33-21 99 45 21	Transportation Engineering	x	n	n	n	n
Discipline	33-11 00 00	Planning, Aesthetics and Landscaping	n	x	n	n	n
Discipline	33-21 31 14	Structural Engineering	n	n	x	n	n
Discipline	33-21 31 14	Detailing	n	n	n	x	n
Discipline	33-25 11 00	Estimation	n	n	n	n	x
Discipline	33-41 14 00	Construction Management	n	n	n	n	n
Discipline	33-25 41 11	Fabrication	n	n	n	n	n
Discipline	33-41 11 11	Construction Engineering	n	n	n	n	n
Discipline	33-21 31 14	Inspection	n	n	n	n	n
Discipline	33-21 31 14	Load Rating	n	n	n	n	n
Discipline	33-21 31 11	Routing and Permitting	n	n	n	n	n
Discipline	33-55 24 00	Maintenance and Management	n	n	n	n	n

Project Stage / Discipline	Omniclass	Name	Initial Load Rating A.FD/LR	Construction Documents Preparation A.BL/SE	Initial Cost Estimate (General Contractor and Subcontractor) A.BL/E	Bid Development A.BL/CM	Final Review / Integration of Structural System A.CD/SE
Project Stage	31-10 14 17	Initiation	n	n	n	n	n
Project Stage	31-10 14 24	Scoping	n	n	n	n	n
Project Stage	31-20 10 00	Preliminary Design	n	n	n	n	n
Project Stage	31-20 20 00	Final Design	x	n	n	n	n
Project Stage	31-30 30 00	Bidding and Letting	n	x	x	x	n
Project Stage	31-40 10 00	Constuction Planning/Detailing	n	n	n	n	x
Project Stage	31-40 40 14	Fabrication	n	n	n	n	n
Project Stage	31-40 40 00	Construction	n	n	n	n	n
Project Stage	31-50 20 21	Inspection and Evaluation	n	n	n	n	n
Project Stage	31-50 20 31	Maintenance and Management	n	n	n	n	n
Discipline	33-21 99 45 21	Transportation Engineering	n	n	n	n	n
Discipline	33-11 00 00	Planning, Aesthetics and Landscaping	n	n	n	n	n
Discipline	33-21 31 14	Structural Engineering	n	x	n	n	x
Discipline	33-21 31 14	Detailing	n	n	n	n	n
Discipline	33-25 11 00	Estimation	n	n	x	n	n
Discipline	33-41 14 00	Construction Management	n	n	n	x	n
Discipline	33-25 41 11	Fabrication	n	n	n	n	n
Discipline	33-41 11 11	Construction Engineering	n	n	n	n	n
Discipline	33-21 31 14	Inspection	n	n	n	n	n
Discipline	33-21 31 14	Load Rating	x	n	n	n	n
Discipline	33-21 31 11	Routing and Permitting	n	n	n	n	n
Discipline	33-55 24 00	Maintenance and Management	n	n	n	n	n

Project Stage / Discipline	Omiclass	Name	Detailing Design Development A.CD/D	Construction Planning and Scheduling A.CD/CM	Production Scheduling A.CD/F	Erection Plan and Analysis A.CD/CE	Modification / Integration of Final Detailing Documents A.F/D
Project Stage	31-10 14 17	Initiation	n	n	n	n	n
Project Stage	31-10 14 24	Scoping	n	n	n	n	n
Project Stage	31-20 10 00	Preliminary Design	n	n	n	n	n
Project Stage	31-20 20 00	Final Design	n	n	n	n	n
Project Stage	31-30 30 00	Bidding and Letting	n	n	n	n	n
Project Stage	31-40 10 00	Constuction Planning/Detailing	x	x	x	x	n
Project Stage	31-40 40 14	Fabrication	n	n	n	n	x
Project Stage	31-40 40 00	Construction	n	n	n	n	n
Project Stage	31-50 20 21	Inspection and Evaluation	n	n	n	n	n
Project Stage	31-50 20 31	Maintenance and Management	n	n	n	n	n
Discipline	33-21 99 45 21	Transportation Engineering	n	n	n	n	n
Discipline	33-11 00 00	Planning, Aesthetics and Landscaping	n	n	n	n	n
Discipline	33-21 31 14	Structural Engineering	n	n	n	n	n
Discipline	33-21 31 14	Detailing	x	n	n	n	x
Discipline	33-25 11 00	Estimation	n	n	n	n	n
Discipline	33-41 14 00	Construction Management	n	x	n	n	n
Discipline	33-25 41 11	Fabrication	n	n	x	n	n
Discipline	33-41 11 11	Construction Engineering	n	n	n	x	n
Discipline	33-21 31 14	Inspection	n	n	n	n	n
Discipline	33-21 31 14	Load Rating	n	n	n	n	n
Discipline	33-21 31 11	Routing and Permitting	n	n	n	n	n
Discipline	33-55 24 00	Maintenance and Management	n	n	n	n	n

Project Stage / Discipline	Omniclass	Name	Product Manufacturing (including CNC) A.F/F	Structural As-Built Data Development A.C/SE	Project Contract Claim / J.O.C. Cost Estimates (Owner) A.C/E	Construction Coordinating and Monitoring A.C/CM	Construction Execution A.C/CE
Project Stage	31-10 14 17	Initiation	n	n	n	n	n
Project Stage	31-10 14 24	Scoping	n	n	n	n	n
Project Stage	31-20 10 00	Preliminary Design	n	n	n	n	n
Project Stage	31-20 20 00	Final Design	n	n	n	n	n
Project Stage	31-30 30 00	Bidding and Letting	n	n	n	n	n
Project Stage	31-40 10 00	Constuction Planning/Detailing	n	n	n	n	n
Project Stage	31-40 40 14	Fabrication	x	n	n	n	n
Project Stage	31-40 40 00	Construction	n	x	x	x	x
Project Stage	31-50 20 21	Inspection and Evaluation	n	n	n	n	n
Project Stage	31-50 20 31	Maintenance and Management	n	n	n	n	n
Discipline	33-21 99 45 21	Transportation Engineering	n	n	n	n	n
Discipline	33-11 00 00	Planning, Aesthetics and Landscaping	n	n	n	n	n
Discipline	33-21 31 14	Structural Engineering	n	x	n	n	n
Discipline	33-21 31 14	Detailing	n	n	n	n	n
Discipline	33-25 11 00	Estimation	n	n	x	n	n
Discipline	33-41 14 00	Construction Management	n	n	n	x	n
Discipline	33-25 41 11	Fabrication	x	n	n	n	n
Discipline	33-41 11 11	Construction Engineering	n	n	n	n	x
Discipline	33-21 31 14	Inspection	n	n	n	n	n
Discipline	33-21 31 14	Load Rating	n	n	n	n	n
Discipline	33-21 31 11	Routing and Permitting	n	n	n	n	n
Discipline	33-55 24 00	Maintenance and Management	n	n	n	n	n

Project Stage / Discipline	Omniclass	Name	Post- Construction Load Rating A.C/LR	Inspection Review A.IE/SE	Inspection A.IE/I	Updated Load Rating A.IE/LR
Project Stage	31-10 14 17	Initiation	n	n	n	n
Project Stage	31-10 14 24	Scoping	n	n	n	n
Project Stage	31-20 10 00	Preliminary Design	n	n	n	n
Project Stage	31-20 20 00	Final Design	n	n	n	n
Project Stage	31-30 30 00	Bidding and Letting	n	n	n	n
Project Stage	31-40 10 00	Constuction Planning/Detailing	n	n	n	n
Project Stage	31-40 40 14	Fabrication	n	n	n	n
Project Stage	31-40 40 00	Construction	x	n	n	n
Project Stage	31-50 20 21	Inspection and Evaluation	n	x	x	x
Project Stage	31-50 20 31	Maintenance and Management	n	n	n	n
Discipline	33-21 99 45 21	Transportation Engineering	n	n	n	n
Discipline	33-11 00 00	Planning, Aesthetics and Landscaping	n	n	n	n
Discipline	33-21 31 14	Structural Engineering	n	x	n	n
Discipline	33-21 31 14	Detailing	n	n	n	n
Discipline	33-25 11 00	Estimation	n	n	n	n
Discipline	33-41 14 00	Construction Management	n	n	n	n
Discipline	33-25 41 11	Fabrication	n	n	n	n
Discipline	33-41 11 11	Construction Engineering	n	n	n	n
Discipline	33-21 31 14	Inspection	n	n	x	n
Discipline	33-21 31 14	Load Rating	x	n	n	x
Discipline	33-21 31 11	Routing and Permitting	n	n	n	n
Discipline	33-55 24 00	Maintenance and Management	n	n	n	n

Project Stage / Discipline	Omniclass	Name	Maintenance A.MM/SE	Routing and Permitting A.MM/RP	Bridge Programming / Retrofit / Rehabilitation A.MM/MM
Project Stage	31-10 14 17	Initiation	n	n	n
Project Stage	31-10 14 24	Scoping	n	n	n
Project Stage	31-20 10 00	Preliminary Design	n	n	n
Project Stage	31-20 20 00	Final Design	n	n	n
Project Stage	31-30 30 00	Bidding and Letting	n	n	n
Project Stage	31-40 10 00	Constuction Planning/Detailing	n	n	n
Project Stage	31-40 40 14	Fabrication	n	n	n
Project Stage	31-40 40 00	Construction	n	n	n
Project Stage	31-50 20 21	Inspection and Evaluation	n	n	n
Project Stage	31-50 20 31	Maintenance and Management	x	x	x
Discipline	33-21 99 45 21	Transportation Engineering	n	n	n
Discipline	33-11 00 00	Planning, Aesthetics and Landscaping	n	n	n
Discipline	33-21 31 14	Structural Engineering	x	n	n
Discipline	33-21 31 14	Detailing	n	n	n
Discipline	33-25 11 00	Estimation	n	n	n
Discipline	33-41 14 00	Construction Management	n	n	n
Discipline	33-25 41 11	Fabrication	n	n	n
Discipline	33-41 11 11	Construction Engineering	n	n	n
Discipline	33-21 31 14	Inspection	n	n	n
Discipline	33-21 31 14	Load Rating	n	n	n
Discipline	33-21 31 11	Routing and Permitting	n	x	n
Discipline	33-55 24 00	Maintenance and Management	n	n	x

4.3 Activity Descriptions

Activities describe the tasks that the use cases need to accomplish. The template for producing Activity Descriptions has been created on the basis of the pattern employed in the PCI NBIMS IDM, as shown in Table 4-1.

Table 4-1. Template for Activity Description

Activity	Name of the activity
Type	Task
Name	Name of the activity
Omniclass Code	What is the project stage? What discipline is involved in this activity?
Documentation	Description of the activity

The following activities refer to the Process Map shown in section 4.1.

4.3.1 Activities in Initiation Stage

Activity	[A.I/PAL] Bridge Planning
Type	Task
Name	Bridge Planning
Omniclass Code	Project Stage: 31-10 14 17 Initiation Discipline: 33-11 00 00 Planning, Aesthetics and Landscaping
Documentation	After a transportation problem or need from a variety of sources has been determined, engineers start initial planning of a bridge program by selecting candidate projects based on program goals. At the initiation stage, engineers describe candidate projects and how the projects address the program goals.

Activity	[A.I/E] Conceptual Estimate (Owner)
Type	Task
Name	Conceptual Estimate (Owner)
Omniclass Code	Project Stage: 31-10 14 17 Initiation Discipline: 33-25 11 00 Estimation
Documentation	Bridge owner uses bridge concept model to accomplish conceptual cost estimate without benefit of detailed field investigations or project design details. Rules of thumb based on experience can be used (cost per mile, cost per square foot, etc.).

4.3.2 Activities in Scoping Stage

Activity	[A.S/SE] Structure Type, Size and Location Design
Type	Task
Name	Structure Type, Size and Location Design
Omniclass Code	Project Stage: 31-10 14 24 Scoping Discipline: 33-21 31 14 Structural Engineering
Documentation	Structural engineers consider and investigate various project issues, elements and initiatives which will have an effect on scope, cost, and schedule. At the end of the scoping stage, stakeholders will have a clear understanding of the problems and needs. They will establish consensus regarding the proper scope of the project and will make informed decisions.

Activity	[A.S/E] Preliminary Estimate (Owner)
Type	Task
Name	Preliminary Estimate (Owner)
Omniclass Code	Project Stage: 31-10 14 24 Scoping Discipline: 33-25 11 00 Estimation
Documentation	Bridge owner updates the conceptual cost estimate according to field investigations, major design elements identified, and major quantities estimated. The estimate methods include Benefit-cost (B/C) analysis and Life Cycle Cost analysis based on shoulder break area.

4.3.3 Activities in Preliminary Design Stage

Activity	[A.PD/TE] Preliminary Roadway Geometry Development
Type	Task
Name	Preliminary Roadway Geometry Development
Omniclass Code	Project Stage: 31-10 41 00 Preliminary Design Discipline: 33-21 99 45 21 Transportation Engineering
Documentation	Transportation engineers specify the minimum requirements for bridge roadway, facility widths, and vertical under-clearances for the bridge project. This work is done primarily based on providing a level of geometric consistency between the bridge and the approach roadway and recognizing the highway functional classification and traffic that the bridge serves.

Activity	[A.PD/PAL] Preliminary Aesthetic Design
Type	Task
Name	Preliminary Aesthetic Design
Omniclass Code	Project Stage: 31-10 41 00 Preliminary Design Discipline: 33-11 00 00 Planning, Aesthetics and Landscaping
Documentation	Engineers design the appearance of the bridge structure and its surroundings when defining structure's type, size and location. This may deal with bridge geometry, superstructure type and shape, substructure type and shape, appearance of appurtenances, etc.

Activity	[A.PD/SE] Preliminary Structural Design
Type	Task
Name	Preliminary Structural Design
Omniclass Code	Project Stage: 31-10 41 00 Preliminary Design Discipline: 33-21 31 14 Structural Engineering
Documentation	At the preliminary design stage, structural engineers collect detailed structure condition data, develop feasible alternatives based on the conceptual design, study social, economic and environmental impacts, collect detailed structure condition data, and finally select the most appropriate alternative to be advanced to final design.

Activity	[A.PD/E] Updated Preliminary Estimate (Owner)
Type	Task
Name	Updated Preliminary Estimate (Owner)
Omniclass Code	Project Stage: 31-10 41 00 Preliminary Design Discipline: 33-25 11 00 Estimation
Documentation	Bridge owner updates the preliminary cost estimate according to bridge structural model, which reflects preliminary design based on detailed field investigation and condition data collection done by structural engineers.

4.3.4 Activities in Final Design Stage

Activity	[A.FD/TE] Final Roadway Geometry Development
Type	Task
Name	Final Roadway Geometry Development
Omniclass Code	Project Stage: 31-20 20 00 Final Design Discipline: 33-21 99 45 21 Transportation Engineering
Documentation	Transportation engineers use structural model from structural engineers to modify the preliminary highway geometry design. This revision is based on changes resulting from new information or review comments from the final structure design. At the end of this stage, highway portion of the contract plans (model), specifications and cost estimate package will be created.

Activity	[A.FD/PAL] Aesthetic Design Development
Type	Task
Name	Aesthetic Design Development
Omniclass Code	Project Stage: 31-20 20 00 Final Design Discipline: 33-11 00 00 Planning, Aesthetics and Landscaping
Documentation	During the completion of the final design, engineers use structural model to revise (if necessary) the preliminary aesthetic design to reflect any changes resulting from new information or review comments.

Activity	[A.FD/SE] Structural Design Development
Type	Task
Name	Structural Design Development
Omniclass Code	Project Stage: 31-20 20 00 Final Design Discipline: 33-21 31 14 Structural Engineering
Documentation	Structural engineers review and complete the preliminary structural package, and then add necessary detailing to the design alternative based on roadway geometry model and aesthetic design model.

Activity	[A.FD/D] Preliminary Detailing Design
Type	Task
Name	Preliminary Detailing Design
Omniclass Code	Project Stage: 31-20 20 00 Final Design Discipline: 33-21 31 14 Detailing
Documentation	Structural engineers modify and detail the design alternative, and finalize the contract plans (model), specifications and cost estimate package.

Activity	[A.FD/E] Detailed Engineer's Estimate (Owner)
Type	Task
Name	Detailed Engineer's Estimate (Owner)
Omniclass Code	Project Stage: 31-20 20 00 Final Design Discipline: 33-25 11 00 Estimation
Documentation	The detailed engineer's estimate which is done by bridge owner should be created based on the items necessary and quantities calculated for the work to be performed. The detailed cost estimate should be refined throughout detailed design. The estimate at the time of contract plans (model), specifications and estimate (PS&E) should reflect the anticipated cost of the project in sufficient detail to permit an effective review and comparison of the bid received.

Activity	[A.FD/LR] Initial Load Rating
Type	Task
Name	Initial Load Rating
Omniclass Code	Project Stage: 31-20 20 00 Final Design Discipline: 33-21 31 14 Load Rating
Documentation	Structural engineers make initial load rating based on final contract plans and specifications before bridge is actually built. The initial load rating includes inventory and operating factors.

4.3.5 Activities in Bidding and Letting Stage

Activity	[A.BL/SE] Construction Documents Preparation
Type	Task
Name	Construction Documents Preparation
Omniclass Code	Project Stage: 31-30 30 00 Bidding and Letting Discipline: 33-21 31 14 Structural Engineering
Documentation	Bridge owner collects and produces contract documents on which various general contractors will in turn bid. Final contract package includes plans (model), specifications and cost estimate regarding transportation, structural and sometimes landscaping.

Activity	[A.BL/E] Initial Cost Estimate (General contractor and Subcontractor)
Type	Task
Name	Initial Cost Estimate (Contractor and Subcontractor)
Omniclass Code	Project Stage: 31-30 30 00 Bidding and Letting Discipline: 33-25 11 00 Estimation
Documentation	After receiving copies of the contract documents, general contractors and subcontractors compile a complete "bid price" for submission by the closing date and time. Bid documents can be based on the quantities of materials, devices, and labor in the completed construction.

Activity	[A.BL/CM] Bid Development
Type	Task
Name	Bid Development
Omniclass Code	Project Stage: 31-30 30 00 Bidding and Letting Discipline: 33-41 14 00 Construction Management
Documentation	Contractor prepares tender documents for bidding bridge contract.

4.3.6 Activities in Construction Planning / Detailing Stage

Activity	[A.CD/D] Detailing Design Development
Type	Task
Name	Detailing Design Development
Omniclass Code	Project Stage: 31-40 10 00 Construction Planning / Detailing Discipline: 33-21 31 14 Detailing
Documentation	After the project is awarded, general contract who receives the contract starts (or ask subcontractors) to develop bridge detailing calculations and drawings for fabrication, installation and erection.

Activity	[A.CD/SE] Final Review / Integration of Structural System
Type	Task
Name	Final Review / Integration of Structural System
Omniclass Code	Project Stage: 31-40 10 00 Construction Planning / Detailing Discipline: 33-21 31 14 Structural Engineering
Documentation	Bridge owner reviews the preliminary bridge detailing calculations and shop drawings (model) submitted from contractor for conformance with the contract documents.

Activity	[A.CD/CM] Construction Planning and Scheduling
Type	Task
Name	Construction Planning and Scheduling
Omniclass Code	Project Stage: 31-40 10 00 Construction Planning / Detailing Discipline: 33-41 14 00 Construction Management
Documentation	Contractor plans and schedules construction work properly to minimize construction time and cost.

Activity	[A.CD/F] Production Scheduling
Type	Task
Name	Production Scheduling
Omniclass Code	Project Stage: 31-40 10 00 Construction Planning / Detailing Discipline: 33-25 41 11 Fabrication
Documentation	Manufacturer schedules production process to minimize the production time and cost, by telling a production facility when to make, with which staff, and on which equipment.

Activity	[A.CD/CE] Erection Plan and Analysis
Type	Task
Name	Erection Plan and Analysis
Omniclass Code	Project Stage: 31-40 10 00 Construction Planning / Detailing Discipline: 33-41 11 00 Construction Engineering
Documentation	Contractor prepares and submits a detailed erection procedure to bridge owner for each structure in the contract. The procedure shall be conformance with the contract documents.

4.3.7 Activities in Fabrication Stage

Activity	[A.F/D] Modification / Integration of Final Detailing Documents
Type	Task
Name	Modification / Integration of Final Detailing Documents
Omniclass Code	Project Stage: 31-40 40 14 21 Fabrication Discipline: 33-21 31 14 Detailing
Documentation	Immediately after receiving comments on the preliminary shop drawings, fabricator shall address all changes into the shop drawings and submit them to bridge owner for final approval.

Activity	[A.F/F] Product Manufacturing (including CNC)
Type	Task
Name	Product Manufacturing (including CNC)
Omniclass Code	Project Stage: 31-40 40 14 21 Fabrication Discipline: 33-25 41 11 Fabrication
Documentation	Manufacturer creates CNC file and produces bridge steel and/or concrete components in plants according to the shop drawings approved by bridge owner.

4.3.8 Activities in Construction Stage

Activity	[A.C/SE] Structural As-Built Data Development
Type	Task
Name	Structural As-Built Data Development
Omniclass Code	Project Stage: 31-40 40 14 Construction Discipline: 33-21 31 14 Structural Engineering
Documentation	Structural engineers modify contract plans (model) and specifications based on the revisions provided by contractor to reflect changes in construction. As-built plans (model) are a reflection of the existing bridge condition.

Activity	[A.C/E] Project Contract Claim/J.O.C. Cost Estimates
Type	Task
Name	Project Contract Claim/J.O.C Cost Estimates
Omniclass Code	Project Stage: 31-40 40 14 Construction Discipline: 33-25 11 00 Estimation
Documentation	During the bridge construction, disputes and claims might occur between bridge owner and contractor, or contractor and subcontractors, due to reasons such as changed conditions, additional works, etc. If so, Cost estimates based on Job Order Contracting (JOC) need to be made.

Activity	[A.C/CM] Construction Coordinating and Monitoring
Type	Task
Name	Construction Coordinating and Monitoring
Omniclass Code	Project Stage: 31-40 40 14 Construction Discipline: 33-41 14 00 Construction Management
Documentation	Contractor and engineer-in-charge assigned by bridge owner monitor bridge construction to verify Quality Control and Quality Assurance.

Activity	[A.C/CE] Construction Execution
Type	Task
Name	Construction Execution
Omniclass Code	Project Stage: 31-40 40 14 Construction Discipline: 33-41 11 00 Construction Engineering
Documentation	General contractor and subcontractors execute bridge construction by following construction plans. Engineer-in-charge assigned by bridge owner is on site for quality assurance.

Activity	[A.C/LR] Post-Construction Load Rating
Type	Task
Name	Post-Construction Load Rating
Omniclass Code	Project Stage: 31-40 40 14 Construction Discipline: 33-21 31 14 Load Rating
Documentation	Structural engineers update the initial load rating based on the as-built bridge model after bridge construction is completed.

4.3.9 Activities in Inspection and Evaluation Stage

Activity	[A.IE/SE] Inspection Review
Type	Task
Name	Inspection Review
Omniclass Code	Project Stage: 31-50 20 21 Inspection and Evaluation Discipline: 33-21 31 14 Structural Engineering
Documentation	Structural engineers and bridge inspectors review the as-built data and/or the previous bridge inspection report. The inspectors identify areas where defects were found in previous inspections. This allows them to determine if the defects previously identified have been repaired or have increased in size and severity.

Activity	[A.IE/I] Inspection
Type	Task
Name	Inspection
Omniclass Code	Project Stage: 31-50 20 21 Inspection and Evaluation Discipline: 33-21 31 14 Inspection
Documentation	Bridge inspectors use a systematic method to observe the bridge, to ensure that the entire bridge is inspected. The exact order of the inspection will vary depending on the type of bridge being inspected. The bridge inspectors document their findings in the bridge inspection report.

Activity	[A.IE/LR] Updated Load Rating
Type	Task
Name	Updated Load Rating
Omniclass Code	Project Stage: 31-50 20 21 Inspection and Evaluation Discipline: 33-21 31 14 Load Rating
Documentation	Structural engineers need to make an updated load rating calculation whenever the capacity of the bridge changes due to the condition of the structure, impact on the bridge due to approach roadway or deck deterioration, or if the dead load of the bridge has been increased.

4.3.10 Activities in Maintenance and Management Stage

Activity	[A.MM/SE] Maintenance
Type	Task
Name	Maintenance
Omniclass Code	Project Stage: 31-50 20 31 Maintenance and Management Discipline: 33-21 31 14 Structural Engineering
Documentation	Cyclical maintenance activities need to be performed by bridge owner to reduce the rate of deterioration of critical bridge elements. These activities are essential for a bridge to reach its maximum useful life and maintain its designed level of service. The activities include bridge cleaning, sealing cracks in the wearing surface, etc.

Activity	[A.MM/RP] Routing and Permitting
Type	Task
Name	Routing and Permitting
Omniclass Code	Project Stage: 31-50 20 31 Maintenance and Management Discipline: 33-21 31 11 Routing and Permitting
Documentation	Based on load rating data in bridge inventory, transportation agencies permit and route oversize and overweight vehicles

Activity	[A.MM/MM] Bridge Programming / Retrofit / Rehabilitation
Type	Task
Name	Bridge Programming / Retrofit / Rehabilitation
Omniclass Code	Project Stage: 31-50 20 31 Maintenance and Management Discipline: 33-55 24 00 Maintenance and Management
Documentation	When the bridge is structurally deficient or functionally obsolete, bridge engineers plan a retrofit / rehabilitation / replacement project based on bridge inspection report and load rating factors.

4.4 Exchange Model Definitions

Exchange Model Definitions show the location of Exchange Models in the stages of the Process Map and the relations between Exchange Models and Disciplines. The key to the following table is “x” represents an Exchange Model selected and “n” represents an Exchange Model not selected.

Project Stage / Discipline	Omniclass	Name	Bridge Concept Model EM.I/PAL-E	Bridge Engineering Concept Model EM.S/SE-E	Preliminary Roadway Geometry Roadway EM.PD/TE-SE	Preliminary Aesthetic Design Model EM.PD/PAL-SE
Project Stage	31-10 14 17	Initiation	x	n	n	n
Project Stage	31-10 14 24	Scoping	n	x	n	n
Project Stage	31-20 10 00	Preliminary Design	n	n	x	x
Project Stage	31-20 20 00	Final Design	n	n	n	n
Project Stage	31-30 30 00	Bidding and Letting	n	n	n	n
Project Stage	31-40 10 00	Construction Planning/Detailing	n	n	n	n
Project Stage	31-40 40 14 21	Fabrication	n	n	n	n
Project Stage	31-40 40 14	Construction	n	n	n	n
Project Stage	31-50 20 21	Inspection and Evaluation	n	n	n	n
Project Stage	31-50 20 31	Maintenance and Management	n	n	n	n
Discipline	33-21 99 45 21	Transportation Engineering	n	n	x	n
Discipline	33-11 00 00	Planning, Aesthetics and Landscaping	x	n	n	x
Discipline	33-21 31 14	Structural Engineering	n	x	x	x
Discipline	33-21 31 14	Detailing	n	n	n	n
Discipline	33-25 11 00	Estimation	x	x	n	n
Discipline	33-41 14 00	Construction Management	n	n	n	n
Discipline	33-25 41 11	Fabrication	n	n	n	n
Discipline	33-41 11 11	Construction Engineering	n	n	n	n
Discipline	33-21 31 14	Inspection	n	n	n	n
Discipline	33-21 31 14	Load Rating	n	n	n	n
Discipline	33-21 31 11	Routing and Permitting	n	n	n	n
Discipline	33-55 24 00	Maintenance and Management	n	n	n	n

Project Stage / Discipline	Omniclass	Name	Initial Structural Model EM.PD/SE-E-PAL	Final Roadway Geometry Model EM.FD/TE-SE	Final Aesthetic Design Model EM.FD/PAL-SE	Advance Structural Model EM.FD/SE-D-TE-PAL
Project Stage	31-10 14 17	Initiation	n	n	n	n
Project Stage	31-10 14 24	Scoping	n	n	n	n
Project Stage	31-20 10 00	Preliminary Design	x	n	n	n
Project Stage	31-20 20 00	Final Design	n	x	x	x
Project Stage	31-30 30 00	Bidding and Letting	n	n	n	n
Project Stage	31-40 10 00	Construction Planning/Detailing	n	n	n	n
Project Stage	31-40 40 14 21	Fabrication	n	n	n	n
Project Stage	31-40 40 14	Construction	n	n	n	n
Project Stage	31-50 20 21	Inspection and Evaluation	n	n	n	n
Project Stage	31-50 20 31	Maintenance and Management	n	n	n	n
Discipline	33-21 99 45 21	Transportation Engineering	n	x	n	n
Discipline	33-11 00 00	Planning, Aesthetics and Landscaping	x	n	x	x
Discipline	33-21 31 14	Structural Engineering	x	x	x	x
Discipline	33-21 31 14	Detailing	n	n	n	x
Discipline	33-25 11 00	Estimation	x	n	n	x
Discipline	33-41 14 00	Construction Management	n	n	n	n
Discipline	33-25 41 11	Fabrication	n	n	n	n
Discipline	33-41 11 11	Construction Engineering	n	n	n	n
Discipline	33-21 31 14	Inspection	n	n	n	n
Discipline	33-21 31 14	Load Rating	n	n	n	n
Discipline	33-21 31 11	Routing and Permitting	n	n	n	n
Discipline	33-55 24 00	Maintenance and Management	n	n	n	n

Project Stage / Discipline	Omniclass	Name	Final Structural Model EM.FD/D-E	Final Structural Model EM.BL/SE-D-E-CM- CE	Advance Detailing Model EM.CD/D-SE	Erection Analysis Model EM.CD/CE-F-CM
Project Stage	31-10 14 17	Initiation	n	n	n	n
Project Stage	31-10 14 24	Scoping	n	n	n	n
Project Stage	31-20 10 00	Preliminary Design	n	n	n	n
Project Stage	31-20 20 00	Final Design	x	n	n	n
Project Stage	31-30 30 00	Bidding and Letting	n	x	n	n
Project Stage	31-40 10 00	Construction Planning/Detailing	n	n	x	x
Project Stage	31-40 40 14 21	Fabrication	n	n	n	n
Project Stage	31-40 40 14	Construction	n	n	n	n
Project Stage	31-50 20 21	Inspection and Evaluation	n	n	n	n
Project Stage	31-50 20 31	Maintenance and Management	n	n	n	n
Discipline	33-21 99 45 21	Transportation Engineering	n	n	n	n
Discipline	33-11 00 00	Planning, Aesthetics and Landscaping	n	n	n	n
Discipline	33-21 31 14	Structural Engineering	n	x	x	n
Discipline	33-21 31 14	Detailing	x	x	x	n
Discipline	33-25 11 00	Estimation	x	x	n	n
Discipline	33-41 14 00	Construction Management	n	x	n	x
Discipline	33-25 41 11	Fabrication	n	n	n	x
Discipline	33-41 11 11	Construction Engineering	n	n	n	x
Discipline	33-21 31 14	Inspection	n	n	n	n
Discipline	33-21 31 14	Load Rating	n	n	n	n
Discipline	33-21 31 11	Routing and Permitting	n	n	n	n
Discipline	33-55 24 00	Maintenance and Management	n	n	n	n

Project Stage / Discipline	Omniclass	Name	Final Detailing Model EM.F/D-F	As-Built Model EM.C/CE-SE-E- LR	Prior Inspection Model EM.IE/I- SE	Structural Deterioration Model EM.IE/I-LR- SE	Retrofit Model EM.MM/SE- MM	GIS Model EM.MM/SE- RP
Project Stage	31-10 14 17	Initiation	n	n	n	n	n	n
Project Stage	31-10 14 24	Scoping	n	n	n	n	n	n
Project Stage	31-20 10 00	Preliminary Design	n	n	n	n	n	n
Project Stage	31-20 20 00	Final Design	n	n	n	n	n	n
Project Stage	31-30 30 00	Bidding and Letting	n	n	n	n	n	n
Project Stage	31-40 10 00	Construction Planning/Detailing	n	n	n	n	n	n
Project Stage	31-40 40 14 21	Fabrication	x	n	n	n	n	n
Project Stage	31-40 40 14	Construction	n	x	n	n	n	n
Project Stage	31-50 20 21	Inspection and Evaluation	n	n	x	x	n	n
Project Stage	31-50 20 31	Maintenance and Management	n	n	n	n	x	x
Discipline	33-21 99 45 21	Transportation Engineering	n	n	n	n	n	n
Discipline	33-11 00 00	Planning, Aesthetics and Landscaping	n	n	n	n	n	n
Discipline	33-21 31 14	Structural Engineering	n	x	x	x	x	x
Discipline	33-21 31 14	Detailing	x	n	n	n	n	n
Discipline	33-25 11 00	Estimation	n	x	n	n	n	n
Discipline	33-41 14 00	Construction Management	n	n	n	n	n	n
Discipline	33-25 41 11	Fabrication	x	n	n	n	n	n
Discipline	33-41 11 11	Construction Engineering	n	x	n	n	n	n
Discipline	33-21 31 14	Inspection	n	n	x	x	n	n
Discipline	33-21 31 14	Load Rating	n	x	n	x	n	n
Discipline	33-21 31 11	Routing and Permitting	n	n	n	n	n	x
Discipline	33-55 24 00	Maintenance and Management	n	n	n	n	x	n

4.5 Exchange Model Descriptions

The next step after defining the use cases and Activities is to define Exchange Models, the content of information to be exchanged in use cases. Exchange Models are defined at four levels:

- 1) Exchange Model Descriptions: a short plain-English description of the purpose, the content and other relative information of each Exchange Model.
- 2) Exchange Model Definitions: a table used to locate the Exchange Models with associated Activities and project stages.
- 3) Exchange Model Specification Tables: a specification that defines the exchange requirements for each attribute set. Different Exchange Model might have different exchange requirements. Detailed description is shown in section 5.
- 4) Data Dictionary: a table of metadata used to define each attribute item involved in all the exchanges. Detailed description is shown in section 6.

The template for producing Exchange Model Descriptions has been created on the basis of the pattern used in the PCI NBIMS IDM, as shown in Table 4-2.

Each Exchange Model (e.g. EM.FD/D-E-LR) is named by its project stage, e.g. Final Design (FD), and the stakeholders involved, e.g. Detailing (D), Estimation (E) and Load Rating (LR).

Table 4-2. Template for Exchange Model Description

Exchange Model	Name of Exchange Model
Project Stage	What is the OmniClass design stage? What is the project phase?
Exchange Disciplines	Participates in this exchange OmniClass discipline number and name (can be > 2 disciplines, but using the same basic data)
Description	Verbal description of: 1. Purpose of the exchange 2. Major elements 3. Level of detail 4. Special attributes
Example Software: Export and Import	Import from: Export to:
Related Exchange Models	Other exchanges this one interacts with (proceeding and succeeding exchanges)

Exchange Model	[EM.I/PAL-E] Bridge Concept Model
Project Stage	31-10 14 17 Initiation
Exchange Disciplines	(33-11 00 00) Planning, Aesthetics and Landscaping (33-25 11 00) Estimation
Description	<p>Purpose: this model is created by engineer to help define candidate projects based on program goals.</p> <p>Major elements: the content of this model includes but is not limited to 1) a description of the problem, 2) a preliminary project objective(s) and description, 3) project elements to be investigated, 4) preliminary environmental classification, 5) issues or circumstances which may arise, and 6) preliminary schedule.</p> <p>Level of detail: conceptual</p> <p>Special attributes: project objectives, environmental recommended classification, etc.</p>
Example Software: Export and Import	<p>Import from: Mathcad, Microsoft Excel</p> <p>Export to: Mathcad, Microsoft Excel</p>
Related Exchange Models	EM.S/SE-E, Bridge Engineering Concept Model EM.PD/SE-E-PAL, Initial Structural Model EM.FD/SE-D-TE-PAL, Final Structural Model

Exchange Model	[EM.S/SE-E] Bridge Engineering Concept Model
Project Stage	31-10 14 24 Scoping
Exchange Disciplines	(33-21 31 14) Structural Engineering (33-25 11 00) Estimation
Description	<p>Purpose: this model helps stakeholders better understand problems and define project scope, cost and schedule.</p> <p>Major elements: the content of this model includes but is not limited to 1) project area's information, 2) project objective(s), 3) design criteria, 4) feasible alternative(s), 5) key environmental issue.</p> <p>Level of detail: sufficient for developing Preliminary Cost Estimate</p> <p>Special attributes: type, size and location</p>
Example Software: Export and Import	<p>Import from: Mathcad, LEAP Bridge, AASHTOWare BrD</p> <p>Export to: Microsoft Excel</p>
Related Exchange Models	EM.I/PAL-E, Bridge Concept Model EM.PD/SE-E-PAL, Initial Structural Model EM.FD/SE-D-TE-PAL, Final Structural Model

Exchange Model	[EM.PD/TE-SE] Preliminary Roadway Geometry Model
Project Stage	31-20 10 00 Preliminary Design
Exchange Disciplines	(33-21 99 45 21) Transportation Engineering (33-21 31 14) Structural Engineering
Description	Purpose: the model has been developed to provide minimum safe geometrics for the bridge project. Major elements: the content of this model includes but is not limited to 1) bridge roadway, 2) facility widths, and 3) vertical under-clearances, 4) vertical profile of all roads, 5) horizontal alignment data. Level of detail: preliminary Special attributes: vertical clearance, etc.
Example Software: Export and Import	Import from: InRoads, MicroStation Export to: LEAP Geomath
Related Exchange Models	EM.FD/TE-SE, Final Roadway Geometry Model

Exchange Model	[EM.PD/PAL-SE] Preliminary Aesthetic Design Model
Project Stage	31-20 10 00 Preliminary Design
Exchange Disciplines	(33-11 00 00) Planning, Aesthetics and Landscaping (33-21 31 14) Structural Engineering
Description	Purpose: The model contains aesthetic design data. Major elements: The content of this model includes but is not limited to 1) location and surroundings, 2) horizontal and vertical geometry, 3) superstructure type and shape, 4) pier shape and placement, 5) abutment shape and placement, 6) appurtenance details, 7) colors, 8) textures, and 9) ornamentation. Level of detail: preliminary Special attributes: slenderness ratios, etc.
Example Software: Export and Import	Import from: MicroStation Export to: LEAP Bridge, AASHTOWare BrD
Related Exchange Models	EM.FD/PAL-SE, Final Aesthetic Design Model

Exchange Model	[EM.PD/SE-E-PAL] Initial Structural Model
Project Stage	31-20 10 00 Preliminary Design
Exchange Disciplines	(33-21 31 14) Structural Engineering (33-25 11 00) Estimation (33-11 00 00) Planning, Aesthetics and Landscaping
Description	Purpose: this model is created to help structural engineer select the most appropriate alternative to be advanced. Major elements: the content of this model includes but is not limited to 1) substructure location, 2) span length, 3) full transverse section, 4) boring locations, etc. Level of detail: preliminary Special attributes: initial component sections
Example Software: Export and Import	Import from: LEAP Bridge, CSiBridge, AASHTOWare BrD Export to: Estimating Link, Microsoft Excel
Related Exchange Models	EM.I/PAL-E, Bridge Concept Model EM.S/SE-E, Bridge Engineering Concept Model EM.FD/SE-D-TE-PAL, Final Structural Model

Exchange Model	[EM.FD/TE-SE] Final Roadway Geometry Model
Project Stage	31-20 20 00 Final Design
Exchange Disciplines	(33-21 99 45 21) Transportation Engineering (33-21 31 14) Structural Engineering
Description	Purpose: the model contains updated roadway geometry data. Major elements: the content of this model includes but is not limited to 1) bridge roadway, 2) facility widths, and 3) vertical under-clearances. Level of detail: sufficient for final Plans, Specifications, and Estimate Special attributes: stations, grades, azimuth, etc.
Example Software: Export and Import	Import from: MicroStation, InRoads, LEAP Geomath Export to: LEAP Bridge, AASHTOWare BrD, CSiBridge
Related Exchange Models	EM.PD/TE-SE, Preliminary Roadway Geometry Model

Exchange Model	[EM.FD/PAL-SE] Final Aesthetic Design Model
Project Stage	31-20 20 00 Final Design
Exchange Disciplines	(33-11 00 00) Planning, Aesthetics and Landscaping (33-21 31 14) Structural Engineering
Description	<p>Purpose: the model contains updated aesthetic design data.</p> <p>Major elements: the content of this model includes but is not limited to 1) location and surroundings, 2) horizontal and vertical geometry, 3) superstructure type and shape, 4) pier shape and placement, 5) abutment shape and placement, 6) appurtenance details, 7) colors, 8) textures, and 9) ornamentation.</p> <p>Level of detail: sufficient for final Plans, Specifications, and Estimate</p> <p>Special attributes: overhang details, etc.</p>
Example Software: Export and Import	<p>Import from: MicroStation</p> <p>Export to: LEAP Bridge, AASHTOWare BrD, CSiBridge</p>
Related Exchange Models	EM.PD/PAL-SE, Preliminary Aesthetic Design Model

Exchange Model	[EM.FD/SE-D-TE-PAL] Advance Structural Model
Project Stage	31-20 20 00 Final Design
Exchange Disciplines	(33-21 31 14) Structural Engineering (33-21 31 14) Detailing (33-21 99 45 21) Transportation Engineering (33-11 00 00) Planning, Aesthetics and Landscaping
Description	<p>Purpose: this model is used for an independent technical progress review, and then used to finalize completed contract plans and specifications.</p> <p>Major elements: this model contains 80% of the final structural plan and specification data, including typical bridge section, bridge plan, girder section, etc.</p> <p>Level of detail: 80% of final PS&E</p> <p>Special attributes: bridge components, reinforcement</p>
Example Software: Export and Import	<p>Import from: LEAP Bridge, AASHTOWare BrD, CSiBridge</p> <p>Export to: Tekla, ProStructures</p>
Related Exchange Models	EM.I/PAL-E, Bridge Concept Model EM.S/SE-E, Bridge Engineering Concept Model EM.PD/SE-E-PAL, Initial Structural Model

Exchange Model	[EM.FD/D-E] Final Structural Model
Project Stage	31-20 20 00 Final Design
Exchange Disciplines	(33-21 31 14) Detailing (33-25 11 00) Estimation
Description	<p>Purpose: this model is used to develop detailed cost estimate and assembled to a contract package to enable bridge owner to advertise, let, and award.</p> <p>Major elements: final structural model contains the data of the final structural plans and specifications including completed general notes, bearing tables, camber tables, etc.</p> <p>Level of detail: sufficient for final cost estimate and contract package</p> <p>Special attributes: reinforcing bar list, etc</p>
Example Software: Export and Import	<p>Import from: Tekla, ProStructures</p> <p>Export to: Microsoft Excel, Estimating Link</p>
Related Exchange Models	EM.BL/SE-D-E-CM, Contract Model EM.CD/D-SE, Advance Detailing Model EM.F/D-F, Final Detailing Model

Exchange Model	[EM.BL/SE-D-E-CM-CE] Contract Model
Project Stage	31-30 30 00 Bidding and Letting
Exchange Disciplines	(33-21 31 14) Structural Engineering (33-21 31 14) Detailing (33-25 11 00) Estimation (33-41 14 00) Construction Management (33-41 00 00) Construction Engineering
Description	<p>Purpose: for contractors to develop contractor's cost estimate, construction planning and detailing.</p> <p>Major elements: contract package containing final contract plans, specifications and cost estimate.</p> <p>Level of detail: sufficient for contractors to understand the project</p> <p>Special attributes:</p>
Example Software: Export and Import	<p>Import from: MicroStation, LEAP Bridge, AASHTOWare</p> <p>Export to: Microsoft Project, Estimating Link, Tekla, ProStructures, UT Bridge</p>
Related Exchange Models	EM.FD/D-E, Final Structural Model EM.CD/D-SE, Advance Detailing Model EM.F/D-F, Final Detailing Model

Exchange Model	[EM.CD/D-SE] Advance Detailing Model
Project Stage	31-40 10 00 Post Award / Pre-Construction Construction Planning / Detailing
Exchange Disciplines	(33-21 31 14) Detailing (33-21 31 14) Structural Engineering
Description	Purpose: bridge detailing for bridge owner and designer to review Major elements: typical sections of components, shear key details, reinforcement layout, rebar list, welding detail, bolt locations, etc. Level of detail: fabrication detailing – some components Special attributes:
Example Software: Export and Import	Import from: Tekla, ProStructures Export to: MicroStation
Related Exchange Models	EM.FD/D-E, Final Structural Model EM.BL/SE-D-E-CM, Contract Model EM.F/D-F, Final Detailing Model

Exchange Model	[EM.CD/CE-F-CM] Erection Analysis Model
Project Stage	31-40 10 00 Post Award / Pre-Construction Construction Planning / Detailing
Exchange Disciplines	(33-41 00 00) Construction Engineering (33-25 41 11) Fabrication (33-41 14 00) Construction Management
Description	Purpose: this model is used for development of construction schedule Major elements: information used for erection including erection calculation, procedure, method, crane types, etc. Level of detail: as required by contractor and erector Special attributes: erection plan, rigging details, etc.
Example Software: Export and Import	Import from: UT Bridge Export to: Microsoft Project, LARSA 4D
Related Exchange Models	N/A

Exchange Model	[EM.F/D-F] Final Detailing Model
Project Stage	31-40 40 14 21 Fabrication
Exchange Disciplines	(33-21 31 14) Detailing (33-25 41 11) Fabrication
Description	Purpose: provide steel components and/or reinforcing concrete components detail layout, with all members defined and rebar placed, for fabrication. Major elements: typical sections of components, shear key details, reinforcement layout, rebar list, welding detail, bolt locations, etc. Level of detail: fabrication detailing – all components Special attributes: welding, splice, prestressing strand pattern, etc.
Example Software: Export and Import	Import from: Tekla, ProStructures Export to: CNC file
Related Exchange Models	EM.FD/D-E, Final Structural Model EM.BL/SE-D-E-CM, Contract Model EM.CD/D-SE, Advance Detailing Model

Exchange Model	[EM.C/CE-SE-E-LR] As-Built Model
Project Stage	31-40 40 14 Construction
Exchange Disciplines	(33-41 00 00) Construction Engineering (33-21 31 14) Structural Engineering (33-25 11 00) Estimation (33-21 31 14) Load Rating
Description	Purpose: this model is used by structural engineers to calculate load rating factors and by inspector for bridge inspection. Major elements: final PS&E with modifications due to change in bridge construction. Level of detail: sufficient for creating as-built drawings Special attributes:
Example Software: Export and Import	Import from: Microsoft Project Export to: MicroStation, Estimating Link, AASHTOWare BrR
Related Exchange Models	EM.BL/SE-D-E-CM, Contract Model

Exchange Model	[EM.IE/I-SE] Prior Inspection Model
Project Stage	31-50 20 21 Inspection and Evaluation
Exchange Disciplines	(33-21 31 14) Inspection (33-21 31 14) Structural Engineering
Description	Purpose: Major elements: Level of detail: Special attributes:
Example Software: Export and Import	Import from: Export to:
Related Exchange Models	EM.C/CE-SE-E-LR, As-Built Model

Exchange Model	[EM.IE/I-LR-SE] Structural Deterioration Model
Project Stage	31-50 20 21 Inspection and Evaluation
Exchange Disciplines	(33-21 31 14) Inspection (33-21 31 14) Load Rating (33-21 31 14) Structural Engineering
Description	Purpose: the model is used for structural engineers to make load rating calculation, and for bridge owner to permit and route vehicles. Major elements: bridge deterioration data including section loss, strand loss, crack, etc. Level of detail: sufficient for load rating Special attributes:
Example Software: Export and Import	Import from: InspectTech Export to: AASHTOWare BrR, LEAP Bridge, CSiBridge, LARS
Related Exchange Models	EM.IE/I-SE, Prior Inspection Model EM.MM/SE-MM, Retrofit Model

Exchange Model	[EM.MM/SE-MM] Retrofit Model
Project Stage	31-50 20 31 Maintenance and Management
Exchange Disciplines	(33-21 31 14) Structural Engineering (33-55 24 00) Maintenance and Management
Description	Purpose: this model is used for development of bridge retrofit / rehabilitation program. Major elements: Level of detail: sufficient for bridge retrofit Special attributes:
Example Software: Export and Import	Import from: AASHTOWare BrD, LEAP Bridge, CSiBridge, LARSA 4D Export to: AASHTOWare BrM
Related Exchange Models	EM.IE/I-SE, Prior Inspection Model EM.IE/I-LR-SE, Structural Deterioration Model

Exchange Model	[EM.MM/SE-RP] GIS Model
Project Stage	31-50 20 31 Maintenance and Management
Exchange Disciplines	(33-21 31 14) Structural Engineering (33-21 31 11) Routing and Permitting
Description	Purpose: Major elements: Level of detail: Special attributes:
Example Software: Export and Import	Import from: AASHTOWare BrR Export to: LARS, Superload
Related Exchange Models	N/A

4.6 Non-Model Exchange Definitions

A building block of the Process Map, Non-Model Exchange (NME) describes verbal communications between stakeholders involved in bridge project life-cycle, such as informal comments or mark on the contract plans (model), which are not necessary to be stored in the Exchange Models (EM).

The Non-Model Exchanges are defined by using Non-Model Exchange Definition and Non-Model Exchange Description. Non-Model Exchange Definitions show the location of Non-Model Exchanges in the stages of the Process Map and the relations between Non-Model Exchanges and Disciplines. The key to the following table is “x” represents an Non-Exchange Model selected and “n” represents an Non-Exchange Model not selected.

Project Stage / Discipline	Omniclass	Name	Pre-Preliminary Cost Estimate Report NME.I/E-PAL	Preliminary Cost Estimate Report NME.S/E-SE	Review Comments NME.PD/SE-TE	Updated Cost Estimate Report NME.PD/E-SE-TE
Project Stage	31-10 14 17	Initiation	x	n	n	n
Project Stage	31-10 14 24	Scoping	n	x	n	n
Project Stage	31-20 10 00	Preliminary Design	n	n	x	x
Project Stage	31-20 20 00	Final Design	n	n	n	n
Project Stage	31-30 30 00	Bidding and Letting	n	n	n	n
Project Stage	31-40 10 00	Construction Planning/Detailing	n	n	n	n
Project Stage	31-40 40 14 21	Fabrication	n	n	n	n
Project Stage	31-40 40 14	Construction	n	n	n	n
Project Stage	31-50 20 21	Inspection and Evaluation	n	n	n	n
Project Stage	31-50 20 31	Maintenance and Management	n	n	n	n
Discipline	33-21 99 45 21	Transportation Engineering	n	n	x	x
Discipline	33-11 00 00	Planning, Aesthetics and Landscaping	x	n	n	n
Discipline	33-21 31 14	Structural Engineering	n	x	x	x
Discipline	33-21 31 14	Detailing	n	n	n	n
Discipline	33-25 11 00	Estimation	x	x	n	x
Discipline	33-41 14 00	Construction Management	n	n	n	n
Discipline	33-25 41 11	Fabrication	n	n	n	n
Discipline	33-41 11 11	Construction Engineering	n	n	n	n
Discipline	33-21 31 14	Inspection	n	n	n	n
Discipline	33-21 31 14	Load Rating	n	n	n	n
Discipline	33-21 31 11	Routing and Permitting	n	n	n	n
Discipline	33-55 24 00	Maintenance and Management	n	n	n	n

Project Stage / Discipline	Omniclass	Name	Review Comments NME.FD/SE-PAL-TE	Final Cost Estimate Report NME.FD/E-D-SE	Load Rating Result NME.FD/LR-D	Bid Information NME.BL/CM-SE
Project Stage	31-10 14 17	Initiation	n	n	n	n
Project Stage	31-10 14 24	Scoping	n	n	n	n
Project Stage	31-20 10 00	Preliminary Design	n	n	n	n
Project Stage	31-20 20 00	Final Design	x	x	x	n
Project Stage	31-30 30 00	Bidding and Letting	n	n	n	x
Project Stage	31-40 10 00	Constuction Planning/Detailing	n	n	n	n
Project Stage	31-40 40 14 21	Fabrication	n	n	n	n
Project Stage	31-40 40 14	Construction	n	n	n	n
Project Stage	31-50 20 21	Inspection and Evaluation	n	n	n	n
Project Stage	31-50 20 31	Maintenance and Management	n	n	n	n
Discipline	33-21 99 45 21	Transportation Engineering	x	n	n	n
Discipline	33-11 00 00	Planning, Aesthetics and Landscaping	x	n	n	n
Discipline	33-21 31 14	Structural Engineering	x	x	n	x
Discipline	33-21 31 14	Detailing	n	x	x	n
Discipline	33-25 11 00	Estimation	n	x	n	n
Discipline	33-41 14 00	Construction Management	n	n	n	x
Discipline	33-25 41 11	Fabrication	n	n	n	n
Discipline	33-41 11 11	Construction Engineering	n	n	n	n
Discipline	33-21 31 14	Inspection	n	n	n	n
Discipline	33-21 31 14	Load Rating	n	n	x	n
Discipline	33-21 31 11	Routing and Permitting	n	n	n	n
Discipline	33-55 24 00	Maintenance and Management	n	n	n	n

Project Stage / Discipline	Omniclass	Name	Contract Award NME.BL/SE- CM	Initial MIS Estimation Report NME.BL/E-CM	Review Comments NME.CD/SE-D	Schedule Information NME.CD/CM-F	Review Comments NME.CD/F-CM
Project Stage	31-10 14 17	Initiation	n	n	n	n	n
Project Stage	31-10 14 24	Scoping	n	n	n	n	n
Project Stage	31-20 10 00	Preliminary Design	n	n	n	n	n
Project Stage	31-20 20 00	Final Design	n	n	n	n	n
Project Stage	31-30 30 00	Bidding and Letting	x	x	n	n	n
Project Stage	31-40 10 00	Constuction Planning/Detailing	n	n	x	x	x
Project Stage	31-40 40 14 21	Fabrication	n	n	n	n	n
Project Stage	31-40 40 14	Construction	n	n	n	n	n
Project Stage	31-50 20 21	Inspection and Evaluation	n	n	n	n	n
Project Stage	31-50 20 31	Maintenance and Management	n	n	n	n	n
Discipline	33-21 99 45 21	Transportation Engineering	n	n	n	n	n
Discipline	33-11 00 00	Planning, Aesthetics and Landscaping	n	n	n	n	n
Discipline	33-21 31 14	Structural Engineering	x	n	x	n	n
Discipline	33-21 31 14	Detailing	n	n	x	n	n
Discipline	33-25 11 00	Estimation	n	x	n	n	n
Discipline	33-41 14 00	Construction Management	x	x	n	x	x
Discipline	33-25 41 11	Fabrication	n	n	n	x	x
Discipline	33-41 11 11	Construction Engineering	n	n	n	n	n
Discipline	33-21 31 14	Inspection	n	n	n	n	n
Discipline	33-21 31 14	Load Rating	n	n	n	n	n
Discipline	33-21 31 11	Routing and Permitting	n	n	n	n	n
Discipline	33-55 24 00	Maintenance and Management	n	n	n	n	n

Project Stage / Discipline	Omniclass	Name	Erection Procedures NME.CD/CE-CM	Review Comments NME.F/F-D	Fabrication and Shipping Information NME.F/F-CE	Execution Plan NME.C/CM-CE
Project Stage	31-10 14 17	Initiation	n	n	n	n
Project Stage	31-10 14 24	Scoping	n	n	n	n
Project Stage	31-20 10 00	Preliminary Design	n	n	n	n
Project Stage	31-20 20 00	Final Design	n	n	n	n
Project Stage	31-30 30 00	Bidding and Letting	n	n	n	n
Project Stage	31-40 10 00	Constuction Planning/Detailing	x	n	n	n
Project Stage	31-40 40 14 21	Fabrication	n	x	x	n
Project Stage	31-40 40 14	Construction	n	n	n	x
Project Stage	31-50 20 21	Inspection and Evaluation	n	n	n	n
Project Stage	31-50 20 31	Maintenance and Management	n	n	n	n
Discipline	33-21 99 45 21	Transportation Engineering	n	n	n	n
Discipline	33-11 00 00	Planning, Aesthetics and Landscaping	n	n	n	n
Discipline	33-21 31 14	Structural Engineering	n	n	n	n
Discipline	33-21 31 14	Detailing	n	n	n	n
Discipline	33-25 11 00	Estimation	n	n	n	n
Discipline	33-41 14 00	Construction Management	x	n	x	x
Discipline	33-25 41 11	Fabrication	n	x	n	n
Discipline	33-41 11 11	Construction Engineering	x	x	x	x
Discipline	33-21 31 14	Inspection	n	n	n	n
Discipline	33-21 31 14	Load Rating	n	n	n	n
Discipline	33-21 31 11	Routing and Permitting	n	n	n	n
Discipline	33-55 24 00	Maintenance and Management	n	n	n	n

Project Stage / Discipline	Omniclass	Name	Execution Status Report NME.C/CE-CM	Initiation Load Rating Result NME.C/LR-SE	Inspection Report NME.IE/I-SE	Rating Report NME.IE/LR-I-SE
Project Stage	31-10 14 17	Initiation	n	n	n	n
Project Stage	31-10 14 24	Scoping	n	n	n	n
Project Stage	31-20 10 00	Preliminary Design	n	n	n	n
Project Stage	31-20 20 00	Final Design	n	n	n	n
Project Stage	31-30 30 00	Bidding and Letting	n	n	n	n
Project Stage	31-40 10 00	Constuction Planning/Detailing	n	n	n	n
Project Stage	31-40 40 14 21	Fabrication	n	n	n	n
Project Stage	31-40 40 14	Construction	x	x	n	n
Project Stage	31-50 20 21	Inspection and Evaluation	n	n	x	x
Project Stage	31-50 20 31	Maintenance and Management	n	n	n	n
Discipline	33-21 99 45 21	Transportation Engineering	n	n	n	n
Discipline	33-11 00 00	Planning, Aesthetics and Landscaping	n	n	n	n
Discipline	33-21 31 14	Structural Engineering	n	x	x	x
Discipline	33-21 31 14	Detailing	n	n	n	n
Discipline	33-25 11 00	Estimation	n	n	n	n
Discipline	33-41 14 00	Construction Management	x	n	n	n
Discipline	33-25 41 11	Fabrication	n	n	n	n
Discipline	33-41 11 11	Construction Engineering	x	n	n	n
Discipline	33-21 31 14	Inspection	n	n	x	x
Discipline	33-21 31 14	Load Rating	n	x	n	x
Discipline	33-21 31 11	Routing and Permitting	n	n	n	n
Discipline	33-55 24 00	Maintenance and Management	n	n	n	n

4.7 Non-Model Exchange Descriptions

The naming convention of the Non-Model Exchanges is the same as that of the Exchange Models. Each Non-Model Exchange (e.g. NME.I/E-PAL) is named by project stage, e.g. Initial (I), and the stakeholder involved, e.g. Estimation (E), and Planning, Aesthetics and Landscaping (PAL). Table 4-3 shows the template of the Non-Model Exchange Description.

Table 4-3. Template for Non-Model Exchange Description

Non-Model Exchange	Name of Non-Model Exchange
Project Stage	What is the OmniClass design stage? What is the project phase?
Exchange Disciplines	Participates in this non-model exchange OmniClass discipline number and name (can be > 2 disciplines, but using the same basic data)
Information Transmitted	Purpose and/or major content of this non-model exchange
Typical Formats	Carrier type, e.g. Excel Spreadsheet.

Non-Model Exchange Descriptions are shown below.

Non-Model Exchange	[NME.I/E-PAL] Pre-Preliminary Cost Estimate Report
Project Stage	31-10 14 17 Initiation
Exchange Disciplines	33-25 11 00 Estimation 33-11 00 00 Planning, Aesthetics and Landscaping
Information Transmitted	Provide conceptual cost estimate of candidate projects throughout project phases with regard to pavement, structures, culverts, operations, and environment.
Typical Formats	Excel spreadsheet

Non-Model Exchange	[NME.S/E-SE] Preliminary Cost Estimate Report
Project Stage	31-10 14 24 Scoping
Exchange Disciplines	33-25 11 00 Estimation 33-21 31 14 Structural Engineering
Information Transmitted	Provide preliminary cost estimate of feasible alternatives based on project information readily available (shoulder break).
Typical Formats	Excel spreadsheet

Non-Model Exchange	[NME.PD/SE-TE] Review Comments
Project Stage	31-20 10 00 Preliminary Design
Exchange Disciplines	33-21 31 14 Structural Engineering 33-21 99 45 21 Transportation Engineering
Information Transmitted	Provide structural consideration feedback on selection of feasible alternatives.
Typical Formats	Marked up drawings, notes

Non-Model Exchange	[NME.PD/E-SE-TE] Updated Cost Estimate Report
Project Stage	31-20 10 00 Preliminary Design
Exchange Disciplines	33-25 11 00 Estimation 33-21 31 14 Structural Engineering 33-21 99 45 21 Transportation Engineering
Information Transmitted	Provide updated cost estimate based on preliminary design and contingency factors.
Typical Formats	Excel spreadsheet

Non-Model Exchange	[NME.FD/SE-PAL-TE] Review Comments
Project Stage	31-20 20 00 Final Design
Exchange Disciplines	33-21 31 14 Structural Engineering 33-11 00 00 Planning, Aesthetics and Landscaping 33-21 99 45 21 Transportation Engineering
Information Transmitted	Provide comments on final plans and specifications.
Typical Formats	Marked up drawings, notes

Non-Model Exchange	[NME.FD/E-D-SE] Final Cost Estimate Report
Project Stage	31-20 20 00 Final Design
Exchange Disciplines	33-25 11 00 Estimate 33-21 31 14 Detailing 33-21 31 14 Structural Engineering
Information Transmitted	Provide refined cost estimate based on detailed design in sufficient detail to permit comparison of bids receives.
Typical Formats	Excel spreadsheet

Non-Model Exchange	[NME.FD/LR-D] Load Rating Result
Project Stage	31-20 20 00 Final Design
Exchange Disciplines	33-21 31 14 Load Rating 33-21 31 14 Detailing
Information Transmitted	Inventory and operating load rating factors
Typical Formats	Drawings

Non-Model Exchange	[NME.BL/CM-SE] Bid Information
Project Stage	31-30 30 00 Bidding and Letting
Exchange Disciplines	33-41 14 00 Construction Management 33-21 31 14 Structural Engineering
Information Transmitted	Contractors provide comments on issued proposed document or final PS&E, and then submit bid documents.
Typical Formats	Bid package

Non-Model Exchange	[NME.BL/SE-CM] Contract Award
Project Stage	31-30 30 00 Bidding and Letting
Exchange Disciplines	33-21 31 14 Structural Engineering 33-41 14 00 Construction Management
Information Transmitted	After all bids are tabulated and reviewed, construction contracts are awarded.
Typical Formats	None

Non-Model Exchange	[NME.BL/E-CM] Initial MIS Estimation Report
Project Stage	31-30 30 00 Bidding and Letting
Exchange Disciplines	33-25 11 00 Estimate 33-41 14 00 Construction Management
Information Transmitted	Contractors provide cost estimate for forming bid document.
Typical Formats	Excel spreadsheet

Non-Model Exchange	[NME.CD/SE-D] Review Comments
Project Stage	31-40 10 00 Construction Planning / Detailing
Exchange Disciplines	33-21 31 14 Structural Engineering 33-21 31 14 Detailing
Information Transmitted	Provide comments on shop drawings provided from detailer.
Typical Formats	Marked up drawings, notes

Non-Model Exchange	[NME.CD/CM-F] Schedule Information
Project Stage	31-40 10 00 Construction Planning / Detailing
Exchange Disciplines	33-41 14 00 Construction Management 33-25 41 11 Fabrication
Information Transmitted	Bar chart, Bridge portion excavation & construction sequencing, etc
Typical Formats	None

Non-Model Exchange	[NME.CD/F-CM] Review Comments
Project Stage	31-40 10 00 Construction Planning / Detailing
Exchange Disciplines	33-25 41 11 Fabrication 33-41 14 00 Construction Management
Information Transmitted	MPT (Maintenance and Protection of Traffic) compliance, etc
Typical Formats	None

Non-Model Exchange	[NME.CD/CE-CM] Erection Procedures
Project Stage	31-40 10 00 Construction Planning / Detailing
Exchange Disciplines	33-41 11 00 Construction Engineering 33-41 14 00 Construction Management
Information Transmitted	Provide erection procedures to construction management personnel for scheduling.
Typical Formats	Drawings, notes

Non-Model Exchange	[NME.F/F-D] Review Comments
Project Stage	31-40 40 14 21 Fabrication
Exchange Disciplines	33-25 41 11 Fabrication 33-21 31 14 Detailing
Information Transmitted	Provide review comments on shop drawings to detailer.
Typical Formats	Marked up drawings, notes

Non-Model Exchange	[NME.F/F-CE] Fabrication and Shipping Information
Project Stage	31-40 40 14 21 Fabrication
Exchange Disciplines	33-25 41 11 Fabrication 33-41 11 00 Construction Engineering
Information Transmitted	Provide fabrication and shipping information to contractor for QA/QC and scheduling.
Typical Formats	None

Non-Model Exchange	[NME.C/CM-CE] Execution Plan
Project Stage	31-40 40 14 Construction
Exchange Disciplines	33-41 14 00 Construction Management 33-41 11 00 Construction Engineering
Information Transmitted	None
Typical Formats	None

Non-Model Exchange	[NME.C/CE-CM] Execution Status Report
Project Stage	31-40 40 14 Construction
Exchange Disciplines	33-41 11 00 Construction Engineering 33-41 14 00 Construction Management
Information Transmitted	None
Typical Formats	None

Non-Model Exchange	[NME.C/LR-SE] Load Rating Result
Project Stage	31-40 40 14 Construction
Exchange Disciplines	33-21 31 14 Load Rating 33-21 31 14 Structural Engineering
Information Transmitted	Provide results of load rating based on as-built bridge data.
Typical Formats	Calculation report

Non-Model Exchange	[NME.IE/I-SE] Inspection Report
Project Stage	31-50 20 21 Inspection and Evaluation
Exchange Disciplines	33-21 31 14 Inspection 33-21 31 14 Structural Engineering
Information Transmitted	Provide deterioration information for load rating.
Typical Formats	Photos, reports

Non-Model Exchange	[NME.IE/LR-I-SE] Rating Report
Project Stage	31-50 20 21 Inspection and Evaluation
Exchange Disciplines	33-21 31 14 Load Rating 33-21 31 14 Inspection 33-21 31 14 Structural Engineering
Information Transmitted	Provide updated load rating results based on inspection report.
Typical Formats	Calculation report

SECTION 5 EXCHANGE MODEL SPECIFICATIONS

AASHTO/NSBA Steel Bridge Collaboration developed nine guidelines and four specifications [69-83] with the aim of standardizing design, fabrication and erection processes of steel bridges to maximize project quality and value. Steel bridge data described in these guidelines and specifications has been retrieved and incorporated in the Information Delivery Manual. Table 5-1 shows the guidelines and specifications reviewed, the area they focus on, and the Exchange Models they affect.

Table 5-1. AASHTO/NSBA Guidelines and Specifications Used in IDM

Software Name	Area	Associated Exchange Models
G1.1 Shop Detail Drawing Review/Approval Guidelines [69]	Bridge Detailing	EM.FD/D-E-LR Final Structural Model EM.CD/D-SE Advance Detailing Model EM.F/D-F Final Detailing Model
G1.2 Design Drawing Presentation Guidelines [70]	Bridge Design	EM.FD/SE-D-TE-PAL Advance Structural Model EM.FD/D-E-LR Final Structural Model EM.BL/SE-D-E-CM-CE Contract Model
G1.3 Shop Detail Drawing Presentation Guidelines [71]	Bridge Detailing	EM.FD/D-E-LR Final Structural Model EM.CD/D-SE Advance Detailing Model EM.F/D-F Final Detailing Model
G1.4 Guidelines for Design Details [72]	Bridge Design	EM.FD/SE-D-TE-PAL Advance Structural Model EM.FD/D-E-LR Final Structural Model EM.BL/SE-D-E-CM-CE Contract Model
G4.2 Recommendations for the Qualification of Structural Bolting Inspectors [73]	Bridge Detailing/Construction	EM.CD/D-SE Advance Detailing Model EM.F/D-F Final Detailing Model
G4.4 Sample Owners Quality Assurance Manual [74]	Bridge Fabrication/Construction	EM.CD/D-SE Advance Detailing Model EM.F/D-F Final Detailing Model
G9.1 Steel Bridge Bearing Design and Detailing Guidelines [75]	Bridge Design/Detailing	EM.FD/SE-D-TE-PAL Advance Structural Model EM.FD/D-E-LR Final Structural Model EM.BL/SE-D-E-CM-CE Contract Model EM.CD/D-SE Advance Detailing Model EM.F/D-F Final Detailing Model
G12.1 Guidelines for Design for Constructability [76]	Bridge Design/Construction	EM.FD/D-E-LR Final Structural Model EM.BL/SE-D-E-CM-CE Contract Model EM.F/D-F Final Detailing Model EM.CD/CE-F-CM Erection Analysis Model
G13.1 Guidelines for Steel Girder Bridge Analysis [77]	Bridge Design	EM.FD/SE-D-TE-PAL Advance Structural Model EM.FD/D-E-LR Final Structural Model EM.BL/SE-D-E-CM-CE Contract Model

Software Name	Area	Associated Exchange Models
S2.1 Steel Bridge Fabrication Guide Specification [78]	Bridge Detailing	EM.CD/D-SE Advance Detailing Model
S4.1 Steel Bridge Fabrication QC/QA Guide Specification [79]	Bridge Detailing	EM.CD/D-SE Advance Detailing Model
S8.1 Guide Specification for Application of Coating Systems with Zinc-Rich Primers to Steel Bridges [80]	Bridge Detailing	EM.CD/D-SE Advance Detailing Model
S10.1 Steel Bridge Erection Guide Specification [81]	Bridge Construction/Erection	EM.CD/CE-F-CM Erection Analysis Model

Multiple software applications are selected and reviewed to retrieve commonly used bridge data for bridge analysis, design, construction, erection, and load rating. The software applications reviewed include AASHTOWare BrD/BrR [5], CSiBridge [84], LEAP Bridge Suite [85], LRFD SIMON [86], NSBA SPLICE [87], Estimating Link [88], Tekla Structures [89], and UT Bridge [90].

AASHTOWare BrD and BrR (formerly named Opis and Virtis) are bridge analysis, design, and load rating software products developed by AASHTO. They are created in accordance with the AASHTO LRFD Bridge Design Specifications, AASHTO Standard Specifications for Highway Bridges, and AASHTO Manual for Bridge Evaluation. AASHTOWare BrD and BrR share a bridge data repository which stores bridge data detailed enough for structural analysis. This data repository was adopted by TransXML for its Bridge Design and Analysis (BDA) schema.

CSiBridge is a software product which can fulfill bridge modeling, analysis and design. It is able to define complex bridge geometries, i.e. bridge on curved horizontal alignment and curved vertical profile. CSiBridge takes into account factors like staged construction, creep and shrinkage, and camber when performing the bridge analysis.

LEAP Bridge Enterprise is a combination of four software products for analysis, design and load rating of concrete bridges.

- LEAP GEOMATH is a software product that defines roadway geometry and bridge layout parametrically.
- LEAP CONBOX is a software product that analyzes, designs and load rates the reinforced and Post-Tensioned concrete box girder, T beam and slab bridges.
- LEAP CONSPAN is a software product that analyzes, designs and load rates the precast prestressed concrete bridges with other girder types.
- LEAP RC-PIER is a software product that analyzes and designs reinforced concrete substructures including piers, abutments and foundations.

LRFD SIMON is a bridge software product developed by NSBA for steel plate and box girder design.

NSBA SPLICE is a software application developed by NSBA for analysis and design of bolted field splices.

Estimating Link is a software product used for construction estimating and bidding.

Tekla Structures is a BIM software product that can be used for bridge detailing, construction and fabrication. It is able to define complex bridge geometries.

UT Bridge is a 3D Finite Element software product that analyzes straight or curved I girder bridges during girder erection and concrete deck placement.

Table 5-2 shows the software products reviewed, the functions they have, and the Exchange Models they affect.

Table 5-2. Software Products Used for Developing IDM

Software Name	Function	Associated Exchange Models
LEAP GEOMATH	Roadway Design	EM.PD/TE-SE Preliminary Roadway Geometry Model EM.FD/TE-SE Final Roadway Geometry Model
LEAP RC-PIER	Concrete Bridge Substructure Design	EM.FD/SE-D-TE-PAL Advance Structural Model EM.FD/D-E-LR Final Structural Model EM.BL/SE-D-E-CM-CE Contract Model
AASHTOWare BrD (AASHTOWare Opis)	Bridge Design	EM.FD/SE-D-TE-PAL Advance Structural Model EM.FD/D-E-LR Final Structural Model EM.BL/SE-D-E-CM-CE Contract Model
CSiBridge	Bridge Design	EM.FD/SE-D-TE-PAL Advance Structural Model EM.FD/D-E-LR Final Structural Model EM.BL/SE-D-E-CM-CE Contract Model
LRFD SIMON	Steel Bridge Design	EM.FD/SE-D-TE-PAL Advance Structural Model EM.FD/D-E-LR Final Structural Model EM.BL/SE-D-E-CM-CE Contract Model
NSBA SPLICE	Bridge Design/Detailing	EM.FD/SE-D-TE-PAL Advance Structural Model EM.FD/D-E-LR Final Structural Model EM.BL/SE-D-E-CM-CE Contract Model EM.CD/D-SE Advance Detailing Model EM.F/D-F Final Detailing Model
Tekla Structures	Bridge Detailing	EM.FD/D-E-LR Final Structural Model EM.CD/D-SE Advance Detailing Model EM.F/D-F Final Detailing Model
Estimating Link	Bridge Cost Estimate	EM.FD/D-E-LR Final Structural Model EM.BL/SE-D-E-CM-CE Contract Model

Software Name	Function	Associated Exchange Models
UT Bridge	Bridge Erection/Construction	EM.CD/CE-F-CM Erection Analysis Model
AASHTOWare BrR (AASHTOWare Virtis)	Bridge Load Rating	EM.FD/D-E-LR Final Structural Model EM.C/CE-SE-E-LR As-Built Model EM.IE/I-LR-SE Structural Deterioration Model

In order to determine data associated with cost estimate made by bridge owner, the Weighted Average Item Price Report (WAIPR) and the Regional and Statewide Average Awarded Price Report (RSWAAPR) from New York State Department of Transportation (NYSDOT) are used. These reports contain a list of all project items used in the contracts that have been let by the NYSDOT within a certain time period. The content of reports include total quantity/weighted average awarded price, totals for each item, overall averages, number of contract occurrences. Besides the price reports, the Pay Item Catalog (PIC) that includes Regional and Statewide average awarded price history has been used to retrieve data for cost estimate.

Multiple existing Data Model Standards for Building and Bridge are used as data sources for development of Information Delivery Manual. Building oriented Data Model Standards, e.g. Industry Foundation Classes (IFC) [2, 91], CIMsteel Integration Standards (CIS/2) [10], and Integrated Structural Modeling (ISM) [12], provides data of materials, member cross sections, and loads and reactions. Data from bridge oriented Data Model Standards, e.g. Steel Bridge Construction Data Model (SBCDM) [3], TransXML [4], and LandXML [16], are used as well. Table 5-3 shows the Data Model Standards reviewed, the area they focus on, and the Exchange Models they affect.

Table 5-3. Data Model Standards Used for Developing IDM

Data Model Standard Name	Area	Associated Exchange Models
Industry Foundation Classes (IFC)	Materials, Cross Sections, Loads and Reactions	EM.FD/SE-D-TE-PAL Advance Structural Model EM.FD/D-E-LR Final Structural Model EM.BL/SE-D-E-CM-CE Contract Model
CIMsteel Integration Standards (CIS/2)	Materials, Cross Sections, Loads and Reactions	EM.FD/SE-D-TE-PAL Advance Structural Model EM.FD/D-E-LR Final Structural Model EM.BL/SE-D-E-CM-CE Contract Model
Integrated Structural Modeling (ISM)	Materials, Cross Sections, Loads and Reactions	EM.FD/SE-D-TE-PAL Advance Structural Model EM.FD/D-E-LR Final Structural Model EM.BL/SE-D-E-CM-CE Contract Model
Steel Bridge Construction Data Model (SBCDM)	Bridge Detailing/Construction	EM.FD/D-E-LR Final Structural Model EM.CD/D-SE Advance Detailing Model EM.F/D-F Final Detailing Model EM.CD/CE-F-CM Erection Analysis Model

Data Model Standard Name	Area	Associated Exchange Models
TransXML	Bridge Design	EM.FD/SE-D-TE-PAL Advance Structural Model EM.FD/D-E-LR Final Structural Model EM.BL/SE-D-E-CM-CE Contract Model
LandXML	Roadway Design	EM.PD/TE-SE Preliminary Roadway Geometry Model EM.FD/TE-SE Final Roadway Geometry Model

The process of developing the data dictionary started with examining Opis/Virtis data model which was later on used as a starting point as Opis/Virtis data model for bridges already had many of the data items that are being used in the bridge industry. A starting gap analysis and placement of Opis/Virtis data items in specific Exchange Models can be found in the Appendix C. The gap analysis confirmed that the Opis/Virtis data model lacked important data dictionary items related to roadway alignment, erection analysis and concrete detailing. The data dictionary was later on expanded by added the missing data items by thoroughly studying contract drawings, NYSDOT bridge design manual, various software such as Tekla and Pro-Concrete, and currently existing data schema for buildings such as the PCI/NBIMS efforts to standardize data for buildings industry.

Legend to the following table: Yellow (M) – mandatory, Cyan (O) – optional, White (N) – not needed.

Information Group	Information Items	Attribute Set	Final Roadway Geometry Model EM.FD/TE-SE	Final Structural Model EM.FD/D-E	Contract Model EM.BL/SE-D-E-CM-CE	Erection Analysis Model EM.CD/CE-F-CM	Final Detailing Model EM.F/D-F
Project information	Identification	Identification numbers	O	M	M	N	O
Project information	Identification	Names	O	M	M	N	O
Project information	Identification	Over roadway identities	O	M	M	N	O
Project information	Identification	Under roadway identities	O	M	M	N	O
Project information	Location	Places	O	M	M	N	O
Project information	Location	Coordinates	O	M	M	N	O
Project information	Meta data	Associated stakeholders	O	M	M	N	O
Project information	Meta data	Dates	O	M	M	N	O
Project information	Meta data	Status	O	M	M	N	O
Project information	Project descriptions	Design data	O	M	M	N	O
Project information	Project descriptions	Design specifications	O	M	M	N	O
Project information	Project descriptions	System of units	O	M	M	N	O
Project information	Project descriptions	Indicators	O	M	M	N	O
Project information	Project descriptions	Miscellaneous information	O	M	M	N	O
Project information	Project descriptions	Environmental information	O	M	M	N	O
Roadway geometry	Horizontal alignment	Types	M	O	O	N	O

Information Group	Information Items	Attribute Set	Final Roadway Geometry Model EM.FD/TE-SE	Final Structural Model EM.FD/D-E	Contract Model EM.BL/SE-D-E-CM-CE	Erection Analysis Model EM.CD/CE-F-CM	Final Detailing Model EM.F/D-F
Roadway geometry	Horizontal alignment	Lines	M	O	O	N	O
Roadway geometry	Horizontal alignment	Stations	M	O	O	N	O
Roadway geometry	Horizontal alignment	Azimuths	M	O	O	N	O
Roadway geometry	Horizontal alignment	Lengths	M	O	O	N	O
Roadway geometry	Horizontal alignment	Radii	M	O	O	N	O
Roadway geometry	Horizontal alignment	Directions	M	O	O	N	O
Roadway geometry	Vertical profile	Types	M	O	O	N	O
Roadway geometry	Vertical profile	Lines	M	O	O	N	O
Roadway geometry	Vertical profile	Stations	M	O	O	N	O
Roadway geometry	Vertical profile	Elevations	M	O	O	N	O
Roadway geometry	Vertical profile	Lengths	M	O	O	N	O
Roadway geometry	Vertical profile	Grades	M	O	O	N	O
Roadway geometry	Vertical profile	Roadway information	M	O	O	N	O
Roadway geometry	Vertical profile	Topographies	M	O	O	N	O
Roadway geometry	Cross section	Geometries	M	O	O	N	O
Roadway geometry	Cross section	Stations	M	O	O	N	O

Information Group	Information Items	Attribute Set	Final Roadway Geometry Model EM.FD/TE-SE	Final Structural Model EM.FD/D-E	Contract Model EM.BL/SE-D-E-CM-CE	Erection Analysis Model EM.CD/CE-F-CM	Final Detailing Model EM.F/D-F
Roadway geometry	Cross section	Slopes	M	O	O	N	O
Roadway geometry	Cross section	Widths	M	O	O	N	O
Roadway geometry	Cross section	Offsets	M	O	O	N	O
Roadway geometry	Cross section	Lane information	M	O	O	N	O
Roadway geometry	Cross section	Shoulder information	M	O	O	N	O
Roadway structure	Approach slabs	Property	N	M	M	N	O
Roadway structure	Approach slabs	Location	N	M	M	N	O
Roadway structure	Approach slabs	Dimension	N	M	M	N	O
Roadway structure	Approach slabs	Material	N	M	M	N	O
Roadway structure	Approach slabs	Protective sealant	N	M	M	N	O
Bridge layout	Bridge control information	Stations	O	M	M	N	O
Bridge layout	Bridge control information	Azimuths	O	M	M	N	O
Bridge layout	Bridge control information	Skew angles	O	M	M	N	O
Bridge layout	Bridge configuration	Span	N	M	M	N	O
Bridge layout	Bridge configuration	Length	N	M	M	N	O
Bridge layout	Bridge configuration	Clearance	N	M	M	N	O

Information Group	Information Items	Attribute Set	Final Roadway Geometry Model EM.FD/TE-SE	Final Structural Model EM.FD/D-E	Contract Model EM.BL/SE-D-E-CM-CE	Erection Analysis Model EM.CD/CE-F-CM	Final Detailing Model EM.F/D-F
Bridge superstructure	Deck	Property	N	M	M	N	O
Bridge superstructure	Deck	Location	N	M	M	N	O
Bridge superstructure	Deck	Dimension	N	M	M	N	O
Bridge superstructure	Deck	Material	N	M	M	N	O
Bridge superstructure	Deck	Overhang	N	M	M	N	O
Bridge superstructure	Deck	Reinforcement	N	M	M	N	O
Bridge superstructure	Haunch	Property	N	M	M	N	O
Bridge superstructure	Haunch	Location	N	M	M	N	O
Bridge superstructure	Haunch	Dimension	N	M	M	N	O
Bridge superstructure	Haunch	Material	N	M	M	N	O
Bridge superstructure	Girder layout	Properties	N	M	M	N	O
Bridge superstructure	Girder layout	Spacing	N	M	M	N	O
Bridge superstructure	Girder layout	Location	N	M	M	N	O
Bridge superstructure	Concrete girder properties	Concrete girder properties	N	M	M	N	O
Bridge superstructure	Concrete girder properties	Concrete girder material	N	M	M	N	O

Information Group	Information Items	Attribute Set	Final Roadway Geometry Model EM.FD/TE-SE	Final Structural Model EM.FD/D-E	Contract Model EM.BL/SE-D-E-CM-CE	Erection Analysis Model EM.CD/CE-F-CM	Final Detailing Model EM.F/D-F
Bridge superstructure	Steel girder properties	Steel girder properties	N	M	M	N	O
Bridge superstructure	Steel girder properties	Steel girder material	N	M	M	N	O
Bridge superstructure	Steel girder properties	Top flange properties	N	M	M	N	O
Bridge superstructure	Steel girder properties	Bottom flange properties	N	M	M	N	O
Bridge superstructure	Steel girder properties	Web properties	N	M	M	N	O
Bridge superstructure	Steel girder properties	Web camber	N	M	M	N	O
Bridge superstructure	Steel girder properties	Girder bill information	N	M	M	N	O
Bridge superstructure	Steel girder properties	Haunch properties	N	M	M	N	O
Bridge superstructure	Bearing	Layout	N	M	M	N	O
Bridge superstructure	Bearing	Properties	N	M	M	N	O
Bridge superstructure	Bearing	Elastomeric bearing properties	N	M	M	N	O
Bridge superstructure	Bearing	Sliding bearing properties	N	M	M	N	O
Bridge superstructure	Cross frame and diaphragm	Properties	N	M	M	N	O
Bridge superstructure	Cross frame and diaphragm	Layout	N	M	M	N	O

Information Group	Information Items	Attribute Set	Final Roadway Geometry Model EM.FD/TE-SE	Final Structural Model EM.FD/D-E	Contract Model EM.BL/SE-D-E-CM-CE	Erection Analysis Model EM.CD/CE-F-CM	Final Detailing Model EM.F/D-F
Bridge superstructure	Cross frame and diaphragm	Dimensions	N	M	M	N	O
Bridge superstructure	Cross frame and diaphragm	Indicators	N	M	M	N	O
Bridge superstructure	Cross frame and diaphragm	Work point definition	N	M	M	N	O
Bridge superstructure	Cross frame and diaphragm	Notes	N	M	M	N	O
Bridge superstructure	Cross frame and diaphragm	Bill information	N	M	M	N	O
Bridge superstructure	Sidewalk	Properties	N	M	M	N	O
Bridge superstructure	Sidewalk	Material	N	M	M	N	O
Bridge superstructure	Sidewalk	Layout	N	M	M	N	O
Bridge superstructure	Sidewalk	Load	N	M	M	N	O
Bridge superstructure	Barrier	Properties	N	M	M	N	O
Bridge superstructure	Barrier	Material	N	M	M	N	O
Bridge superstructure	Barrier	Layout	N	M	M	N	O
Bridge superstructure	Barrier	Load	N	M	M	N	O

Information Group	Information Items	Attribute Set	Final Roadway Geometry Model EM.FD/TE-SE	Final Structural Model EM.FD/D-E	Contract Model EM.BL/SE-D-E-CM-CE	Erection Analysis Model EM.CD/CE-F-CM	Final Detailing Model EM.F/D-F
Bridge superstructure	Parapet	Properties	N	M	M	N	O
Bridge superstructure	Parapet	Material	N	M	M	N	O
Bridge superstructure	Parapet	Layout	N	M	M	N	O
Bridge superstructure	Parapet	Load	N	M	M	N	O
Bridge superstructure	Median	Properties	N	M	M	N	O
Bridge superstructure	Parapet	Material	N	M	M	N	O
Bridge superstructure	Parapet	Layout	N	M	M	N	O
Bridge superstructure	Parapet	Load	N	M	M	N	O
Bridge superstructure	Railing	Properties	N	M	M	N	O
Bridge superstructure	Railing	Material	N	M	M	N	O
Bridge superstructure	Railing	Layout	N	M	M	N	O
Bridge superstructure	Railing	Load	N	M	M	N	O
Bridge substructure	Pedestal	Properties	N	M	M	N	O
Bridge substructure	Pedestal	Location	N	M	M	N	O
Bridge substructure	Pedestal	Dimensions	N	M	M	N	O
Bridge substructure	Pedestal	Material	N	M	M	N	O

Information Group	Information Items	Attribute Set	Final Roadway Geometry Model EM.FD/TE-SE	Final Structural Model EM.FD/D-E	Contract Model EM.BL/SE-D-E-CM-CE	Erection Analysis Model EM.CD/CE-F-CM	Final Detailing Model EM.F/D-F
Bridge substructure	Cap beam	Properties	N	M	M	N	O
Bridge substructure	Cap beam	Location	N	M	M	N	O
Bridge substructure	Cap beam	Dimensions	N	M	M	N	O
Bridge substructure	Cap beam	Tapered cap beam dimensions	N	M	M	N	O
Bridge substructure	Cap beam	Stepped cap beam dimensions	N	M	M	N	O
Bridge substructure	Cap beam	Inverted T cap beam dimensions	N	M	M	N	O
Bridge substructure	Cap beam	Material	N	M	M	N	O
Bridge substructure	Hammer head	Properties	N	M	M	N	O
Bridge substructure	Hammer head	Location	N	M	M	N	O
Bridge substructure	Hammer head	Dimensions	N	M	M	N	O
Bridge substructure	Hammer head	Void dimensions	N	M	M	N	O
Bridge substructure	Hammer head	Material	N	M	M	N	O
Bridge substructure	Pier column	Properties	N	M	M	N	O
Bridge substructure	Pier column	Location	N	M	M	N	O
Bridge substructure	Pier column	Dimensions	N	M	M	N	O

Information Group	Information Items	Attribute Set	Final Roadway Geometry Model EM.FD/TE-SE	Final Structural Model EM.FD/D-E	Contract Model EM.BL/SE-D-E-CM-CE	Erection Analysis Model EM.CD/CE-F-CM	Final Detailing Model EM.F/D-F
Bridge substructure	Pier column	Support condition	N	M	M	N	O
Bridge substructure	Pier column	Material	N	M	M	N	O
Bridge substructure	Wall pier	Properties	N	M	M	N	O
Bridge substructure	Wall pier	Location	N	M	M	N	O
Bridge substructure	Wall pier	Dimensions	N	M	M	N	O
Bridge substructure	Wall pier	Material	N	M	M	N	O
Bridge substructure	Drilled shaft	Properties	N	M	M	N	O
Bridge substructure	Drilled shaft	Location	N	M	M	N	O
Bridge substructure	Drilled shaft	Dimensions	N	M	M	N	O
Bridge substructure	Drilled shaft	Support condition	N	M	M	N	O
Bridge substructure	Drilled shaft	Material	N	M	M	N	O
Bridge substructure	Pile	Properties	N	M	M	N	O
Bridge substructure	Pile	Location	N	M	M	N	O
Bridge substructure	Pile	Dimensions	N	M	M	N	O
Bridge substructure	Pile	Support condition	N	M	M	N	O
Bridge substructure	Pile	Material	N	M	M	N	O

Information Group	Information Items	Attribute Set	Final Roadway Geometry Model EM.FD/TE-SE	Final Structural Model EM.FD/D-E	Contract Model EM.BL/SE-D-E-CM-CE	Erection Analysis Model EM.CD/CE-F-CM	Final Detailing Model EM.F/D-F
Bridge substructure	Footing/pile cap/shaft cap	Properties	N	M	M	N	O
Bridge substructure	Footing/pile cap/shaft cap	Location	N	M	M	N	O
Bridge substructure	Footing/pile cap/shaft cap	Dimensions	N	M	M	N	O
Bridge substructure	Footing/pile cap/shaft cap	Material	N	M	M	N	O
Bridge substructure	Wing wall/stem wall	Properties	N	M	M	N	O
Bridge substructure	Wing wall/stem wall	Location	N	M	M	N	O
Bridge substructure	Wing wall/stem wall	Dimensions	N	M	M	N	O
Bridge substructure	Wing wall/stem wall	Material	N	M	M	N	O
Bridge substructure	Wing wall/stem wall	Backfill properties	N	M	M	N	O
Fabrication	Fabrication information	General information	N	O	O	N	M
Fabrication	Bridge information	Bridge layout	N	O	O	N	M
Fabrication	Horizontal curve	Horizontal curve dimensions	N	O	O	N	M
Fabrication	Member information	Member Identification	N	O	O	N	M
Fabrication	Stiffener	Properties	N	O	O	N	M
Fabrication	Stiffener	Layout	N	O	O	N	M

Information Group	Information Items	Attribute Set	Final Roadway Geometry Model EM.FD/TE-SE	Final Structural Model EM.FD/D-E	Contract Model EM.BL/SE-D-E-CM-CE	Erection Analysis Model EM.CD/CE-F-CM	Final Detailing Model EM.F/D-F
Fabrication	Stiffener	Dimensions	N	O	O	N	M
Fabrication	Stiffener	Material	N	O	O	N	M
Fabrication	Stiffener	Indicators	N	O	O	N	M
Fabrication	Stiffener	Notes	N	O	O	N	M
Fabrication	Stiffener	Bill information	N	O	O	N	M
Fabrication	Stiffener	Weld properties	N	O	O	N	M
Fabrication	Field splice	Properties	N	O	O	N	M
Fabrication	Field splice	Layout	N	O	O	N	M
Fabrication	Field splice	Dimensions	N	O	O	N	M
Fabrication	Field splice	Material	N	O	O	N	M
Fabrication	Field splice	Indicators	N	O	O	N	M
Fabrication	Field splice	Notes	N	O	O	N	M
Fabrication	Field splice	Miscellaneous information	N	O	O	N	M
Fabrication	Field splice	Bill information	N	O	O	N	M
Fabrication	Field splice	Bolt properties	N	O	O	N	M
Fabrication	Connection plate	Properties	N	O	O	N	M
Fabrication	Connection plate	Layout	N	O	O	N	M
Fabrication	Connection plate	Dimensions	N	O	O	N	M

Information Group	Information Items	Attribute Set	Final Roadway Geometry Model EM.FD/TE-SE	Final Structural Model EM.FD/D-E	Contract Model EM.BL/SE-D-E-CM-CE	Erection Analysis Model EM.CD/CE-F-CM	Final Detailing Model EM.F/D-F
Fabrication	Connection plate	Material	N	O	O	N	M
Fabrication	Connection plate	Indicators	N	O	O	N	M
Fabrication	Connection plate	Notes	N	O	O	N	M
Fabrication	Connection plate	Bill information	N	O	O	N	M
Fabrication	Connection plate	Weld properties	N	O	O	N	M
Fabrication	Connection plate	Bolt properties	N	O	O	N	M
Fabrication	Cover plate	Properties	N	O	O	N	M
Fabrication	Cover plate	Layout	N	O	O	N	M
Fabrication	Cover plate	Dimensions	N	O	O	N	M
Fabrication	Cover plate	Material	N	O	O	N	M
Fabrication	Cover plate	Weld properties	N	O	O	N	M
Fabrication	Cover plate	Bolt properties	N	O	O	N	M
Fabrication	Gusset plate	Properties	N	O	O	N	M
Fabrication	Gusset plate	Layout	N	O	O	N	M
Fabrication	Gusset plate	Dimensions	N	O	O	N	M
Fabrication	Gusset plate	Material	N	O	O	N	M
Fabrication	Gusset plate	Indicators	N	O	O	N	M
Fabrication	Gusset plate	Notes	N	O	O	N	M

Information Group	Information Items	Attribute Set	Final Roadway Geometry Model EM.FD/TE-SE	Final Structural Model EM.FD/D-E	Contract Model EM.BL/SE-D-E-CM-CE	Erection Analysis Model EM.CD/CE-F-CM	Final Detailing Model EM.F/D-F
Fabrication	Gusset plate	Bill information	N	O	O	N	M
Fabrication	Gusset plate	Weld properties	N	O	O	N	M
Fabrication	Gusset plate	Bolt properties	N	O	O	N	M
Fabrication	Fill plate	Properties	N	O	O	N	M
Fabrication	Fill plate	Layout	N	O	O	N	M
Fabrication	Fill plate	Dimensions	N	O	O	N	M
Fabrication	Fill plate	Material	N	O	O	N	M
Fabrication	Fill plate	Indicators	N	O	O	N	M
Fabrication	Fill plate	Notes	N	O	O	N	M
Fabrication	Fill plate	Bill information	N	O	O	N	M
Fabrication	Fill plate	Weld properties	N	O	O	N	M
Fabrication	Fill plate	Bolt properties	N	O	O	N	M
Fabrication	Feature	Hole	N	O	O	N	M
Fabrication	Feature	Bolt hole	N	O	O	N	M
Fabrication	Feature	Slotted hole	N	O	O	N	M
Fabrication	Feature	Cope	N	O	O	N	M
Fabrication	Feature	Opening	N	O	O	N	M
Fabrication	Feature	Skewed end	N	O	O	N	M
Fabrication	Feature	Cutting plane	N	O	O	N	M
Fabrication	Feature	Edge chamfer	N	O	O	N	M

Information Group	Information Items	Attribute Set	Final Roadway Geometry Model EM.FD/TE-SE	Final Structural Model EM.FD/D-E	Contract Model EM.BL/SE-D-E-CM-CE	Erection Analysis Model EM.CD/CE-F-CM	Final Detailing Model EM.F/D-F
Fabrication	Feature	Surface feature	N	O	O	N	M
Fabrication	Feature	Thread	N	O	O	N	M
Fabrication	Feature	Volume prismatic chamfer	N	O	O	N	M
Fabrication	Feature	Volume prismatic flange chamfer	N	O	O	N	M
Fabrication	Feature	Volume prismatic flange notch	N	O	O	N	M
Fabrication	Feature	Volume prismatic notch	N	O	O	N	M
Fabrication	Feature	Volume prismatic skewed end	N	O	O	N	M
Fabrication	Feature	Castellation	N	O	O	N	M
Fabrication	Feature	Miscellaneous features	N	O	O	N	M
Fabrication	Shear connector (stud)	Properties	N	O	O	N	M
Fabrication	Shear connector (stud)	Layout	N	O	O	N	M
Fabrication	Shear connector (stud)	Dimensions	N	O	O	N	M
Fabrication	Shear connector (stud)	Material	N	O	O	N	M

Information Group	Information Items	Attribute Set	Final Roadway Geometry Model EM.FD/TE-SE	Final Structural Model EM.FD/D-E	Contract Model EM.BL/SE-D-E-CM-CE	Erection Analysis Model EM.CD/CE-F-CM	Final Detailing Model EM.F/D-F
Fabrication	Shear connector (stud)	Channel properties	N	O	O	N	M
Fabrication	Shear connector (stud)	Weld properties	N	O	O	N	M
Fabrication	Bolt assembly	Properties	N	O	O	N	M
Fabrication	Bolt assembly	Bolt	N	O	O	N	M
Fabrication	Bolt assembly	Washer	N	O	O	N	M
Fabrication	Bolt assembly	Nut	N	O	O	N	M
Fabrication	Bolt assembly	Thread	N	O	O	N	M
Fabrication	Bolt assembly	Bolt number	N	O	O	N	M
Fabrication	Bolt assembly	Rotational capacity test data	N	O	O	N	M
Fabrication	Weld	Properties	N	O	O	N	M
Fabrication	Weld	Dimensions	N	O	O	N	M
Fabrication	Weld	Electrode data	N	O	O	N	M
Fabrication	Weld	Note	N	O	O	N	M
Fabrication	Weld	Non-destructive testing information	N	O	O	N	M
Fabrication	Weld	Miscellaneous information	N	O	O	N	M
Fabrication	Chemical joint systems	Chemical mechanism	N	O	O	N	M

Information Group	Information Items	Attribute Set	Final Roadway Geometry Model EM.FD/TE-SE	Final Structural Model EM.FD/D-E	Contract Model EM.BL/SE-D-E-CM-CE	Erection Analysis Model EM.CD/CE-F-CM	Final Detailing Model EM.F/D-F
Fabrication	Process	Dimensions	N	O	O	N	M
Fabrication	Process	Painting	N	O	O	N	M
Fabrication	Process	Priming	N	O	O	N	M
Fabrication	Process	Coating	N	O	O	N	M
Fabrication	Process	Cleaning	N	O	O	N	M
Fabrication	Process	Cutting	N	O	O	N	M
Fabrication	Process	Surface	N	O	O	N	M
Fabrication	Process	Weathering	N	O	O	N	M
Fabrication	Process	Blasting	N	O	O	N	M
Fabrication	Process	Assemble	N	O	O	N	M
Fabrication	Process	Dispatch	N	O	O	N	M
Fabrication	Process	Move	N	O	O	N	M
Fabrication	Process	Procure	N	O	O	N	M
Fabrication	Process	Project process item	N	O	O	N	M
Fabrication	Process	Other surface treatment	N	O	O	N	M
Fabrication	Process	Bending	N	O	O	N	M
Fabrication	Nail	Nail properties	N	O	O	N	M
Fabrication	Pin	Pin properties	N	O	O	N	M
Fabrication	Screw	Screw properties	N	O	O	N	M

Information Group	Information Items	Attribute Set	Final Roadway Geometry Model EM.FD/TE-SE	Final Structural Model EM.FD/D-E	Contract Model EM.BL/SE-D-E-CM-CE	Erection Analysis Model EM.CD/CE-F-CM	Final Detailing Model EM.F/D-F
Fabrication	Screw	Screw self drilling properties	N	O	O	N	M
Fabrication	Screw	Screw self tapping	N	O	O	N	M
Fabrication	Screw	Screw tapered	N	O	O	N	M
Fabrication	Charpy V-Notch (CVN) impact testing	CVN definition	N	O	O	N	M
Fabrication	Fatigue	Fatigue properties	N	O	O	N	M
Fabrication	Fatigue	Fatigue geometry	N	O	O	N	M
Fabrication	Process information	Cutting	N	O	O	N	M
Fabrication	Process information	Drilling	N	O	O	N	M
Fabrication	Process information	Welding	N	O	O	N	M
Fabrication	Process information	Layout	N	O	O	N	M
Contract	Contract information	Pay item information	N	O	M	N	N
Construction	Girder Erection Analysis	Construction Information	N	O	N	M	O
Construction	Girder Erection Analysis	Number of Girders lifted per analysis	N	O	N	M	O

Information Group	Information Items	Attribute Set	Final Roadway Geometry Model EM.FD/TE-SE	Final Structural Model EM.FD/D-E	Contract Model EM.BL/SE-D-E-CM-CE	Erection Analysis Model EM.CD/CE-F-CM	Final Detailing Model EM.F/D-F
Construction	Girder Erection Analysis	Lifted Segment lengths	N	O	N	M	O
Construction	Dead Loads & Wind loads	Dead Load	N	O	N	M	O
Construction	Dead Loads & Wind loads	Wind Load	N	O	N	M	O
Construction	Shore Tower Data	Shore Tower Input	N	O	N	M	O
Construction	Shore Tower Data	Shore Tower Data	N	O	N	M	O
Construction	Shore Tower Data	Holding Crane or Other Concentrated Loads Input	N	O	N	M	O
Construction	Shore Tower Data	Holding Crane or Other Concentrated Loads Data	N	O	N	M	O
Construction	Erection Construction Descriptions	Drawings	N	O	N	M	O
Construction	Erection Construction Descriptions	Safety Requirements	N	O	N	M	O
Construction	Erection Construction Descriptions	Crane	N	O	N	M	O
Construction	Erection Construction Descriptions	Utility	N	O	N	M	O

Information Group	Information Items	Attribute Set	Final Roadway Geometry Model EM.FD/TE-SE	Final Structural Model EM.FD/D-E	Contract Model EM.BL/SE-D-E-CM-CE	Erection Analysis Model EM.CD/CE-F-CM	Final Detailing Model EM.F/D-F
Construction	Check	Skew bridge checks	N	O	N	M	O
Construction	Check	Camber	N	O	N	M	O
Construction	Miscellaneous information	Conduit support system	N	O	N	M	O
Construction	Miscellaneous information	Demolition and removal	N	O	N	M	O
Construction	Miscellaneous information	Bolting order	N	O	N	M	O
Section Library	Common sections	Common section properties	N	M	M	O	M
Section Library	Common sections	Circular hollow shape	N	M	M	O	M
Section Library	Common sections	Rectangular shape	N	M	M	O	M
Section Library	Common sections	Compound section	N	M	M	O	M
Section Library	Steel shapes	Rolled steel angle shape	N	M	M	O	M
Section Library	Steel shapes	Rolled steel channel shape	N	M	M	O	M
Section Library	Steel shapes	Steel I shape	N	M	M	O	M
Section Library	Steel shapes	Rolled steel tee shape	N	M	M	O	M
Section Library	Steel shapes	AISC Rolled shapes	N	M	M	O	M
Section Library	Prestressed concrete shapes	Prestressed tee beam shape	N	M	M	O	M

Information Group	Information Items	Attribute Set	Final Roadway Geometry Model EM.FD/TE-SE	Final Structural Model EM.FD/D-E	Contract Model EM.BL/SE-D-E-CM-CE	Erection Analysis Model EM.CD/CE-F-CM	Final Detailing Model EM.F/D-F
Section Library	Prestressed concrete shapes	Prestressed u beam shape	N	M	M	O	M
Section Library	Prestressed concrete shapes	Prestressed I beam shape	N	M	M	O	M
Section Library	Prestressed concrete shapes	Prestressed box beam shape	N	M	M	O	M
Section Library	Prestressed concrete shapes	AASHTO solid and voided slab beams	N	M	M	O	M
Section Library	Prestressed concrete shapes	Deck bulb-tees	N	M	M	O	M
Section Library	Prestressed concrete shapes	Double tee beams	N	M	M	O	M
Section Library	Prestressed concrete shapes	AASHTO PCI ASBI standard segment for span-by-span construction	N	M	M	O	M
Section Library	Timber beam shapes	Rectangular timber beam shape	N	M	M	O	M
Section Library	Arbitrary profile	-	N	M	M	O	M
Material Library	Material properties	General Properties	N	M	M	O	M
Material Library	Material properties	Concrete	N	M	M	O	M

Information Group	Information Items	Attribute Set	Final Roadway Geometry Model EM.FD/TE-SE	Final Structural Model EM.FD/D-E	Contract Model EM.BL/SE-D-E-CM-CE	Erection Analysis Model EM.CD/CE-F-CM	Final Detailing Model EM.F/D-F
Material Library	Material properties	Structural steel	N	M	M	O	M
Material Library	Material properties	Reinforcing steel	N	M	M	O	M
Material Library	Material properties	Prestress strand material	N	M	M	O	M
Material Library	Material properties	Sawn timber	N	M	M	O	M
Deterioration	Deterioration Information	Deterioration Information	N	N	N	N	N
Reinforcement	Longitudinal Bar	Properties	N	M	M	N	M
Reinforcement	Longitudinal Bar	Pattern	N	M	M	N	M
Reinforcement	Longitudinal Bar	Dimensions	N	M	M	N	M
Reinforcement	Longitudinal Bar	End Conditions	N	M	M	N	M
Reinforcement	Longitudinal Bar	Material	N	M	M	N	M
Reinforcement	Transverse Reinforcement	Properties	N	M	M	N	M
Reinforcement	Transverse Reinforcement	Pattern	N	M	M	N	M
Reinforcement	Transverse Reinforcement	Dimensions	N	M	M	N	M
Reinforcement	Transverse Reinforcement	End Conditions	N	M	M	N	M
Reinforcement	Transverse Reinforcement	Material	N	M	M	N	M

Information Group	Information Items	Attribute Set	Final Roadway Geometry Model EM.FD/TE-SE	Final Structural Model EM.FD/D-E	Contract Model EM.BL/SE-D-E-CM-CE	Erection Analysis Model EM.CD/CE-F-CM	Final Detailing Model EM.F/D-F
Reinforcement	Accessories	Chairs	N	M	M	N	M
Reinforcement	Accessories	Support bars	N	M	M	N	M
Reinforcement	Accessories	Standees	N	M	M	N	M
Reinforcement	Structural component reinforcement	Properties	N	M	M	N	M
Reinforcement	Structural component reinforcement	Dimensions	N	M	M	N	M
Reinforcement	Structural component reinforcement	Calculations	N	M	M	N	M
Reinforcement	Structural component reinforcement	Bar mark	N	M	M	N	M
Reinforcement	Prestressing	Pattern	N	M	M	N	M
Reinforcement	Prestressing	Properties	N	M	M	N	M
Reinforcement	Prestressing	Duct properties	N	M	M	N	M
Reinforcement	Prestressing	Calculations	N	M	M	N	M
Reinforcement	Prestressing	Prestressing properties	N	M	M	N	M
Reinforcement	Post-Tensioning	Properties	N	M	M	N	M
Reinforcement	Post-Tensioning	Dimensions	N	M	M	N	M
Reinforcement	Post-Tensioning	Calculations	N	M	M	N	M

Information Group	Information Items	Attribute Set	Final Roadway Geometry Model EM.FD/TE-SE	Final Structural Model EM.FD/D-E	Contract Model EM.BL/SE-D-E-CM-CE	Erection Analysis Model EM.CD/CE-F-CM	Final Detailing Model EM.F/D-F
Reinforcement	Post-Tensioning	PT Hardware	N	M	M	N	M
Reinforcement	Post-Tensioning	Spliced Girders	N	M	M	N	M

The Exchange Model Specification Table in Excel format is attached as an appendix to this Information Delivery Manual.

SECTION 6 DATA DICTIONARY

Information Group	Information Items	Attribute Sets	Attributes
Project information	Identification	Identification numbers	Project Identification Number (PIN)
Project information	Identification	Identification numbers	Bridge Identification Number (BIN)
Project information	Identification	Identification numbers	Contract number
Project information	Identification	Names	Project name
Project information	Identification	Names	Bridge name
Project information	Identification	Names	Bridge alternative name (current)
Project information	Identification	Names	Bridge alternative name (existing)
Project information	Identification	Over roadway identities	State highway name and number
Project information	Identification	Over roadway identities	Route number
Project information	Identification	Over roadway identities	Local road number/name
Project information	Identification	Over roadway identities	Functional classification
Project information	Identification	Over roadway identities	Design classification
Project information	Identification	Under feature identities	State highway name and number
Project information	Identification	Under feature identities	Route number
Project information	Identification	Under feature identities	Local road number/name
Project information	Identification	Under feature identities	Functional classification
Project information	Identification	Under feature identities	River name
Project information	Location	Places	State

Information Group	Information Items	Attribute Sets	Attributes
Project information	Location	Places	Region
Project information	Location	Places	County
Project information	Location	Places	District
Project information	Location	Places	Town
Project information	Location	Places	City/Village
Project information	Location	Places	Name of USGS quadrangle
Project information	Location	Coordinates	Project start coordinates
Project information	Location	Coordinates	Project end coordinates
Project information	Location	Coordinates	Latitude
Project information	Location	Coordinates	Longitude
Project information	Location	Coordinates	Site Issues
Project information	Meta data	Associated stakeholders	Project manager
Project information	Meta data	Associated stakeholders	Project developer
Project information	Meta data	Associated stakeholders	Owner
Project information	Meta data	Associated stakeholders	Regional director
Project information	Meta data	Associated stakeholders	Designer
Project information	Meta data	Associated stakeholders	Reviewer
Project information	Meta data	Associated stakeholders	Drafter
Project information	Meta data	Associated stakeholders	Consultant
Project information	Meta data	Associated stakeholders	Design approval grantor
Project information	Meta data	Associated stakeholders	Engineer-in-charge

Information Group	Information Items	Attribute Sets	Attributes
Project information	Meta data	Associated stakeholders	Contractor
Project information	Meta data	Associated stakeholders	Subcontractor
Project information	Meta data	Associated stakeholders	Detailer
Project information	Meta data	Associated stakeholders	Manufacturer
Project information	Meta data	Associated stakeholders	Maintainer
Project information	Meta data	Associated stakeholders	Foreman
Project information	Meta data	Associated stakeholders	Crane operator
Project information	Meta data	Associated stakeholders	Welders
Project information	Meta data	Dates	PS&E Date
Project information	Meta data	Dates	Prepared on
Project information	Meta data	Dates	Altered on
Project information	Meta data	Dates	Year built
Project information	Meta data	Dates	Review started date
Project information	Meta data	Dates	Review completed date
Project information	Meta data	Dates	Project letting date
Project information	Meta data	Status	Approval status
Project information	Meta data	Status	Design status
Project information	Meta data	Status	Construction status
Project information	Meta data	Status	Production status
Project information	Meta data	Status	Fabrication status
Project information	Meta data	Status	Approval status

Information Group	Information Items	Attribute Sets	Attributes
Project information	Meta data	Status	Life cycle stage
Project information	Project descriptions	Design data	Recent ADTT
Project information	Project descriptions	Design data	Design speed
Project information	Project descriptions	Design data	AADT
Project information	Project descriptions	Design data	AADT year
Project information	Project descriptions	Design data	Percent trucks
Project information	Project descriptions	Design data	Design year
Project information	Project descriptions	Design data	Average humidity
Project information	Project descriptions	Design data	Number of lanes available to trucks
Project information	Project descriptions	Design specifications	Design code
Project information	Project descriptions	Design specifications	State specifications
Project information	Project descriptions	System of units	Metric system
Project information	Project descriptions	System of units	Imperial system
Project information	Project descriptions	Indicators	Mpf reduce based on ADTT Indicator
Project information	Project descriptions	Indicators	National highway system indicator
Project information	Project descriptions	Indicators	Template indicator
Project information	Project descriptions	Miscellaneous information	Project type
Project information	Project descriptions	Miscellaneous information	Final Cost
Project information	Project descriptions	Miscellaneous information	Project description
Project information	Project descriptions	Miscellaneous information	Feature intersected
Project information	Project descriptions	Miscellaneous information	Facility carried

Information Group	Information Items	Attribute Sets	Attributes
Project information	Project descriptions	Miscellaneous information	Site Survey
Project information	Project descriptions	Environmental information	NEPA Class
Project information	Project descriptions	Environmental information	SEQR Type
Roadway geometry	Horizontal alignment	Types	Tangent
Roadway geometry	Horizontal alignment	Types	Circular
Roadway geometry	Horizontal alignment	Types	Spiral
Roadway geometry	Horizontal alignment	Lines	Horizontal Control Line (HCL)
Roadway geometry	Horizontal alignment	Lines	Baseline
Roadway geometry	Horizontal alignment	Lines	Centerline
Roadway geometry	Horizontal alignment	Stations	Point of curvature (P.C.)
Roadway geometry	Horizontal alignment	Stations	Point of tangency (P.T.)
Roadway geometry	Horizontal alignment	Stations	Point of Continuing Curve (P.C.C.)
Roadway geometry	Horizontal alignment	Stations	Tangent to spiral point (T.S.)
Roadway geometry	Horizontal alignment	Stations	Spiral to tangent point (S.T.)
Roadway geometry	Horizontal alignment	Stations	Spiral to curve point (S.C.)
Roadway geometry	Horizontal alignment	Stations	Curve to spiral point (C.S.)
Roadway geometry	Horizontal alignment	Stations	Point of rotation (POR)
Roadway geometry	Horizontal alignment	Stations	Point of intersection
Roadway geometry	Horizontal alignment	Stations	Equality station
Roadway geometry	Horizontal alignment	Azimuths	Azimuth
Roadway geometry	Horizontal alignment	Lengths	Length of circular curve, Lc

Information Group	Information Items	Attribute Sets	Attributes
Roadway geometry	Horizontal alignment	Lengths	Length of spiral, Ls
Roadway geometry	Horizontal alignment	Lengths	Tangent length
Roadway geometry	Horizontal alignment	Radii	Radius
Roadway geometry	Horizontal alignment	Directions	Direction
Roadway geometry	Vertical profile	Types	Tangent
Roadway geometry	Vertical profile	Types	Parabolic
Roadway geometry	Vertical profile	Lines	Vertical control line
Roadway geometry	Vertical profile	Lines	Profile grade line (PGL)
Roadway geometry	Vertical profile	Stations	Point of Vertical Intersection (PVI)
Roadway geometry	Vertical profile	Stations	Point of Vertical Curvature (PVC)
Roadway geometry	Vertical profile	Stations	Point of Vertical Tangency (PVT)
Roadway geometry	Vertical profile	Elevations	Elevation
Roadway geometry	Vertical profile	Lengths	Length of vertical curve
Roadway geometry	Vertical profile	Grades	G1
Roadway geometry	Vertical profile	Grades	G2
Roadway geometry	Vertical profile	Roadway information	Stopping Sight Distance (S.S.D.)
Roadway geometry	Vertical profile	Roadway information	C.C.
Roadway geometry	Vertical profile	Topographies	Existing topography
Roadway geometry	Vertical profile	Topographies	Adjacent topography
Roadway geometry	Cross-section	Geometries	Left edge to H.C.L./T.G.L
Roadway geometry	Cross-section	Geometries	H.C.L./T.G.L. to right edge

Information Group	Information Items	Attribute Sets	Attributes
Roadway geometry	Cross-section	Stations	Station
Roadway geometry	Cross-section	Slopes	Slope
Roadway geometry	Cross-section	Widths	Out-to-out width
Roadway geometry	Cross-section	Offsets	Centerline offset from H.C.L.
Roadway geometry	Cross-section	Offsets	Crown offset from H.C.L.
Roadway geometry	Cross-section	Lane information	Number of lanes
Roadway geometry	Cross-section	Lane information	Lane width
Roadway geometry	Cross-section	Lane information	Centerline of lane offset from H.C.L
Roadway geometry	Cross-section	Shoulder information	Number of shoulders
Roadway geometry	Cross-section	Shoulder information	Shoulder width
Roadway geometry	Cross-section	Shoulder information	Centerline of shoulder offset from H.C.L
Roadway structure	Approach slabs	Property	Slab name
Roadway structure	Approach slabs	Property	GUID
Roadway structure	Approach slabs	Location	Station at approach slab begins
Roadway structure	Approach slabs	Location	Station at approach slab ends
Roadway structure	Approach slabs	Location	Skew angle at approach slab begins
Roadway structure	Approach slabs	Location	Skew angle at approach slab ends
Roadway structure	Approach slabs	Dimension	Cross section name
Roadway structure	Approach slabs	Dimension	Slab effective thickness
Roadway structure	Approach slabs	Dimension	Slab sacrificial thickness
Roadway structure	Approach slabs	Material	Slab material designation

Information Group	Information Items	Attribute Sets	Attributes
Roadway structure	Approach slabs	Protective sealant	Sealant type
Roadway structure	Approach slabs	Protective sealant	Sealant thickness
Bridge layout	Bridge control information	Station	Station at road work begins
Bridge layout	Bridge control information	Station	Station at pavement begins
Bridge layout	Bridge control information	Station	Station at bridge begins
Bridge layout	Bridge control information	Station	Station at centerline of bearings at begin abutment
Bridge layout	Bridge control information	Station	Station at centerline of bearings at pier
Bridge layout	Bridge control information	Station	Station at centerline of bearings at end abutment
Bridge layout	Bridge control information	Station	Station at bridge ends
Bridge layout	Bridge control information	Station	Station at pavement ends
Bridge layout	Bridge control information	Station	Station at road work ends
Bridge layout	Bridge control information	Azimuths	Azimuth at begin abutment
Bridge layout	Bridge control information	Azimuths	Azimuth at pier
Bridge layout	Bridge control information	Azimuths	Azimuth at end abutment
Bridge layout	Bridge control information	Slew angles	Skew angle at begin abutment
Bridge layout	Bridge control information	Slew angles	Skew angle at pier
Bridge layout	Bridge control information	Slew angles	Skew angle at end abutment
Bridge layout	Bridge configuration	Span	Number of spans
Bridge layout	Bridge configuration	Span	Number of supports
Bridge layout	Bridge configuration	Length	Bridge length
Bridge layout	Bridge configuration	Length	Pier to pier length

Information Group	Information Items	Attribute Sets	Attributes
Bridge layout	Bridge configuration	Length	Precast girder length
Bridge layout	Bridge configuration	Length	Bearing to bearing length
Bridge layout	Bridge configuration	Length	Release span length
Bridge layout	Bridge configuration	Length	Pier centerline to precast beam end
Bridge layout	Bridge configuration	Clearance	Minimum vertical clearance
Bridge layout	Bridge configuration	Clearance	Minimum horizontal clearance
Bridge superstructure	Deck	Property	Deck name
Bridge superstructure	Deck	Property	GUID
Bridge superstructure	Deck	Location	Station at deck begins
Bridge superstructure	Deck	Location	Station at deck ends
Bridge superstructure	Deck	Location	Skew angle at deck begins
Bridge superstructure	Deck	Location	Skew angle at deck ends
Bridge superstructure	Deck	Dimension	Cross section name
Bridge superstructure	Deck	Dimension	Deck effective thickness
Bridge superstructure	Deck	Dimension	Deck sacrificial thickness
Bridge superstructure	Deck	Dimension	Deck out-to-out width
Bridge superstructure	Deck	Material	Deck material designation
Bridge superstructure	Deck	Overhang	Deck overhang thickness
Bridge superstructure	Deck	Overhang	Deck overhang width
Bridge superstructure	Deck	Reinforcement	Reinforcing steel area
Bridge superstructure	Deck	Reinforcement	Reinforcing steel centroid location

Information Group	Information Items	Attribute Sets	Attributes
Bridge superstructure	Haunch	Property	Haunch name
Bridge superstructure	Haunch	Property	GUID
Bridge superstructure	Haunch	Location	Station at start of span
Bridge superstructure	Haunch	Location	Station at end of span
Bridge superstructure	Haunch	Dimension	Haunch width
Bridge superstructure	Haunch	Dimension	Haunch thickness
Bridge superstructure	Haunch	Dimension	Required bottom of slab elevation
Bridge superstructure	Haunch	Dimension	Top of steel elevation (field measure)
Bridge superstructure	Haunch	Dimension	Concrete + S.D.L. deflection
Bridge superstructure	Haunch	Material	Haunch material designation
Bridge superstructure	Girder layout	Properties	Girder name
Bridge superstructure	Girder layout	Properties	GUID
Bridge superstructure	Girder layout	Properties	Girder section type
Bridge superstructure	Girder layout	Properties	Girder geometric type
Bridge superstructure	Girder layout	Properties	Number of girders
Bridge superstructure	Girder layout	Properties	Precast girder length
Bridge superstructure	Girder layout	Properties	Section orientation
Bridge superstructure	Girder layout	Spacings	Girder spacing at start of span
Bridge superstructure	Girder layout	Spacings	Girder spacing at end of span
Bridge superstructure	Girder layout	Location	Station at start of span
Bridge superstructure	Girder layout	Location	Station at end of span

Information Group	Information Items	Attribute Sets	Attributes
Bridge superstructure	Girder layout	Location	Skew angle at start of span
Bridge superstructure	Girder layout	Location	Skew angle at end of span
Bridge superstructure	Girder layout	Location	Centerline offset from HCL at start of span
Bridge superstructure	Girder layout	Location	Centerline offset from HCL at end of span
Bridge superstructure	Concrete girder properties	Concrete girder properties	Concrete girder section
Bridge superstructure	Concrete girder properties	Concrete girder properties	Concrete girder section area
Bridge superstructure	Concrete girder properties	Concrete girder properties	Concrete girder height
Bridge superstructure	Concrete girder properties	Concrete girder material	Concrete girder material designation
Bridge superstructure	Steel girder properties	Steel girder properties	Steel girder section at start of span
Bridge superstructure	Steel girder properties	Steel girder properties	Steel girder section at end of span
Bridge superstructure	Steel girder properties	Steel girder properties	Web variation type
Bridge superstructure	Steel girder properties	Steel girder properties	Steel girder section area
Bridge superstructure	Steel girder properties	Steel girder properties	Steel girder height
Bridge superstructure	Steel girder properties	Steel girder material	Steel girder material designation
Bridge superstructure	Steel girder properties	Top flange properties	Top flange plate thickness
Bridge superstructure	Steel girder properties	Top flange properties	Top flange plate width
Bridge superstructure	Steel girder properties	Top flange properties	Top flange plate length
Bridge superstructure	Steel girder properties	Top flange properties	Top flange plate material
Bridge superstructure	Steel girder properties	Top flange properties	Top flange piece mark
Bridge superstructure	Steel girder properties	Top flange properties	Top flange shipping mark
Bridge superstructure	Steel girder properties	Top flange properties	Top flange set-back dimension
Bridge superstructure	Steel girder properties	Top flange properties	Top flange CVN testing indicator
Bridge superstructure	Steel girder properties	Top flange properties	Top flange Fracture Critical Material indicator

Information Group	Information Items	Attribute Sets	Attributes
Bridge superstructure	Steel girder properties	Bottom flange properties	Bottom flange plate thickness
Bridge superstructure	Steel girder properties	Bottom flange properties	Bottom flange plate width
Bridge superstructure	Steel girder properties	Bottom flange properties	Bottom flange plate length
Bridge superstructure	Steel girder properties	Bottom flange properties	Bottom flange plate material
Bridge superstructure	Steel girder properties	Bottom flange properties	Bottom flange piece mark
Bridge superstructure	Steel girder properties	Bottom flange properties	Bottom flange shipping mark
Bridge superstructure	Steel girder properties	Bottom flange properties	Bottom flange set-back dimension
Bridge superstructure	Steel girder properties	Bottom flange properties	Bottom flange CVN testing indicator
Bridge superstructure	Steel girder properties	Bottom flange properties	Bottom flange Fracture Critical Material indicator
Bridge superstructure	Steel girder properties	Web properties	Web plate thickness
Bridge superstructure	Steel girder properties	Web properties	Web plate depth
Bridge superstructure	Steel girder properties	Web properties	Web plate length
Bridge superstructure	Steel girder properties	Web properties	Web plate material
Bridge superstructure	Steel girder properties	Web properties	Web piece mark
Bridge superstructure	Steel girder properties	Web properties	Web shipping mark
Bridge superstructure	Steel girder properties	Web properties	Web set-back dimension
Bridge superstructure	Steel girder properties	Web properties	Web CVN testing indicator
Bridge superstructure	Steel girder properties	Web properties	Web Fracture Critical Material indicator
Bridge superstructure	Steel girder properties	Web camber	Top line dimension (TL)
Bridge superstructure	Steel girder properties	Web camber	Bottom line dimension (BL)
Bridge superstructure	Steel girder properties	Web camber	Left end cut (LE)
Bridge superstructure	Steel girder properties	Web camber	Right end cut (RE)
Bridge superstructure	Steel girder properties	Web camber	WD1

Information Group	Information Items	Attribute Sets	Attributes
Bridge superstructure	Steel girder properties	Web camber	WX1
Bridge superstructure	Steel girder properties	Web camber	TBL
Bridge superstructure	Steel girder properties	Web camber	TBR
Bridge superstructure	Steel girder properties	Web camber	BBL
Bridge superstructure	Steel girder properties	Web camber	BBR
Bridge superstructure	Steel girder properties	Web camber	LD
Bridge superstructure	Steel girder properties	Web camber	Camber ordinate
Bridge superstructure	Steel girder properties	Girder bill information	Page number
Bridge superstructure	Steel girder properties	Girder bill information	Line number
Bridge superstructure	Steel girder properties	Haunch properties	Haunch at supports
Bridge superstructure	Steel girder properties	Haunch properties	Haunch at 10th points
Bridge superstructure	Bearing	Layout	Number of bearing
Bridge superstructure	Bearing	Layout	Bearing spacing
Bridge superstructure	Bearing	Layout	Distance from centerline of bearing to centerline of support
Bridge superstructure	Bearing	Layout	Centerline of bearing offset from HCL
Bridge superstructure	Bearing	Layout	GUID
Bridge superstructure	Bearing	Properties	Bearing name
Bridge superstructure	Bearing	Properties	Bearing support condition
Bridge superstructure	Bearing	Properties	Bearing type
Bridge superstructure	Bearing	Properties	Bearing station
Bridge superstructure	Bearing	Properties	Bearing bottom elevation
Bridge superstructure	Bearing	Elastomeric bearing properties	Elastomeric bearing type
Bridge superstructure	Bearing	Elastomeric bearing properties	Elastomeric bearing shape

Information Group	Information Items	Attribute Sets	Attributes
Bridge superstructure	Bearing	Elastomeric bearing properties	Elastomeric pad diameter
Bridge superstructure	Bearing	Elastomeric bearing properties	Elastomeric pad width
Bridge superstructure	Bearing	Elastomeric bearing properties	Elastomeric pad height
Bridge superstructure	Bearing	Elastomeric bearing properties	Elastomeric pad length
Bridge superstructure	Bearing	Elastomeric bearing properties	Elastomeric pad material designation
Bridge superstructure	Bearing	Elastomeric bearing properties	Number of steel shims
Bridge superstructure	Bearing	Elastomeric bearing properties	Steel shim spacing
Bridge superstructure	Bearing	Elastomeric bearing properties	Steel shim clear cover
Bridge superstructure	Bearing	Elastomeric bearing properties	Steel shim width
Bridge superstructure	Bearing	Elastomeric bearing properties	Steel shim height
Bridge superstructure	Bearing	Elastomeric bearing properties	Steel shim length
Bridge superstructure	Bearing	Elastomeric bearing properties	Steel shim material designation
Bridge superstructure	Bearing	Elastomeric bearing properties	Hole diameter
Bridge superstructure	Bearing	Elastomeric bearing properties	Slot length
Bridge superstructure	Bearing	Sliding bearing properties	Sliding bearing shape
Bridge superstructure	Bearing	Sliding bearing properties	Sliding bearing diameter
Bridge superstructure	Bearing	Sliding bearing properties	Sliding bearing width
Bridge superstructure	Bearing	Sliding bearing properties	Sliding bearing height
Bridge superstructure	Bearing	Sliding bearing properties	Sliding bearing material designation
Bridge superstructure	Bearing	Sliding bearing properties	Sliding surface type
Bridge superstructure	Cross frame and diaphragm	Properties	Cross frame name
Bridge superstructure	Cross frame and diaphragm	Properties	Cross frame piece mark
Bridge superstructure	Cross frame and diaphragm	Properties	Cross frame shipping mark

Information Group	Information Items	Attribute Sets	Attributes
Bridge superstructure	Cross frame and diaphragm	Properties	Cross frame type
Bridge superstructure	Cross frame and diaphragm	Properties	Top chord section
Bridge superstructure	Cross frame and diaphragm	Properties	Bottom chord section
Bridge superstructure	Cross frame and diaphragm	Properties	Diagonal section
Bridge superstructure	Cross frame and diaphragm	Properties	Cross frame quantity
Bridge superstructure	Cross frame and diaphragm	Properties	Cross frame drop
Bridge superstructure	Cross frame and diaphragm	Properties	Cross frame weight
Bridge superstructure	Cross frame and diaphragm	Properties	Cross frame finish
Bridge superstructure	Cross frame and diaphragm	Properties	GUID
Bridge superstructure	Cross frame and diaphragm	Layout	Distance from support
Bridge superstructure	Cross frame and diaphragm	Layout	Number of cross frames
Bridge superstructure	Cross frame and diaphragm	Layout	Number of spaces
Bridge superstructure	Cross frame and diaphragm	Layout	Spacing
Bridge superstructure	Cross frame and diaphragm	Layout	Angle
Bridge superstructure	Cross frame and diaphragm	Dimensions	Top chord length
Bridge superstructure	Cross frame and diaphragm	Dimensions	Bottom chord length
Bridge superstructure	Cross frame and diaphragm	Dimensions	Diagonal chord length
Bridge superstructure	Cross frame and diaphragm	Dimensions	Distance between top work point and top of girder
Bridge superstructure	Cross frame and diaphragm	Dimensions	Distance between bottom work point and bottom of girder
Bridge superstructure	Cross frame and diaphragm	Dimensions	Set-back dimension
Bridge superstructure	Cross frame and diaphragm	Dimensions	Rounded dimension
Bridge superstructure	Cross frame and diaphragm	Dimensions	Slopes

Information Group	Information Items	Attribute Sets	Attributes
Bridge superstructure	Cross frame and diaphragm	Dimensions	Cut to length
Bridge superstructure	Cross frame and diaphragm	Indicators	CVN testing indicator
Bridge superstructure	Cross frame and diaphragm	Indicators	Fracture Critical Material indicator
Bridge superstructure	Cross frame and diaphragm	Work point definition	Horizontal distance between WPs
Bridge superstructure	Cross frame and diaphragm	Work point definition	Vertical distance between WPs
Bridge superstructure	Cross frame and diaphragm	Work point definition	Distance between WPs along slope
Bridge superstructure	Cross frame and diaphragm	Notes	Bolts
Bridge superstructure	Cross frame and diaphragm	Notes	Paint
Bridge superstructure	Cross frame and diaphragm	Bill information	Page number
Bridge superstructure	Cross frame and diaphragm	Bill information	Line number
Bridge superstructure	Sidewalk	Properties	Name
Bridge superstructure	Sidewalk	Properties	Description
Bridge superstructure	Sidewalk	Properties	Section
Bridge superstructure	Sidewalk	Properties	Connecting members
Bridge superstructure	Sidewalk	Properties	GUID
Bridge superstructure	Sidewalk	Material	Material designation
Bridge superstructure	Sidewalk	Layout	Length
Bridge superstructure	Sidewalk	Layout	Width
Bridge superstructure	Sidewalk	Layout	Location
Bridge superstructure	Sidewalk	Load	Additional load
Bridge superstructure	Sidewalk	Load	Distance to additional load
Bridge superstructure	Barrier	Properties	Name
Bridge superstructure	Barrier	Properties	Description

Information Group	Information Items	Attribute Sets	Attributes
Bridge superstructure	Barrier	Properties	Section
Bridge superstructure	Barrier	Properties	Connecting members
Bridge superstructure	Barrier	Properties	GUID
Bridge superstructure	Barrier	Material	Material designation
Bridge superstructure	Barrier	Layout	Length
Bridge superstructure	Barrier	Layout	Location
Bridge superstructure	Barrier	Load	Additional load
Bridge superstructure	Barrier	Load	Distance to additional load
Bridge superstructure	Parapet	Properties	Name
Bridge superstructure	Parapet	Properties	Description
Bridge superstructure	Parapet	Properties	Section
Bridge superstructure	Parapet	Properties	Connecting members
Bridge superstructure	Parapet	Properties	GUID
Bridge superstructure	Parapet	Material	Material designation
Bridge superstructure	Parapet	Layout	Length
Bridge superstructure	Parapet	Layout	Location
Bridge superstructure	Parapet	Load	Additional load
Bridge superstructure	Parapet	Load	Distance to additional load
Bridge superstructure	Median	Properties	Name
Bridge superstructure	Median	Properties	Description
Bridge superstructure	Median	Properties	Section
Bridge superstructure	Median	Properties	Connecting members
Bridge superstructure	Median	Properties	GUID

Information Group	Information Items	Attribute Sets	Attributes
Bridge superstructure	Median	Properties	Material designation
Bridge superstructure	Median	Properties	Length
Bridge superstructure	Median	Properties	Location
Bridge superstructure	Median	Load	Additional load
Bridge superstructure	Median	Load	Distance to additional load
Bridge superstructure	Railing	Properties	Name
Bridge superstructure	Railing	Properties	Description
Bridge superstructure	Railing	Properties	Section
Bridge superstructure	Railing	Properties	Connecting members
Bridge superstructure	Railing	Properties	GUID
Bridge superstructure	Railing	Material	Material designation
Bridge superstructure	Railing	Layout	Length
Bridge superstructure	Railing	Layout	Location
Bridge superstructure	Railing	Load	Additional load
Bridge superstructure	Railing	Load	Distance to additional load
Bridge substructure	Pedestal	Properties	Pedestal name
Bridge substructure	Pedestal	Properties	Pedestal description
Bridge substructure	Pedestal	Properties	GUID
Bridge substructure	Pedestal	Location	Station at pedestal location
Bridge substructure	Pedestal	Location	Skew angle at pedestal location
Bridge substructure	Pedestal	Location	Elevation at the upper surface
Bridge substructure	Pedestal	Location	Elevation at the bottom surface
Bridge substructure	Pedestal	Dimensions	Pedestal length

Information Group	Information Items	Attribute Sets	Attributes
Bridge substructure	Pedestal	Dimensions	Pedestal width
Bridge substructure	Pedestal	Dimensions	Pedestal depth
Bridge substructure	Pedestal	Materials	Pedestal material designation
Bridge substructure	Cap beam	Properties	Cap beam name
Bridge substructure	Cap beam	Properties	Cap beam description
Bridge substructure	Cap beam	Properties	GUID
Bridge substructure	Cap beam	Location	Station at cap beam location
Bridge substructure	Cap beam	Location	Skew angle at cap beam location
Bridge substructure	Cap beam	Location	Elevation at the left end
Bridge substructure	Cap beam	Location	Elevation at the right end
Bridge substructure	Cap beam	Dimensions	Cap beam length
Bridge substructure	Cap beam	Dimensions	Cap beam width
Bridge substructure	Cap beam	Dimensions	Cap beam thickness
Bridge substructure	Cap beam	Dimensions	Cap beam depth
Bridge substructure	Cap beam	Dimensions	Top offset
Bridge substructure	Cap beam	Dimensions	Fillet radius
Bridge substructure	Cap beam	Dimensions	Horizontal chamfer
Bridge substructure	Cap beam	Dimensions	Vertical chamfer
Bridge substructure	Cap beam	Tapered cap beam dimensions	Length of non-tapered segment
Bridge substructure	Cap beam	Tapered cap beam dimensions	Cap beam minimum depth
Bridge substructure	Cap beam	Tapered cap beam dimensions	Cap beam maximum depth
Bridge substructure	Cap beam	Stepped cap beam dimensions	Number of steps
Bridge substructure	Cap beam	Stepped cap beam dimensions	Step length

Information Group	Information Items	Attribute Sets	Attributes
Bridge substructure	Cap beam	Stepped cap beam dimensions	Step depth
Bridge substructure	Cap beam	Stepped cap beam dimensions	Elevation of top of step
Bridge substructure	Cap beam	Stepped cap beam dimensions	Elevation of bottom of step
Bridge substructure	Cap beam	Inverted T cap beam dimensions	Stem width
Bridge substructure	Cap beam	Inverted T cap beam dimensions	Ledge width
Bridge substructure	Cap beam	Inverted T cap beam dimensions	Stem depth
Bridge substructure	Cap beam	Inverted T cap beam dimensions	Ledge depth
Bridge substructure	Cap beam	Material	Cap beam material designation
Bridge substructure	Hammer head	Properties	Hammer head name
Bridge substructure	Hammer head	Properties	Hammer head description
Bridge substructure	Hammer head	Properties	GUID
Bridge substructure	Hammer head	Location	Station at hammer head location
Bridge substructure	Hammer head	Location	Skew angle at hammer head location
Bridge substructure	Hammer head	Dimensions	Hammer head profile
Bridge substructure	Hammer head	Dimensions	Hammer head top elevation
Bridge substructure	Hammer head	Void dimensions	Void top width
Bridge substructure	Hammer head	Void dimensions	Void bottom width
Bridge substructure	Hammer head	Void dimensions	Void depth
Bridge substructure	Hammer head	Material	Hammer head material designation
Bridge substructure	Pier column	Properties	Pier column name
Bridge substructure	Pier column	Properties	Pier column description
Bridge substructure	Pier column	Properties	Number of columns
Bridge substructure	Pier column	Properties	Spacing of columns

Information Group	Information Items	Attribute Sets	Attributes
Bridge substructure	Pier column	Properties	GUID
Bridge substructure	Pier column	Location	Station at pier column location
Bridge substructure	Pier column	Location	Skew angle at pier column location
Bridge substructure	Pier column	Location	Elevation at the top of pier column
Bridge substructure	Pier column	Location	Elevation at the bottom of pier column
Bridge substructure	Pier column	Dimensions	Pier column diameter
Bridge substructure	Pier column	Dimensions	Pier column width
Bridge substructure	Pier column	Dimensions	Pier column depth
Bridge substructure	Pier column	Dimensions	Pier column length
Bridge substructure	Pier column	Dimensions	Chamfer
Bridge substructure	Pier column	Dimensions	Fillet radius
Bridge substructure	Pier column	Support condition	Pier column top fixity
Bridge substructure	Pier column	Support condition	Pier column bottom fixity
Bridge substructure	Pier column	Support condition	Pier column Kx
Bridge substructure	Pier column	Support condition	Pier column Ky
Bridge substructure	Pier column	Support condition	Pier column Kz
Bridge substructure	Pier column	Support condition	Pier column Rx
Bridge substructure	Pier column	Support condition	Pier column Ry
Bridge substructure	Pier column	Support condition	Pier column Rz
Bridge substructure	Pier column	Materials	Pier column material designation
Bridge substructure	Wall pier	Properties	Wall pier name
Bridge substructure	Wall pier	Properties	Wall pier description
Bridge substructure	Wall pier	Properties	GUID

Information Group	Information Items	Attribute Sets	Attributes
Bridge substructure	Wall pier	Location	Station at wall pier location
Bridge substructure	Wall pier	Location	Skew angle at wall pier location
Bridge substructure	Wall pier	Location	Elevation at the upper left corner
Bridge substructure	Wall pier	Location	Elevation at the upper right corner
Bridge substructure	Wall pier	Dimensions	Wall pier thickness
Bridge substructure	Wall pier	Dimensions	Wall pier depth
Bridge substructure	Wall pier	Dimensions	Wall pier width
Bridge substructure	Wall pier	Dimensions	Fillet radius
Bridge substructure	Wall pier	Material	Wall pier material designation
Bridge substructure	Drilled shaft	Properties	Drilled shaft name
Bridge substructure	Drilled shaft	Properties	Drilled shaft description
Bridge substructure	Drilled shaft	Properties	Drilled shaft type
Bridge substructure	Drilled shaft	Properties	GUID
Bridge substructure	Drilled shaft	Location	Station at drilled shaft location
Bridge substructure	Drilled shaft	Location	Skew angle at drilled shaft location
Bridge substructure	Drilled shaft	Location	Elevation at the top of drilled shaft
Bridge substructure	Drilled shaft	Location	Elevation at the bottom of drilled shaft
Bridge substructure	Drilled shaft	Dimensions	Drilled shaft section
Bridge substructure	Drilled shaft	Dimensions	Drilled shaft diameter
Bridge substructure	Drilled shaft	Dimensions	Drilled shaft width
Bridge substructure	Drilled shaft	Dimensions	Drilled shaft depth
Bridge substructure	Drilled shaft	Dimensions	Drilled shaft length
Bridge substructure	Drilled shaft	Dimensions	Drilled shaft effective length

Information Group	Information Items	Attribute Sets	Attributes
Bridge substructure	Drilled shaft	Support condition	Drilled shaft top fixity
Bridge substructure	Drilled shaft	Support condition	Drilled shaft Kx
Bridge substructure	Drilled shaft	Support condition	Drilled shaft Ky
Bridge substructure	Drilled shaft	Support condition	Drilled shaft Kz
Bridge substructure	Drilled shaft	Support condition	Drilled shaft Rx
Bridge substructure	Drilled shaft	Support condition	Drilled shaft Ry
Bridge substructure	Drilled shaft	Support condition	Drilled shaft Rz
Bridge substructure	Drilled shaft	Material	Drilled shaft material designation
Bridge substructure	Pile	Properties	Pile name
Bridge substructure	Pile	Properties	Pile description
Bridge substructure	Pile	Properties	Pile type
Bridge substructure	Pile	Properties	GUID
Bridge substructure	Pile	Location	Station at pile location
Bridge substructure	Pile	Location	Skew angle at pile location
Bridge substructure	Pile	Location	Elevation at the top of pile
Bridge substructure	Pile	Location	Elevation at the bottom of pile
Bridge substructure	Pile	Dimensions	Pile section
Bridge substructure	Pile	Dimensions	Pile diameter
Bridge substructure	Pile	Dimensions	Pile width
Bridge substructure	Pile	Dimensions	Pile depth
Bridge substructure	Pile	Dimensions	Pile length
Bridge substructure	Pile	Dimensions	Pile effective length
Bridge substructure	Pile	Support condition	Pile top fixity

Information Group	Information Items	Attribute Sets	Attributes
Bridge substructure	Pile	Support condition	Pile Kx
Bridge substructure	Pile	Support condition	Pile Ky
Bridge substructure	Pile	Support condition	Pile Kz
Bridge substructure	Pile	Support condition	Pile Rx
Bridge substructure	Pile	Support condition	Pile Ry
Bridge substructure	Pile	Support condition	Pile Rz
Bridge substructure	Pile	Material	Pile material designation
Bridge substructure	Footing/pile	Properties	Footing name
Bridge substructure	Footing/pile	Properties	Footing description
Bridge substructure	Footing/pile	Properties	Footing type
Bridge substructure	Footing/pile	Properties	Number of footing
Bridge substructure	Footing/pile	Properties	GUID
Bridge substructure	Footing/pile	Location	Station at footing location
Bridge substructure	Footing/pile	Location	Skew angle at footing location
Bridge substructure	Footing/pile	Location	Elevation at the top of footing
Bridge substructure	Footing/pile	Location	Elevation at the bottom of footing
Bridge substructure	Footing/pile	Location	Center to center distance to the column
Bridge substructure	Footing/pile	Dimensions	Footing section
Bridge substructure	Footing/pile	Dimensions	Footing width
Bridge substructure	Footing/pile	Dimensions	Footing depth
Bridge substructure	Footing/pile	Dimensions	Footing spread/cap height
Bridge substructure	Footing/pile	Dimensions	Footing strap height
Bridge substructure	Footing/pile	Material	Footing material designation

Information Group	Information Items	Attribute Sets	Attributes
Bridge substructure	Wing wall/stem wall	Properties	Wall name
Bridge substructure	Wing wall/stem wall	Properties	Wall description
Bridge substructure	Wing wall/stem wall	Properties	Wall type
Bridge substructure	Wing wall/stem wall	Properties	GUID
Bridge substructure	Wing wall/stem wall	Location	Station at wall location
Bridge substructure	Wing wall/stem wall	Location	Skew angle at wall location
Bridge substructure	Wing wall/stem wall	Location	Top of wall elevation at start
Bridge substructure	Wing wall/stem wall	Location	Bottom of wall elevation at start
Bridge substructure	Wing wall/stem wall	Location	Top of wall elevation at end
Bridge substructure	Wing wall/stem wall	Location	Bottom of wall elevation at end
Bridge substructure	Wing wall/stem wall	Dimensions	Wall length
Bridge substructure	Wing wall/stem wall	Dimensions	Batter
Bridge substructure	Wing wall/stem wall	Dimensions	Wall width
Bridge substructure	Wing wall/stem wall	Dimensions	Wall depth
Bridge substructure	Wing wall/stem wall	Dimensions	Stem width
Bridge substructure	Wing wall/stem wall	Dimensions	Stem depth
Bridge substructure	Wing wall/stem wall	Material	Wall material designation
Bridge substructure	Wing wall/stem wall	Backfill	Backfill type
Fabrication	Fabrication information	General information	Fabrication type
Fabrication	Bridge information	Bridge layout	Sloping length between field splices
Fabrication	Bridge information	Bridge layout	Sloping length between cross frames
Fabrication	Bridge information	Bridge layout	Grade at begin abutment
Fabrication	Bridge information	Bridge layout	Grade at end abutment

Information Group	Information Items	Attribute Sets	Attributes
Fabrication	Bridge information	Bridge layout	Grade at pier
Fabrication	Horizontal curve	Horizontal curve dimensions	Arc length
Fabrication	Horizontal curve	Horizontal curve dimensions	Chord length
Fabrication	Horizontal curve	Horizontal curve dimensions	Curve ordinate
Fabrication	Horizontal curve	Horizontal curve dimensions	Radius
Fabrication	Member information	Member Identification	Assembly mark
Fabrication	Member information	Member Identification	Client mark
Fabrication	Member information	Member Identification	Preliminary mark
Fabrication	Member information	Member Identification	Shipping mark
Fabrication	Member information	Member Identification	Piece mark
Fabrication	Member information	Member Identification	Piece mark of adjacent member
Fabrication	Member information	Member Identification	Indication mark
Fabrication	Member information	Member Identification	Bar code
Fabrication	Member information	Member Identification	Mark location information
Fabrication	Member information	Member Identification	Mark piece tag
Fabrication	Member information	Member Identification	Purchase order number
Fabrication	Member information	Member Identification	Shop order number
Fabrication	Member information	Member Identification	Production stage (station) number
Fabrication	Stiffener	Properties	Stiffener name
Fabrication	Stiffener	Properties	Stiffener type
Fabrication	Stiffener	Properties	Transverse stiffener type
Fabrication	Stiffener	Properties	Stiffener piece mark
Fabrication	Stiffener	Properties	Stiffener shipping mark

Information Group	Information Items	Attribute Sets	Attributes
Fabrication	Stiffener	Properties	Stiffener end condition
Fabrication	Stiffener	Properties	Stiffener quantity
Fabrication	Stiffener	Properties	Stiffener weight
Fabrication	Stiffener	Properties	Stiffener finish
Fabrication	Stiffener	Properties	GUID
Fabrication	Stiffener	Layout	Longitudinal distance from support
Fabrication	Stiffener	Layout	Vertical distance to top of girder
Fabrication	Stiffener	Layout	Vertical distance to bottom of girder
Fabrication	Stiffener	Layout	Number of spaces
Fabrication	Stiffener	Layout	Spacing
Fabrication	Stiffener	Dimensions	Length
Fabrication	Stiffener	Dimensions	Width
Fabrication	Stiffener	Dimensions	Thickness
Fabrication	Stiffener	Dimensions	Top gap to flange
Fabrication	Stiffener	Dimensions	Bottom gap to flange
Fabrication	Stiffener	Dimensions	Theoretical gap to web
Fabrication	Stiffener	Dimensions	Bottom inside clip horizontal length
Fabrication	Stiffener	Dimensions	Bottom inside clip vertical length
Fabrication	Stiffener	Dimensions	Bottom outside clip length
Fabrication	Stiffener	Dimensions	Top inside clip horizontal length
Fabrication	Stiffener	Dimensions	Top inside clip vertical length
Fabrication	Stiffener	Dimensions	Top outside clip length
Fabrication	Stiffener	Dimensions	Snipe dimension

Information Group	Information Items	Attribute Sets	Attributes
Fabrication	Stiffener	Dimensions	Chip dimension
Fabrication	Stiffener	Dimensions	Slot size
Fabrication	Stiffener	Dimensions	No paint zone
Fabrication	Stiffener	Dimensions	Cut to length
Fabrication	Stiffener	Material	Stiffener material designation
Fabrication	Stiffener	Indicators	CVN testing indicator
Fabrication	Stiffener	Indicators	Fracture Critical Material indicator
Fabrication	Stiffener	Indicators	Plain indicator
Fabrication	Stiffener	Notes	Bolt
Fabrication	Stiffener	Notes	Paint
Fabrication	Stiffener	Bill information	Page number
Fabrication	Stiffener	Bill information	Line number
Fabrication	Stiffener	Weld properties	Top weld name
Fabrication	Stiffener	Weld properties	Bottom weld name
Fabrication	Stiffener	Weld properties	Web weld name
Fabrication	Field splice	Properties	Field splice name
Fabrication	Field splice	Properties	Field splice piece mark
Fabrication	Field splice	Properties	Field splice shipping mark
Fabrication	Field splice	Properties	Field splice location type
Fabrication	Field splice	Properties	Field splice quantity
Fabrication	Field splice	Properties	Field splice weight
Fabrication	Field splice	Properties	Field splice finish
Fabrication	Field splice	Properties	GUID

Information Group	Information Items	Attribute Sets	Attributes
Fabrication	Field splice	Properties	Faying surface class
Fabrication	Field splice	Layout	Longitudinal distance from support
Fabrication	Field splice	Layout	Vertical distance to top of girder
Fabrication	Field splice	Layout	Vertical distance to bottom of girder
Fabrication	Field splice	Layout	Minimum number of longitudinal bolt rows in the web
Fabrication	Field splice	Layout	Minimum number of longitudinal bolt rows in the flange
Fabrication	Field splice	Layout	Maximum variation to allow double shear on bolts
Fabrication	Field splice	Layout	Minimum lateral spacing of flange bolts across the web
Fabrication	Field splice	Layout	Girder clear gap
Fabrication	Field splice	Dimensions	Length
Fabrication	Field splice	Dimensions	Width
Fabrication	Field splice	Dimensions	Thickness
Fabrication	Field splice	Dimensions	No paint zone
Fabrication	Field splice	Dimensions	Cut to length
Fabrication	Field splice	Material	Field splice material designation
Fabrication	Field splice	Indicators	CVN testing indicator
Fabrication	Field splice	Indicators	Fracture Critical Material indicator
Fabrication	Field splice	Indicators	DOR indicator
Fabrication	Field splice	Notes	Bolt
Fabrication	Field splice	Notes	Paint
Fabrication	Field splice	Miscellaneous information	Bolting clearance
Fabrication	Field splice	Miscellaneous information	Gap between girders

Information Group	Information Items	Attribute Sets	Attributes
Fabrication	Field splice	Bill information	Page number
Fabrication	Field splice	Bill information	Line number
Fabrication	Field splice	Bolt properties	Bolt hole effective number
Fabrication	Field splice	Bolt properties	Bolt hole size
Fabrication	Connection plate	Properties	Connection plate name
Fabrication	Connection plate	Properties	Connection plate piece mark
Fabrication	Connection plate	Properties	Connection plate shipping mark
Fabrication	Connection plate	Properties	Connection plate type
Fabrication	Connection plate	Properties	Connection plate end condition
Fabrication	Connection plate	Properties	Connection plate quantity
Fabrication	Connection plate	Properties	Connection plate weight
Fabrication	Connection plate	Properties	Connection plate finish
Fabrication	Connection plate	Properties	GUID
Fabrication	Connection plate	Layout	Distance
Fabrication	Connection plate	Layout	Number of spaces
Fabrication	Connection plate	Layout	Spacing
Fabrication	Connection plate	Dimensions	Length
Fabrication	Connection plate	Dimensions	Width
Fabrication	Connection plate	Dimensions	Thickness
Fabrication	Connection plate	Dimensions	Top gap to flange
Fabrication	Connection plate	Dimensions	Bottom gap to flange
Fabrication	Connection plate	Dimensions	Theoretical gap to web
Fabrication	Connection plate	Dimensions	Bottom inside clip horizontal length

Information Group	Information Items	Attribute Sets	Attributes
Fabrication	Connection plate	Dimensions	Bottom inside clip vertical length
Fabrication	Connection plate	Dimensions	Bottom outside clip length
Fabrication	Connection plate	Dimensions	Top inside clip horizontal length
Fabrication	Connection plate	Dimensions	Top inside clip vertical length
Fabrication	Connection plate	Dimensions	Top outside clip length
Fabrication	Connection plate	Dimensions	Snipe dimension
Fabrication	Connection plate	Dimensions	Chip dimension
Fabrication	Connection plate	Dimensions	Slot size
Fabrication	Connection plate	Dimensions	No paint zone
Fabrication	Connection plate	Dimensions	Cut to length
Fabrication	Connection plate	Material	Connection plate material designation
Fabrication	Connection plate	Indicators	CVN testing indicator
Fabrication	Connection plate	Indicators	Fracture Critical Material indicator
Fabrication	Connection plate	Indicators	Plain indicator
Fabrication	Connection plate	Notes	Bolt
Fabrication	Connection plate	Notes	Paint
Fabrication	Connection plate	Bill information	Page number
Fabrication	Connection plate	Bill information	Line number
Fabrication	Connection plate	Weld properties	End weld name
Fabrication	Connection plate	Weld properties	Side weld name
Fabrication	Connection plate	Bolt properties	Bolt hole effective number
Fabrication	Connection plate	Bolt properties	Bolt hole size
Fabrication	Cover plate	Properties	Cover plate name

Information Group	Information Items	Attribute Sets	Attributes
Fabrication	Cover plate	Properties	Cover plate piece mark
Fabrication	Cover plate	Properties	Cover plate shipping mark
Fabrication	Cover plate	Properties	Cover plate end condition
Fabrication	Cover plate	Properties	Cover plate quantity
Fabrication	Cover plate	Properties	Cover plate weight
Fabrication	Cover plate	Properties	Cover plate finish
Fabrication	Cover plate	Properties	GUID
Fabrication	Cover plate	Layout	Longitudinal distance from support
Fabrication	Cover plate	Layout	Transverse distance from edge of flange
Fabrication	Cover plate	Dimensions	Length
Fabrication	Cover plate	Dimensions	Thickness
Fabrication	Cover plate	Dimensions	Width
Fabrication	Cover plate	Dimensions	No paint zone
Fabrication	Cover plate	Dimensions	Cut to length
Fabrication	Cover plate	Material	Cover plate material designation
Fabrication	Cover plate	Weld properties	End weld name
Fabrication	Cover plate	Weld properties	Side weld name
Fabrication	Cover plate	Bolt properties	Bolt hole effective number
Fabrication	Cover plate	Bolt properties	Bolt hole size
Fabrication	Gusset plate	Properties	Gusset plate name
Fabrication	Gusset plate	Properties	Gusset plate piece mark
Fabrication	Gusset plate	Properties	Gusset plate shipping mark
Fabrication	Gusset plate	Properties	Gusset plate quantity

Information Group	Information Items	Attribute Sets	Attributes
Fabrication	Gusset plate	Properties	Gusset plate weight
Fabrication	Gusset plate	Properties	Gusset plate finish
Fabrication	Gusset plate	Properties	GUID
Fabrication	Gusset plate	Layout	Longitudinal distance from support
Fabrication	Gusset plate	Layout	Transverse distance from edge of flange
Fabrication	Gusset plate	Dimensions	Length
Fabrication	Gusset plate	Dimensions	Width
Fabrication	Gusset plate	Dimensions	Thickness
Fabrication	Gusset plate	Dimensions	Slot size
Fabrication	Gusset plate	Dimensions	Horizontal clip dimension
Fabrication	Gusset plate	Dimensions	Vertical clip dimension
Fabrication	Gusset plate	Dimensions	No paint zone
Fabrication	Gusset plate	Dimensions	Cut to length
Fabrication	Gusset plate	Material	Gusset plate material designation
Fabrication	Gusset plate	Indicators	CVN testing indicator
Fabrication	Gusset plate	Indicators	Fracture Critical Material indicator
Fabrication	Gusset plate	Notes	Bolts
Fabrication	Gusset plate	Notes	Paint
Fabrication	Gusset plate	Bill information	Page number
Fabrication	Gusset plate	Bill information	Line number
Fabrication	Gusset plate	Weld properties	End weld name
Fabrication	Gusset plate	Weld properties	Side weld name
Fabrication	Gusset plate	Bolt properties	Bolt hole effective number

Information Group	Information Items	Attribute Sets	Attributes
Fabrication	Gusset plate	Bolt properties	Bolt hole size
Fabrication	Fill plate	Properties	Fill plate name
Fabrication	Fill plate	Properties	Fill plate piece mark
Fabrication	Fill plate	Properties	Fill plate shipping mark
Fabrication	Fill plate	Properties	Fill plate quantity
Fabrication	Fill plate	Properties	Fill plate weight
Fabrication	Fill plate	Properties	Fill plate finish
Fabrication	Fill plate	Properties	GUID
Fabrication	Fill plate	Layout	Longitudinal distance from support
Fabrication	Fill plate	Layout	Transverse distance from edge of flange
Fabrication	Fill plate	Dimensions	Length
Fabrication	Fill plate	Dimensions	Width
Fabrication	Fill plate	Dimensions	Thickness
Fabrication	Fill plate	Dimensions	Slot size
Fabrication	Fill plate	Dimensions	Horizontal clip dimension
Fabrication	Fill plate	Dimensions	Vertical clip dimension
Fabrication	Fill plate	Dimensions	No paint zone
Fabrication	Fill plate	Dimensions	Cut to length
Fabrication	Fill plate	Material	Fill plate material designation
Fabrication	Fill plate	Indicators	CVN testing indicator
Fabrication	Fill plate	Indicators	Fracture Critical Material indicator
Fabrication	Fill plate	Notes	Bolts
Fabrication	Fill plate	Notes	Paint

Information Group	Information Items	Attribute Sets	Attributes
Fabrication	Fill plate	Bill information	Page number
Fabrication	Fill plate	Bill information	Line number
Fabrication	Fill plate	Weld properties	End weld name
Fabrication	Fill plate	Weld properties	Side weld name
Fabrication	Fill plate	Bolt properties	Bolt hole effective number
Fabrication	Fill plate	Bolt properties	Bolt hole size
Fabrication	Feature	Hole	Relative location to critical surface
Fabrication	Feature	Hole	Location from end point
Fabrication	Feature	Hole	Through hole indicator
Fabrication	Feature	Hole	Hole length
Fabrication	Feature	Hole	Hole height
Fabrication	Feature	Hole	Fillet radius
Fabrication	Feature	Bolt hole	Type
Fabrication	Feature	Bolt hole	Hole diameter
Fabrication	Feature	Bolt hole	Hole fabrication method
Fabrication	Feature	Bolt hole	Horizontal hole spacing
Fabrication	Feature	Bolt hole	Vertical hole spacing
Fabrication	Feature	Bolt hole	Horizontal hole to edge distance
Fabrication	Feature	Bolt hole	Vertical hole to edge distance
Fabrication	Feature	Bolt hole	Minimum clearance
Fabrication	Feature	Slotted hole	Slot height
Fabrication	Feature	Slotted hole	Slot length
Fabrication	Feature	Slotted hole	Curve radius

Information Group	Information Items	Attribute Sets	Attributes
Fabrication	Feature	Slotted hole	Sector angle
Fabrication	Feature	Slotted hole	Slot radius
Fabrication	Feature	Slotted hole	Other information
Fabrication	Feature	Slotted hole	Location
Fabrication	Feature	Cope	Type
Fabrication	Feature	Cope	Dimension
Fabrication	Feature	Cope	Location
Fabrication	Feature	Opening	Dimension
Fabrication	Feature	Opening	Location
Fabrication	Feature	Skewed end	Dimension
Fabrication	Feature	Skewed end	Location
Fabrication	Feature	Cutting plane	Plane angle 1
Fabrication	Feature	Cutting plane	Plane angle 2
Fabrication	Feature	Cutting plane	Plane definition
Fabrication	Feature	Edge chamfer	Edge chamfer type
Fabrication	Feature	Edge chamfer	Edge chamfer depth
Fabrication	Feature	Edge chamfer	Edge chamfer width
Fabrication	Feature	Edge chamfer	Edge fillet radius
Fabrication	Feature	Edge chamfer	Edge rounding radius
Fabrication	Feature	Surface feature	Surface boundary
Fabrication	Feature	Surface feature	Surface name tag
Fabrication	Feature	Surface feature	Surface treatment definition
Fabrication	Feature	Thread	Thread pitch

Information Group	Information Items	Attribute Sets	Attributes
Fabrication	Feature	Thread	Thread length
Fabrication	Feature	Thread	Thread profile
Fabrication	Feature	Thread	Right handed indicator
Fabrication	Feature	Thread	Number of thread
Fabrication	Feature	Volume prismatic chamfer	Chamfer length
Fabrication	Feature	Volume prismatic chamfer	Chamfer depth
Fabrication	Feature	Volume prismatic flange chamfer	Flange chamfer length
Fabrication	Feature	Volume prismatic flange chamfer	Flange chamfer width
Fabrication	Feature	Volume prismatic flange notch	Flange notch length
Fabrication	Feature	Volume prismatic flange notch	Flange notch width
Fabrication	Feature	Volume prismatic flange notch	Flange notch radius
Fabrication	Feature	Volume prismatic notch	Notch length
Fabrication	Feature	Volume prismatic notch	Notch depth
Fabrication	Feature	Volume prismatic notch	Notch radius
Fabrication	Feature	Volume prismatic skewed end	Skew angle 1
Fabrication	Feature	Volume prismatic skewed end	Skew angle 2
Fabrication	Feature	Castellation	Castellation type
Fabrication	Feature	Castellation	End post width 1
Fabrication	Feature	Castellation	End post width 2
Fabrication	Feature	Castellation	Castellation spacing
Fabrication	Feature	Castellation	Castellation height
Fabrication	Feature	Castellation	Castellation width
Fabrication	Feature	Castellation	Castellation depth

Information Group	Information Items	Attribute Sets	Attributes
Fabrication	Feature	Miscellaneous features	Critical end point
Fabrication	Feature	Miscellaneous features	Angle of end cuts
Fabrication	Feature	Miscellaneous features	Clip angle
Fabrication	Shear connector (stud)	Properties	Shear connector name
Fabrication	Shear connector (stud)	Properties	Shear connector type
Fabrication	Shear connector (stud)	Properties	Shear connector quantity
Fabrication	Shear connector (stud)	Properties	Shear connector weight
Fabrication	Shear connector (stud)	Properties	Shear connector finish
Fabrication	Shear connector (stud)	Properties	Shear connector applied method
Fabrication	Shear connector (stud)	Properties	Shear connector testing method
Fabrication	Shear connector (stud)	Properties	Head shape
Fabrication	Shear connector (stud)	Properties	Connector type
Fabrication	Shear connector (stud)	Properties	Connector method
Fabrication	Shear connector (stud)	Properties	Place of assembly
Fabrication	Shear connector (stud)	Properties	GUID
Fabrication	Shear connector (stud)	Layout	Longitudinal distance from support
Fabrication	Shear connector (stud)	Layout	Transverse distance from edge of flange
Fabrication	Shear connector (stud)	Layout	Number of shear connector per row
Fabrication	Shear connector (stud)	Layout	Number of spaces
Fabrication	Shear connector (stud)	Layout	Transverse spacing
Fabrication	Shear connector (stud)	Layout	Longitudinal spacing
Fabrication	Shear connector (stud)	Dimensions	Stud diameter
Fabrication	Shear connector (stud)	Dimensions	Stud height

Information Group	Information Items	Attribute Sets	Attributes
Fabrication	Shear connector (stud)	Dimensions	Cap diameter
Fabrication	Shear connector (stud)	Dimensions	Cap thickness
Fabrication	Shear connector (stud)	Dimensions	Thread length 1
Fabrication	Shear connector (stud)	Dimensions	Thread length 2
Fabrication	Shear connector (stud)	Dimensions	Shank length
Fabrication	Shear connector (stud)	Dimensions	Full section area
Fabrication	Shear connector (stud)	Dimensions	Reduced section area
Fabrication	Shear connector (stud)	Material	Shear connector material designation
Fabrication	Shear connector (stud)	Channel properties	Channel name
Fabrication	Shear connector (stud)	Channel properties	Channel length
Fabrication	Shear connector (stud)	Weld properties	End weld name
Fabrication	Shear connector (stud)	Weld properties	Side weld name
Fabrication	Bolt assembly	Properties	Name
Fabrication	Bolt assembly	Properties	Description
Fabrication	Bolt assembly	Properties	Sequence
Fabrication	Bolt assembly	Properties	Joint system type
Fabrication	Bolt assembly	Properties	Location in assembly
Fabrication	Bolt assembly	Properties	Place of assembly
Fabrication	Bolt assembly	Properties	Fastening direction
Fabrication	Bolt assembly	Properties	Connected elements
Fabrication	Bolt assembly	Properties	Direct tension indicators
Fabrication	Bolt assembly	Properties	GUID
Fabrication	Bolt assembly	Bolt	Bolt type

Information Group	Information Items	Attribute Sets	Attributes
Fabrication	Bolt assembly	Bolt	Bolt head type
Fabrication	Bolt assembly	Bolt	Bolt hex size
Fabrication	Bolt assembly	Bolt	Nominal bolt diameter
Fabrication	Bolt assembly	Bolt	Bolt finish
Fabrication	Bolt assembly	Bolt	Bolt head thickness
Fabrication	Bolt assembly	Bolt	Bolt length
Fabrication	Bolt assembly	Bolt	Bolt shank diameter
Fabrication	Bolt assembly	Bolt	Bolt shank length
Fabrication	Bolt assembly	Bolt	Full section area
Fabrication	Bolt assembly	Bolt	Reduced section area
Fabrication	Bolt assembly	Bolt	Bolt material
Fabrication	Bolt assembly	Bolt	Bolt standard
Fabrication	Bolt assembly	Bolt	Bolt grade identification mark
Fabrication	Bolt assembly	Bolt	Bolt marks on head
Fabrication	Bolt assembly	Bolt	Bolt tensile strength
Fabrication	Bolt assembly	Bolt	Bolt yield strength
Fabrication	Bolt assembly	Bolt	Bolt proof strength
Fabrication	Bolt assembly	Bolt	Bolted connection type
Fabrication	Bolt assembly	Bolt	Surface class type
Fabrication	Bolt assembly	Bolt	Bolt head direction
Fabrication	Bolt assembly	Bolt	Bolt weight
Fabrication	Bolt assembly	Bolt	Bolt preload
Fabrication	Bolt assembly	Bolt	Bolt head height

Information Group	Information Items	Attribute Sets	Attributes
Fabrication	Bolt assembly	Bolt	Bolt head diameter
Fabrication	Bolt assembly	Bolt	Distance across vertices
Fabrication	Bolt assembly	Bolt	Distance across flats
Fabrication	Bolt assembly	Bolt	Countersink angle
Fabrication	Bolt assembly	Bolt	Countersink depth
Fabrication	Bolt assembly	Bolt	Curve definition
Fabrication	Bolt assembly	Washer	Washer named location
Fabrication	Bolt assembly	Washer	Washer type
Fabrication	Bolt assembly	Washer	Washer shape
Fabrication	Bolt assembly	Washer	Washer material
Fabrication	Bolt assembly	Washer	Washer standard
Fabrication	Bolt assembly	Washer	Washer outer diameter
Fabrication	Bolt assembly	Washer	Washer inner diameter
Fabrication	Bolt assembly	Washer	Washer thickness upper bound
Fabrication	Bolt assembly	Washer	Washer thickness lower bound
Fabrication	Bolt assembly	Washer	Washer slope (taper)
Fabrication	Bolt assembly	Washer	Approximate Lbs per M Pcs
Fabrication	Bolt assembly	Washer	Washer finish
Fabrication	Bolt assembly	Washer	Washer weight
Fabrication	Bolt assembly	Washer	Final gap
Fabrication	Bolt assembly	Nuts	Nut type
Fabrication	Bolt assembly	Nuts	Nut material
Fabrication	Bolt assembly	Nuts	Nut material specification

Information Group	Information Items	Attribute Sets	Attributes
Fabrication	Bolt assembly	Nuts	Nut mechanical specification
Fabrication	Bolt assembly	Nuts	Nut dimensional specification
Fabrication	Bolt assembly	Nuts	Nominal nut size
Fabrication	Bolt assembly	Nuts	Nut thickness
Fabrication	Bolt assembly	Nuts	Nut weight
Fabrication	Bolt assembly	Nuts	Nut finish
Fabrication	Bolt assembly	Nuts	Distance across vertices
Fabrication	Bolt assembly	Nuts	Distance across flats
Fabrication	Bolt assembly	Nuts	Nut inner diameter
Fabrication	Bolt assembly	Thread	Thread type
Fabrication	Bolt assembly	Thread	Thread location type
Fabrication	Bolt assembly	Thread	Threaded length
Fabrication	Bolt assembly	Thread	Thread pitch
Fabrication	Bolt assembly	Thread	Thread direction
Fabrication	Bolt assembly	Thread	Nominal thread diameter
Fabrication	Bolt assembly	Thread	Basic pitch diameter
Fabrication	Bolt assembly	Thread	Thread section at minor diameter
Fabrication	Bolt assembly	Thread	Threads per inch
Fabrication	Bolt assembly	Thread	Thread tensile stress area
Fabrication	Bolt assembly	Thread	Thread root area
Fabrication	Bolt assembly	Thread	Exclude threads indicator
Fabrication	Bolt assembly	Bolt number	Total count of bolts
Fabrication	Bolt assembly	Bolt number	Actual count of bolts

Information Group	Information Items	Attribute Sets	Attributes
Fabrication	Bolt assembly	Bolt number	Percentage of extra bolts
Fabrication	Bolt assembly	Bolt number	Number of bolts for testing
Fabrication	Bolt assembly	Bolt number	Number of bolts for possible field losses
Fabrication	Bolt assembly	Rotational capacity test data	Rotational capacity test scenario
Fabrication	Bolt assembly	Rotational capacity test data	Rotational capacity test done by
Fabrication	Weld	Properties	Weld name
Fabrication	Weld	Properties	Weld description
Fabrication	Weld	Properties	Sequence
Fabrication	Weld	Properties	Joint system type
Fabrication	Weld	Properties	Weld type
Fabrication	Weld	Properties	Weld process
Fabrication	Weld	Properties	Place of assembly
Fabrication	Weld	Properties	Weld controlling specification/code
Fabrication	Weld	Properties	Weld symbol
Fabrication	Weld	Properties	Weld preparation type
Fabrication	Weld	Properties	Weld joint type
Fabrication	Weld	Properties	Weld termination detail
Fabrication	Weld	Properties	Weld direction
Fabrication	Weld	Properties	Weld distance to edge
Fabrication	Weld	Properties	Weld material
Fabrication	Weld	Properties	Weld procedure specification identification number
Fabrication	Weld	Properties	WPS number
Fabrication	Weld	Properties	Weld path

Information Group	Information Items	Attribute Sets	Attributes
Fabrication	Weld	Properties	Weld position
Fabrication	Weld	Properties	Weld surface
Fabrication	Weld	Properties	Weld design strength
Fabrication	Weld	Properties	GUID
Fabrication	Weld	Dimensions	Weld dimension
Fabrication	Weld	Dimensions	Weld dimension name
Fabrication	Weld	Dimensions	Weld length
Fabrication	Weld	Electrode data	Electrode classification
Fabrication	Weld	Note	Fracture Critical Weld (FCW)
Fabrication	Weld	Note	AWS approved
Fabrication	Weld	Non-destructive testing information	Testing method
Fabrication	Weld	Non-destructive testing information	Testing location
Fabrication	Weld	Non-destructive testing information	Testing term
Fabrication	Weld	Miscellaneous information	Connection type
Fabrication	Weld	Miscellaneous information	Load direction type
Fabrication	Weld	Miscellaneous information	Surface class type
Fabrication	Weld	Miscellaneous information	Fatigue category type
Fabrication	Weld	Miscellaneous information	Grind smooth for testing
Fabrication	Weld	Miscellaneous information	Connected elements
Fabrication	Chemical joint systems	Chemical mechanism	Layer thickness
Fabrication	Chemical joint systems	Chemical mechanism	Layer design strength
Fabrication	Chemical joint systems	Chemical mechanism	Layer type
Fabrication	Chemical joint systems	Chemical mechanism	Joining surface

Information Group	Information Items	Attribute Sets	Attributes
Fabrication	Chemical joint systems	Chemical mechanism	Joined surface
Fabrication	Chemical joint systems	Chemical mechanism	Specification
Fabrication	Chemical joint systems	Chemical mechanism	Number of layers
Fabrication	Process	Dimensions	Wet film thickness
Fabrication	Process	Dimensions	Dry film thickness
Fabrication	Process	Dimensions	Profile depth
Fabrication	Process	Dimensions	Areas of no paint/mist coats
Fabrication	Process	Dimensions	Field weld block out area
Fabrication	Process	Painting	Paint type
Fabrication	Process	Painting	Paint system
Fabrication	Process	Painting	Paint color
Fabrication	Process	Painting	Number of coats
Fabrication	Process	Painting	Controlling specifications
Fabrication	Process	Painting	Material corner preparation
Fabrication	Process	Painting	Manufacture data sheet
Fabrication	Process	Painting	Surface preparation
Fabrication	Process	Painting	OSHA requirement
Fabrication	Process	Painting	AISC paint certification
Fabrication	Process	Priming	Shop primer
Fabrication	Process	Priming	Primer type
Fabrication	Process	Priming	Pre priming requirement
Fabrication	Process	Priming	Time limits between blasting and priming
Fabrication	Process	Coating	Coating purpose

Information Group	Information Items	Attribute Sets	Attributes
Fabrication	Process	Coating	Coating method
Fabrication	Process	Coating	Coating specifications
Fabrication	Process	Coating	Number of layers
Fabrication	Process	Cleaning	Cleaning method
Fabrication	Process	Cutting	Cutting type
Fabrication	Process	Surface	Faying surface restriction
Fabrication	Process	Surface	Shop contact surface
Fabrication	Process	Weathering	Weathering steel finish
Fabrication	Process	Weathering	Uniform weathering
Fabrication	Process	Blasting	Blasting requirement
Fabrication	Process	Assemble	Resulting assembly
Fabrication	Process	Assemble	Component
Fabrication	Process	Assemble	Required processes
Fabrication	Process	Dispatch	Transported product
Fabrication	Process	Dispatch	Dispatch address
Fabrication	Process	Dispatch	Delivery address
Fabrication	Process	Dispatch	Dispatch date
Fabrication	Process	Dispatch	Delivery date
Fabrication	Process	Move	Initial location
Fabrication	Process	Move	Final location
Fabrication	Process	Move	Path
Fabrication	Process	Procure	Vendors
Fabrication	Process	Procure	Purchaser

Information Group	Information Items	Attribute Sets	Attributes
Fabrication	Process	Procure	Purchased products
Fabrication	Process	Procure	Sales contract
Fabrication	Process	Procure	Delivery dates
Fabrication	Process	Procure	Prices
Fabrication	Process	Project process item	Scheduled process
Fabrication	Process	Project process item	Resulting product
Fabrication	Process	Project process item	Processed product
Fabrication	Process	Other surface treatment	Finished surface irregularity
Fabrication	Process	Other surface treatment	Hard stamp method
Fabrication	Process	Other surface treatment	Initial temperature
Fabrication	Process	Other surface treatment	Final temperature
Fabrication	Process	Other surface treatment	Maximum temperature
Fabrication	Process	Other surface treatment	Time to maximum temperature
Fabrication	Process	Other surface treatment	Time at maximum temperature
Fabrication	Process	Other surface treatment	Time to final temperature
Fabrication	Process	Bending	Assembly component select
Fabrication	Process	Bending	Bending method
Fabrication	Nail	Nail properties	Name
Fabrication	Nail	Nail properties	Description
Fabrication	Nail	Nail properties	Nail type
Fabrication	Nail	Nail properties	Nail drive type
Fabrication	Nail	Nail properties	Nail head shape
Fabrication	Nail	Nail properties	Nail point type

Information Group	Information Items	Attribute Sets	Attributes
Fabrication	Nail	Nail properties	Nail diameter
Fabrication	Nail	Nail properties	Nail length
Fabrication	Nail	Nail properties	Penny weight
Fabrication	Nail	Nail properties	GUID
Fabrication	Pin	Pin properties	Pin type
Fabrication	Screw	Screw properties	Screw type
Fabrication	Screw	Screw properties	Screw drive type
Fabrication	Screw	Screw properties	Screw point type
Fabrication	Screw	Screw properties	Screw head height
Fabrication	Screw	Screw properties	Full section area
Fabrication	Screw	Screw properties	Reduced section area
Fabrication	Screw	Screw self drilling properties	Hole cutting method
Fabrication	Screw	Screw self drilling properties	Pilot hole diameter
Fabrication	Screw	Screw self drilling properties	Drill diameter
Fabrication	Screw	Screw self drilling properties	Nominal diameter
Fabrication	Screw	Screw self tapping	Thread cutting method
Fabrication	Screw	Screw self tapping	Pilot hole diameter
Fabrication	Screw	Screw tapered	Absolute taper
Fabrication	Screw	Screw tapered	Relative taper
Fabrication	Charpy V-Notch (CVN) impact testing	CVN definition	Name
Fabrication	Charpy V-Notch (CVN) impact testing	CVN definition	Description
Fabrication	Charpy V-Notch (CVN) impact testing	CVN definition	Energy value

Information Group	Information Items	Attribute Sets	Attributes
Fabrication	Charpy V-Notch (CVN) impact testing	CVN definition	Energy unit
Fabrication	Charpy V-Notch (CVN) impact testing	CVN definition	Temperature value
Fabrication	Charpy V-Notch (CVN) impact testing	CVN definition	Temperature unit
Fabrication	Fatigue	Fatigue properties	Fatigue category type
Fabrication	Fatigue	Fatigue properties	Allowable fatigue stress
Fabrication	Fatigue	Fatigue properties	Nominal fatigue resistance
Fabrication	Fatigue	Fatigue geometry	Vertical distance
Fabrication	Fatigue	Fatigue geometry	Vertical distance reference type
Fabrication	Process information	Cutting	Process type
Fabrication	Process information	Drilling	Process type
Fabrication	Process information	Welding	-
Fabrication	Process information	Layout	-
Contract	Contract information	Pay item information	Item number
Contract	Contract information	Pay item information	Status
Contract	Contract information	Pay item information	Special specification indicator
Contract	Contract information	Pay item information	Specification book version
Contract	Contract information	Pay item information	Calendar quarter
Contract	Contract information	Pay item information	Effective date
Contract	Contract information	Pay item information	Fabrication cost factor
Contract	Contract information	Pay item information	Units
Contract	Contract information	Pay item information	Lump sum indicator
Contract	Contract information	Pay item information	Price indicator

Information Group	Information Items	Attribute Sets	Attributes
Contract	Contract information	Pay item information	File name
Contract	Contract information	Pay item information	EIEB number
Contract	Contract information	Pay item information	EIEB identification
Contract	Contract information	Pay item information	Number of occurrence
Contract	Contract information	Pay item information	Total quantity
Contract	Contract information	Pay item information	Average awarded price
Contract	Contract information	Pay item information	Average of low 3 bidders
Contract	Contract information	Pay item information	Message
Contract	Contract information	Pay item information	Material unit costs
Contract	Contract information	Pay item information	Item description
Construction	Girder Erection Analysis	Construction Information	Number of Analysis Runs
Construction	Girder Erection Analysis	Construction Information	Situation (Construct Ahead/Back)
Construction	Girder Erection Analysis	Number of Girders lifted per analysis	Analysis number
Construction	Girder Erection Analysis	Number of Girders lifted per analysis	Number of Girders lifted
Construction	Girder Erection Analysis	Lifted Segment lengths	Analysis number
Construction	Girder Erection Analysis	Lifted Segment lengths	Lift number
Construction	Girder Erection Analysis	Lifted Segment lengths	Lifted Segment Length
Construction	Dead Loads & Wind loads	Dead Load	Dead Load Factor
Construction	Dead Loads & Wind loads	Wind Load	Wind applied to girder number
Construction	Dead Loads & Wind loads	Wind Load	Wind Load X-Direction
Construction	Dead Loads & Wind loads	Wind Load	Wind Load Y-Direction

Information Group	Information Items	Attribute Sets	Attributes
Construction	Shore Tower Data	Shore Tower Input	Location
Construction	Shore Tower Data	Shore Tower Data	Analysis number
Construction	Shore Tower Data	Shore Tower Data	Location
Construction	Shore Tower Data	Holding Crane or Other Concentrated Loads Data	Analysis number
Construction	Shore Tower Data	Holding Crane or Other Concentrated Loads Data	Location
Construction	Shore Tower Data	Holding Crane or Other Concentrated Loads Data	Load
Construction	Shore Tower Data	Holding Crane or Other Concentrated Loads Data	Load Direction
Construction	Erection Construction Descriptions	Drawings	Erection procedure drawings
Construction	Erection Construction Descriptions	Drawings	Tensioning procedure
Construction	Erection Construction Descriptions	Drawings	Erection sequence
Construction	Erection Construction Descriptions	Safety Requirements	Girder safety
Construction	Erection Construction Descriptions	Safety Requirements	Safety handrails
Construction	Erection Construction Descriptions	Safety Requirements	Fall protection
Construction	Erection Construction Descriptions	Crane	Crane size
Construction	Erection Construction Descriptions	Crane	Crane type
Construction	Erection Construction Descriptions	Crane	Crane lifting capacity
Construction	Erection Construction Descriptions	Crane	Crane location

Information Group	Information Items	Attribute Sets	Attributes
Construction	Erection Construction Descriptions	Crane	Crane capacity
Construction	Erection Construction Descriptions	Crane	Crane boom length
Construction	Erection Construction Descriptions	Crane	Crane rigging arrangement
Construction	Erection Construction Descriptions	Crane	Crane radius
Construction	Erection Construction Descriptions	Crane	Crane access road
Construction	Erection Construction Descriptions	Crane	Crane counterweight
Construction	Erection Construction Descriptions	Utility	Utility attachments
Construction	Erection Construction Descriptions	Utility	Utility connections
Construction	Deck placement	Deck placement information	Number of deck segments
Construction	Deck placement	Deck placement information	Number of concrete placement
Construction	Deck placement	Deck placement information	Deck segment length
Construction	Deck placement	Deck placement information	Pour stage
Construction	Deck placement	Deck placement information	Time of pour
Construction	Check	Skew bridge checks	Camber value control
Construction	Check	Skew bridge checks	Transverse rotation
Construction	Check	Skew bridge checks	Monitoring of rotation change
Construction	Check	Skew bridge checks	Application of loads
Construction	Check	Skew bridge checks	Girder web vertical position
Construction	Check	Camber	Camber spot check
Construction	Check	Camber	Erected camber verification
Construction	Miscellaneous information	Conduit support system	-

Information Group	Information Items	Attribute Sets	Attributes
Construction	Miscellaneous information	Demolition and removal	-
Construction	Miscellaneous information	Bolting order	-
Section Library	Common sections	Common section properties	Original offset
Section Library	Common sections	Common section properties	Torsional constant
Section Library	Common sections	Common section properties	Moment of inertia
Section Library	Common sections	Common section properties	Sectional area
Section Library	Common sections	Common section properties	Shear area
Section Library	Common sections	Common section properties	Shear deformation area
Section Library	Common sections	Common section properties	Surface per length
Section Library	Common sections	Common section properties	Radius of gyration
Section Library	Common sections	Common section properties	Plastic modulus
Section Library	Common sections	Common section properties	Warping constant
Section Library	Common sections	Common section properties	Torsional index
Section Library	Common sections	Common section properties	Buckling parameter
Section Library	Common sections	Common section properties	Nominal mass
Section Library	Common sections	Common section properties	Actual mass
Section Library	Common sections	Circular hollow shape	External radius
Section Library	Common sections	Circular hollow shape	Wall thickness
Section Library	Common sections	Circular hollow shape	Inside radius
Section Library	Common sections	Rectangular shape	Overall depth
Section Library	Common sections	Rectangular shape	Overall width
Section Library	Common sections	Rectangular shape	External fillet
Section Library	Common sections	Rectangular shape	Wall thickness
Section Library	Common sections	Rectangular shape	Internal fillet radius
Section Library	Common sections	Compound section	Component section
Section Library	Common sections	Compound section	Positions
Section Library	Common sections	Compound section	Orientations
Section Library	Common sections	Compound section	Number of sections
Section Library	Steel shapes	Rolled steel angle shape	Angle size 1

Information Group	Information Items	Attribute Sets	Attributes
Section Library	Steel shapes	Rolled steel angle shape	Angle size 2
Section Library	Steel shapes	Rolled steel angle shape	Angle thickness
Section Library	Steel shapes	Rolled steel angle shape	Area
Section Library	Steel shapes	Rolled steel angle shape	Description
Section Library	Steel shapes	Rolled steel angle shape	Depth
Section Library	Steel shapes	Rolled steel angle shape	Ixx
Section Library	Steel shapes	Rolled steel angle shape	Iyy
Section Library	Steel shapes	Rolled steel angle shape	K
Section Library	Steel shapes	Rolled steel angle shape	Name
Section Library	Steel shapes	Rolled steel angle shape	Nominal weight or mass
Section Library	Steel shapes	Rolled steel angle shape	rzz
Section Library	Steel shapes	Rolled steel angle shape	xyy
Section Library	Steel shapes	Rolled steel angle shape	yxx
Section Library	Steel shapes	Rolled steel angle shape	Tan alpha
Section Library	Steel shapes	Rolled steel angle shape	Width
Section Library	Steel shapes	Rolled steel angle shape	Internal fillet radius
Section Library	Steel shapes	Rolled steel angle shape	Edge fillet radius
Section Library	Steel shapes	Rolled steel angle shape	Leg slope
Section Library	Steel shapes	Rolled steel angle shape	GUID
Section Library	Steel shapes	Rolled steel channel shape	Area
Section Library	Steel shapes	Rolled steel channel shape	Average flange thickness
Section Library	Steel shapes	Rolled steel channel shape	Channel type
Section Library	Steel shapes	Rolled steel channel shape	Overall depth
Section Library	Steel shapes	Rolled steel channel shape	Description
Section Library	Steel shapes	Rolled steel channel shape	Distance K
Section Library	Steel shapes	Rolled steel channel shape	eo
Section Library	Steel shapes	Rolled steel channel shape	Flange width
Section Library	Steel shapes	Rolled steel channel shape	Flange thickness
Section Library	Steel shapes	Rolled steel channel shape	Flange slope

Information Group	Information Items	Attribute Sets	Attributes
Section Library	Steel shapes	Rolled steel channel shape	Grip
Section Library	Steel shapes	Rolled steel channel shape	Ixx
Section Library	Steel shapes	Rolled steel channel shape	Iyy
Section Library	Steel shapes	Rolled steel channel shape	Maximum flange fastener
Section Library	Steel shapes	Rolled steel channel shape	Name
Section Library	Steel shapes	Rolled steel channel shape	Nominal depth
Section Library	Steel shapes	Rolled steel channel shape	Nominal weight or mass
Section Library	Steel shapes	Rolled steel channel shape	Web thickness
Section Library	Steel shapes	Rolled steel channel shape	x bar
Section Library	Steel shapes	Rolled steel channel shape	Root radius
Section Library	Steel shapes	Rolled steel channel shape	Fillet radius
Section Library	Steel shapes	Rolled steel channel shape	GUID
Section Library	Steel shapes	Steel I shape	Area
Section Library	Steel shapes	Steel I shape	Overall depth
Section Library	Steel shapes	Steel I shape	Web depth
Section Library	Steel shapes	Steel I shape	Description
Section Library	Steel shapes	Steel I shape	Distance K
Section Library	Steel shapes	Steel I shape	Flange thickness
Section Library	Steel shapes	Steel I shape	Flange width
Section Library	Steel shapes	Steel I shape	Flange slope
Section Library	Steel shapes	Steel I shape	Root radius
Section Library	Steel shapes	Steel I shape	Edge radius
Section Library	Steel shapes	Steel I shape	Ixx
Section Library	Steel shapes	Steel I shape	Iyy

Information Group	Information Items	Attribute Sets	Attributes
Section Library	Steel shapes	Steel I shape	Name
Section Library	Steel shapes	Steel I shape	Nominal depth
Section Library	Steel shapes	Steel I shape	Nominal weight or mass
Section Library	Steel shapes	Steel I shape	Shape type
Section Library	Steel shapes	Steel I shape	Web thickness
Section Library	Steel shapes	Steel I shape	zx
Section Library	Steel shapes	Steel I shape	zy
Section Library	Steel shapes	Steel I shape	Top flange width
Section Library	Steel shapes	Steel I shape	Bottom flange width
Section Library	Steel shapes	Steel I shape	Bottom flange thickness
Section Library	Steel shapes	Steel I shape	Bottom root radius
Section Library	Steel shapes	Steel I shape	Bottom flange slope
Section Library	Steel shapes	Steel I shape	Bottom flange edge radius
Section Library	Steel shapes	Steel I shape	Top edge radius
Section Library	Steel shapes	Steel I shape	Bottom edge radius
Section Library	Steel shapes	Steel I shape	Top flange inner slope
Section Library	Steel shapes	Steel I shape	Bottom flange inner slope
Section Library	Steel shapes	Steel I shape	Transition radius top
Section Library	Steel shapes	Steel I shape	Transition radius bottom
Section Library	Steel shapes	Steel I shape	GUID
Section Library	Steel shapes	Rolled steel tee shape	Area
Section Library	Steel shapes	Rolled steel tee shape	Description
Section Library	Steel shapes	Rolled steel tee shape	Distance Y to Cg

Information Group	Information Items	Attribute Sets	Attributes
Section Library	Steel shapes	Rolled steel tee shape	Distance K
Section Library	Steel shapes	Rolled steel tee shape	Flange thickness
Section Library	Steel shapes	Rolled steel tee shape	Flange width
Section Library	Steel shapes	Rolled steel tee shape	Flange slope
Section Library	Steel shapes	Rolled steel tee shape	Ixx
Section Library	Steel shapes	Rolled steel tee shape	Iyy
Section Library	Steel shapes	Rolled steel tee shape	Name
Section Library	Steel shapes	Rolled steel tee shape	Nominal weight or mass
Section Library	Steel shapes	Rolled steel tee shape	Shape type
Section Library	Steel shapes	Rolled steel tee shape	Stem area
Section Library	Steel shapes	Rolled steel tee shape	Stem thickness
Section Library	Steel shapes	Rolled steel tee shape	Stem slope
Section Library	Steel shapes	Rolled steel tee shape	Tee depth
Section Library	Steel shapes	Rolled steel tee shape	Overall depth
Section Library	Steel shapes	Rolled steel tee shape	Root radius
Section Library	Steel shapes	Rolled steel tee shape	Edge radius
Section Library	Steel shapes	Rolled steel tee shape	GUID
Section Library	Steel shapes	AISC Rolled shapes	-
Section Library	Prestressed concrete shapes	Prestressed tee beam shape	Area
Section Library	Prestressed concrete shapes	Prestressed tee beam shape	Bottom web thickness
Section Library	Prestressed concrete shapes	Prestressed tee beam shape	Deck included indicator

Information Group	Information Items	Attribute Sets	Attributes
Section Library	Prestressed concrete shapes	Prestressed tee beam shape	Depth
Section Library	Prestressed concrete shapes	Prestressed tee beam shape	Description
Section Library	Prestressed concrete shapes	Prestressed tee beam shape	Distance between webs
Section Library	Prestressed concrete shapes	Prestressed tee beam shape	Distance y to cg
Section Library	Prestressed concrete shapes	Prestressed tee beam shape	Flange haunch flange height
Section Library	Prestressed concrete shapes	Prestressed tee beam shape	Flange haunch web height
Section Library	Prestressed concrete shapes	Prestressed tee beam shape	Flange haunch web width
Section Library	Prestressed concrete shapes	Prestressed tee beam shape	Flange thickness
Section Library	Prestressed concrete shapes	Prestressed tee beam shape	Half depth area negative flexure
Section Library	Prestressed concrete shapes	Prestressed tee beam shape	Half depth area positive flexure
Section Library	Prestressed concrete shapes	Prestressed tee beam shape	Ixx
Section Library	Prestressed concrete shapes	Prestressed tee beam shape	Left flange width
Section Library	Prestressed concrete shapes	Prestressed tee beam shape	Max span
Section Library	Prestressed concrete shapes	Prestressed tee beam shape	Name
Section Library	Prestressed concrete shapes	Prestressed tee beam shape	Nominal depth
Section Library	Prestressed concrete shapes	Prestressed tee beam shape	Nominal weight or mass
Section Library	Prestressed concrete shapes	Prestressed tee beam shape	Number of webs
Section Library	Prestressed concrete shapes	Prestressed tee beam shape	Right flange width
Section Library	Prestressed concrete shapes	Prestressed tee beam shape	St Venant torsional constant
Section Library	Prestressed concrete shapes	Prestressed tee beam shape	Sxx bottom
Section Library	Prestressed concrete shapes	Prestressed tee beam shape	Sxx top

Information Group	Information Items	Attribute Sets	Attributes
Section Library	Prestressed concrete shapes	Prestressed tee beam shape	Top web thickness
Section Library	Prestressed concrete shapes	Prestressed tee beam shape	Volume surface ratio
Section Library	Prestressed concrete shapes	Prestressed tee beam shape	Weight
Section Library	Prestressed concrete shapes	Prestressed tee beam shape	GUID
Section Library	Prestressed concrete shapes	Prestressed u beam shape	Area
Section Library	Prestressed concrete shapes	Prestressed u beam shape	Bottom flange thickness
Section Library	Prestressed concrete shapes	Prestressed u beam shape	Bottom flange width
Section Library	Prestressed concrete shapes	Prestressed u beam shape	Depth
Section Library	Prestressed concrete shapes	Prestressed u beam shape	Description
Section Library	Prestressed concrete shapes	Prestressed u beam shape	Distance Y To Cg
Section Library	Prestressed concrete shapes	Prestressed u beam shape	Half depth area negative flexure
Section Library	Prestressed concrete shapes	Prestressed u beam shape	Half depth area positive flexure
Section Library	Prestressed concrete shapes	Prestressed u beam shape	Inside wall bottom haunch height
Section Library	Prestressed concrete shapes	Prestressed u beam shape	Inside wall bottom haunch width
Section Library	Prestressed concrete shapes	Prestressed u beam shape	Inside wall top haunch horizontal
Section Library	Prestressed concrete shapes	Prestressed u beam shape	Inside wall top haunch vertical
Section Library	Prestressed concrete shapes	Prestressed u beam shape	Ixx
Section Library	Prestressed concrete shapes	Prestressed u beam shape	Max span
Section Library	Prestressed concrete shapes	Prestressed u beam shape	Name
Section Library	Prestressed concrete shapes	Prestressed u beam shape	Nominal depth
Section Library	Prestressed concrete shapes	Prestressed u beam shape	Nominal weight or mass

Information Group	Information Items	Attribute Sets	Attributes
Section Library	Prestressed concrete shapes	Prestressed u beam shape	Outside wall horizontal
Section Library	Prestressed concrete shapes	Prestressed u beam shape	St Venant torsional constant
Section Library	Prestressed concrete shapes	Prestressed u beam shape	Sxx bottom
Section Library	Prestressed concrete shapes	Prestressed u beam shape	Sxx top
Section Library	Prestressed concrete shapes	Prestressed u beam shape	Top flange haunch height
Section Library	Prestressed concrete shapes	Prestressed u beam shape	Top flange haunch width
Section Library	Prestressed concrete shapes	Prestressed u beam shape	Top flange thickness
Section Library	Prestressed concrete shapes	Prestressed u beam shape	Top flange width
Section Library	Prestressed concrete shapes	Prestressed u beam shape	Volume surface ratio
Section Library	Prestressed concrete shapes	Prestressed u beam shape	Wall thickness
Section Library	Prestressed concrete shapes	Prestressed u beam shape	Weight
Section Library	Prestressed concrete shapes	Prestressed u beam shape	GUID
Section Library	Prestressed concrete shapes	Prestressed I beam shape	Area
Section Library	Prestressed concrete shapes	Prestressed I beam shape	Bottom flange haunch height
Section Library	Prestressed concrete shapes	Prestressed I beam shape	Bottom flange radius flange
Section Library	Prestressed concrete shapes	Prestressed I beam shape	Bottom flange radius web
Section Library	Prestressed concrete shapes	Prestressed I beam shape	Bottom flange thickness
Section Library	Prestressed concrete shapes	Prestressed I beam shape	Bottom flange width
Section Library	Prestressed concrete shapes	Prestressed I beam shape	B1
Section Library	Prestressed concrete shapes	Prestressed I beam shape	B2
Section Library	Prestressed concrete shapes	Prestressed I beam shape	B3
Section Library	Prestressed concrete shapes	Prestressed I beam shape	B4
Section Library	Prestressed concrete shapes	Prestressed I beam shape	B5

Information Group	Information Items	Attribute Sets	Attributes
Section Library	Prestressed concrete shapes	Prestressed I beam shape	B6
Section Library	Prestressed concrete shapes	Prestressed I beam shape	D1
Section Library	Prestressed concrete shapes	Prestressed I beam shape	D2
Section Library	Prestressed concrete shapes	Prestressed I beam shape	D3
Section Library	Prestressed concrete shapes	Prestressed I beam shape	D4
Section Library	Prestressed concrete shapes	Prestressed I beam shape	D5
Section Library	Prestressed concrete shapes	Prestressed I beam shape	D6
Section Library	Prestressed concrete shapes	Prestressed I beam shape	Deck included indicator
Section Library	Prestressed concrete shapes	Prestressed I beam shape	Depth
Section Library	Prestressed concrete shapes	Prestressed I beam shape	Description
Section Library	Prestressed concrete shapes	Prestressed I beam shape	Distance Y To Cg
Section Library	Prestressed concrete shapes	Prestressed I beam shape	Half depth area negative flexure
Section Library	Prestressed concrete shapes	Prestressed I beam shape	Half depth area positive flexure
Section Library	Prestressed concrete shapes	Prestressed I beam shape	I beam type
Section Library	Prestressed concrete shapes	Prestressed I beam shape	Ixx
Section Library	Prestressed concrete shapes	Prestressed I beam shape	Max span
Section Library	Prestressed concrete shapes	Prestressed I beam shape	Name
Section Library	Prestressed concrete shapes	Prestressed I beam shape	Nominal depth
Section Library	Prestressed concrete shapes	Prestressed I beam shape	Nominal weight or mass
Section Library	Prestressed concrete shapes	Prestressed I beam shape	Radius fillet indicator
Section Library	Prestressed concrete shapes	Prestressed I beam shape	St Venant torsional constant
Section Library	Prestressed concrete shapes	Prestressed I beam shape	Sxx bottom
Section Library	Prestressed concrete shapes	Prestressed I beam shape	Sxx top

Information Group	Information Items	Attribute Sets	Attributes
Section Library	Prestressed concrete shapes	Prestressed I beam shape	Top flange bottom deck horizontal width
Section Library	Prestressed concrete shapes	Prestressed I beam shape	Top flange haunch height
Section Library	Prestressed concrete shapes	Prestressed I beam shape	Top flange haunch 2 height
Section Library	Prestressed concrete shapes	Prestressed I beam shape	Top flange haunch 2 width
Section Library	Prestressed concrete shapes	Prestressed I beam shape	Top flange radius flange
Section Library	Prestressed concrete shapes	Prestressed I beam shape	Top flange radius web
Section Library	Prestressed concrete shapes	Prestressed I beam shape	Top flange thickness
Section Library	Prestressed concrete shapes	Prestressed I beam shape	Top flange width
Section Library	Prestressed concrete shapes	Prestressed I beam shape	Volume surface ratio
Section Library	Prestressed concrete shapes	Prestressed I beam shape	Web thickness
Section Library	Prestressed concrete shapes	Prestressed I beam shape	Weight
Section Library	Prestressed concrete shapes	Prestressed I beam shape	GUID
Section Library	Prestressed concrete shapes	Prestressed box beam shape	Area
Section Library	Prestressed concrete shapes	Prestressed box beam shape	Bottom haunch height
Section Library	Prestressed concrete shapes	Prestressed box beam shape	Bottom haunch width
Section Library	Prestressed concrete shapes	Prestressed box beam shape	Bottom slab thickness
Section Library	Prestressed concrete shapes	Prestressed box beam shape	Bottom width
Section Library	Prestressed concrete shapes	Prestressed box beam shape	Box beam type
Section Library	Prestressed concrete shapes	Prestressed box beam shape	Ctc distance voids
Section Library	Prestressed concrete shapes	Prestressed box beam shape	Depth
Section Library	Prestressed concrete shapes	Prestressed box beam shape	Description
Section Library	Prestressed concrete shapes	Prestressed box beam shape	Distance Y To Cg
Section Library	Prestressed concrete shapes	Prestressed box beam shape	Distance to Cg void bottom

Information Group	Information Items	Attribute Sets	Attributes
Section Library	Prestressed concrete shapes	Prestressed box beam shape	Exterior void diameter
Section Library	Prestressed concrete shapes	Prestressed box beam shape	Half depth area negative flexure
Section Library	Prestressed concrete shapes	Prestressed box beam shape	Half depth area positive flexure
Section Library	Prestressed concrete shapes	Prestressed box beam shape	Interior void diameter
Section Library	Prestressed concrete shapes	Prestressed box beam shape	Ixx
Section Library	Prestressed concrete shapes	Prestressed box beam shape	Max span
Section Library	Prestressed concrete shapes	Prestressed box beam shape	Name
Section Library	Prestressed concrete shapes	Prestressed box beam shape	Nominal depth
Section Library	Prestressed concrete shapes	Prestressed box beam shape	Nominal weight or mass
Section Library	Prestressed concrete shapes	Prestressed box beam shape	Number circular voids
Section Library	Prestressed concrete shapes	Prestressed box beam shape	Shear key depth
Section Library	Prestressed concrete shapes	Prestressed box beam shape	Shear key height
Section Library	Prestressed concrete shapes	Prestressed box beam shape	Shear key vertical location
Section Library	Prestressed concrete shapes	Prestressed box beam shape	St Venant torsional constant
Section Library	Prestressed concrete shapes	Prestressed box beam shape	Sxx bottom
Section Library	Prestressed concrete shapes	Prestressed box beam shape	Sxx top
Section Library	Prestressed concrete shapes	Prestressed box beam shape	Three void box shape indicator
Section Library	Prestressed concrete shapes	Prestressed box beam shape	Top haunch height
Section Library	Prestressed concrete shapes	Prestressed box beam shape	Top haunch width
Section Library	Prestressed concrete shapes	Prestressed box beam shape	Top slab thickness
Section Library	Prestressed concrete shapes	Prestressed box beam shape	Top width
Section Library	Prestressed concrete shapes	Prestressed box beam shape	Void diameter
Section Library	Prestressed concrete shapes	Prestressed box beam shape	Volume surface ratio

Information Group	Information Items	Attribute Sets	Attributes
Section Library	Prestressed concrete shapes	Prestressed box beam shape	Web thickness
Section Library	Prestressed concrete shapes	Prestressed box beam shape	Weight
Section Library	Prestressed concrete shapes	Prestressed box beam shape	GUID
Section Library	Prestressed concrete shapes	Post Tensioned Box Girder Shape	Width of top slab
Section Library	Prestressed concrete shapes	Post Tensioned Box Girder Shape	Top slab thickness
Section Library	Prestressed concrete shapes	Post Tensioned Box Girder Shape	Length of cantiliver wing on the left
Section Library	Prestressed concrete shapes	Post Tensioned Box Girder Shape	Length of cantiliver wing on the right
Section Library	Prestressed concrete shapes	Post Tensioned Box Girder Shape	Number of cells
Section Library	Prestressed concrete shapes	Post Tensioned Box Girder Shape	Depth of girder
Section Library	Prestressed concrete shapes	Post Tensioned Box Girder Shape	Exterior web thickenss
Section Library	Prestressed concrete shapes	Post Tensioned Box Girder Shape	Interior web thickness
Section Library	Prestressed concrete shapes	Post Tensioned Box Girder Shape	Width of bottom slab
Section Library	Prestressed concrete shapes	Post Tensioned Box Girder Shape	Angle of top slab with horizontal
Section Library	Prestressed concrete shapes	Post Tensioned Box Girder Shape	Angle of bottom slab with horizontal
Section Library	Prestressed concrete shapes	Post Tensioned Box Girder Shape	Thickness of top slab
Section Library	Prestressed concrete shapes	Post Tensioned Box Girder Shape	Thickness of bottom slab
Section Library	Prestressed concrete shapes	Post Tensioned Box Girder Shape	Angle of exterior webs with vertical
Section Library	Prestressed concrete shapes	Post Tensioned Box Girder Shape	Number of ducts in the exterior web
Section Library	Prestressed concrete shapes	Post Tensioned Box Girder Shape	Number of ducts in the interior web
Section Library	Prestressed concrete shapes	Post Tensioned Box Girder Shape	Total number of ducts
Section Library	Prestressed concrete shapes	Post Tensioned Box Girder Shape	Size of ducts
Section Library	Prestressed concrete shapes	Post Tensioned Box Girder Shape	Location of ducts in the webs
Section Library	Prestressed concrete shapes	AASHTO solid and voided slab beams	L

Information Group	Information Items	Attribute Sets	Attributes
Section Library	Prestressed concrete shapes	AASHTO solid and voided slab beams	H
Section Library	Prestressed concrete shapes	AASHTO solid and voided slab beams	L1
Section Library	Prestressed concrete shapes	AASHTO solid and voided slab beams	L2
Section Library	Prestressed concrete shapes	AASHTO solid and voided slab beams	Number of voids
Section Library	Prestressed concrete shapes	AASHTO solid and voided slab beams	D1
Section Library	Prestressed concrete shapes	AASHTO solid and voided slab beams	D2
Section Library	Prestressed concrete shapes	AASHTO solid and voided slab beams	Area
Section Library	Prestressed concrete shapes	AASHTO solid and voided slab beams	Ybottom
Section Library	Prestressed concrete shapes	AASHTO solid and voided slab beams	Inertia
Section Library	Prestressed concrete shapes	AASHTO solid and voided slab beams	Weight
Section Library	Prestressed concrete shapes	AASHTO solid and voided slab beams	Max span
Section Library	Prestressed concrete shapes	AASHTO solid and voided slab beams	GUID
Section Library	Prestressed concrete shapes	Deck bulb-tees	H
Section Library	Prestressed concrete shapes	Deck bulb-tees	Hw
Section Library	Prestressed concrete shapes	Deck bulb-tees	W
Section Library	Prestressed concrete shapes	Deck bulb-tees	Area
Section Library	Prestressed concrete shapes	Deck bulb-tees	Ybottom
Section Library	Prestressed concrete shapes	Deck bulb-tees	Inertia

Information Group	Information Items	Attribute Sets	Attributes
Section Library	Prestressed concrete shapes	Deck bulb-tees	Weight
Section Library	Prestressed concrete shapes	Deck bulb-tees	Max span
Section Library	Prestressed concrete shapes	Deck bulb-tees	GUID
Section Library	Prestressed concrete shapes	Double tee beams	W
Section Library	Prestressed concrete shapes	Double tee beams	H
Section Library	Prestressed concrete shapes	Double tee beams	T
Section Library	Prestressed concrete shapes	Double tee beams	A
Section Library	Prestressed concrete shapes	Double tee beams	C
Section Library	Prestressed concrete shapes	Double tee beams	E
Section Library	Prestressed concrete shapes	Double tee beams	Area
Section Library	Prestressed concrete shapes	Double tee beams	Inertia
Section Library	Prestressed concrete shapes	Double tee beams	Ybottom
Section Library	Prestressed concrete shapes	Double tee beams	Weight
Section Library	Prestressed concrete shapes	Double tee beams	Max span
Section Library	Prestressed concrete shapes	Double tee beams	GUID
Section Library	Prestressed concrete shapes	AASHTO PCI ASBI standard segment for span-by-span construction	Deck width
Section Library	Prestressed concrete shapes	AASHTO PCI ASBI standard segment for span-by-span construction	A
Section Library	Prestressed concrete shapes	AASHTO PCI ASBI standard segment for span-by-span construction	Area
Section Library	Prestressed concrete shapes	AASHTO PCI ASBI standard segment for span-by-span construction	Kn

Information Group	Information Items	Attribute Sets	Attributes
Section Library	Prestressed concrete shapes	AASHTO PCI ASBI standard segment for span-by-span construction	Ix
Section Library	Prestressed concrete shapes	AASHTO PCI ASBI standard segment for span-by-span construction	Yt
Section Library	Prestressed concrete shapes	AASHTO PCI ASBI standard segment for span-by-span construction	GUID
Section Library	Timber beam shapes	Rectangular timber beam shape	Area
Section Library	Timber beam shapes	Rectangular timber beam shape	Cg bottom
Section Library	Timber beam shapes	Rectangular timber beam shape	Description
Section Library	Timber beam shapes	Rectangular timber beam shape	Height
Section Library	Timber beam shapes	Rectangular timber beam shape	Ixx
Section Library	Timber beam shapes	Rectangular timber beam shape	Name
Section Library	Timber beam shapes	Rectangular timber beam shape	Nominal height
Section Library	Timber beam shapes	Rectangular timber beam shape	Nominal weight
Section Library	Timber beam shapes	Rectangular timber beam shape	Nominal width
Section Library	Timber beam shapes	Rectangular timber beam shape	Sxx bottom
Section Library	Timber beam shapes	Rectangular timber beam shape	Sxx top
Section Library	Timber beam shapes	Rectangular timber beam shape	Width
Section Library	Timber beam shapes	Rectangular timber beam shape	GUID
Section Library	Timber beam shapes	Arbitrary profile	-
Material Library	Material properties	General Properties	Material type
Material Library	Material properties	General Properties	Parent material
Material Library	Material properties	General Properties	Constituent amount

Information Group	Information Items	Attribute Sets	Attributes
Material Library	Material properties	General Properties	Composition basis
Material Library	Material properties	General Properties	Class
Material Library	Material properties	General Properties	Determination method
Material Library	Material properties	General Properties	Lower value for dimension
Material Library	Material properties	General Properties	Upper value for dimension
Material Library	Material properties	General Properties	Lower value for strain
Material Library	Material properties	General Properties	Upper value for strain
Material Library	Material properties	General Properties	Lower value for stress
Material Library	Material properties	General Properties	Upper value for stress
Material Library	Material properties	General Properties	Temperature lower bound
Material Library	Material properties	General Properties	Temperature upper bound
Material Library	Material properties	Concrete	Material designation
Material Library	Material properties	Concrete	Material ID
Material Library	Material properties	Concrete	Description
Material Library	Material properties	Concrete	Concrete type
Material Library	Material properties	Concrete	Composition type
Material Library	Material properties	Concrete	Unit mass
Material Library	Material properties	Concrete	Unit mass for elastic modulus
Material Library	Material properties	Concrete	Nominal mass
Material Library	Material properties	Concrete	Actual mass
Material Library	Material properties	Concrete	Poisson's ratio
Material Library	Material properties	Concrete	Thermal expansion coefficient
Material Library	Material properties	Concrete	Initial compressive strength

Information Group	Information Items	Attribute Sets	Attributes
Material Library	Material properties	Concrete	Initial elastic modulus
Material Library	Material properties	Concrete	Compressive strength at 28 days
Material Library	Material properties	Concrete	Elastic modulus at 28 days
Material Library	Material properties	Concrete	Shear factor
Material Library	Material properties	Concrete	Shear modulus
Material Library	Material properties	Concrete	Secant modulus
Material Library	Material properties	Concrete	Modulus of rupture
Material Library	Material properties	Concrete	Hardness
Material Library	Material properties	Concrete	Supply chain sustainability data
Material Library	Material properties	Concrete	Finish
Material Library	Material properties	Concrete	Sequence of pour
Material Library	Material properties	Concrete	Overlapping Concrete
Material Library	Material properties	Structural steel	Material designation
Material Library	Material properties	Structural steel	Associated mill test report (MTR)
Material Library	Material properties	Structural steel	Grade
Material Library	Material properties	Structural steel	Description
Material Library	Material properties	Structural steel	Unit mass
Material Library	Material properties	Structural steel	Nominal mass
Material Library	Material properties	Structural steel	Actual mass
Material Library	Material properties	Structural steel	Elastic modulus
Material Library	Material properties	Structural steel	Poisson's ratio
Material Library	Material properties	Structural steel	Shear modulus
Material Library	Material properties	Structural steel	Secant modulus

Information Group	Information Items	Attribute Sets	Attributes
Material Library	Material properties	Structural steel	Thermal expansion coefficient
Material Library	Material properties	Structural steel	Yield strength
Material Library	Material properties	Structural steel	Tensile strength
Material Library	Material properties	Structural steel	Governing specification
Material Library	Material properties	Structural steel	Heat number
Material Library	Material properties	Structural steel	Steel surface condition
Material Library	Material properties	Structural steel	Supply chain sustainability data
Material Library	Material properties	Reinforcing steel	Material designation
Material Library	Material properties	Reinforcing steel	Grade
Material Library	Material properties	Reinforcing steel	Description
Material Library	Material properties	Reinforcing steel	Unit mass
Material Library	Material properties	Reinforcing steel	Nominal mass
Material Library	Material properties	Reinforcing steel	Actual mass
Material Library	Material properties	Reinforcing steel	Elastic modulus
Material Library	Material properties	Reinforcing steel	Poisson's ratio
Material Library	Material properties	Reinforcing steel	Shear modulus
Material Library	Material properties	Reinforcing steel	Secant modulus
Material Library	Material properties	Reinforcing steel	Yield strength
Material Library	Material properties	Reinforcing steel	Ultimate strength
Material Library	Material properties	Reinforcing steel	Supply chain sustainability data
Material Library	Material properties	Prestress strand material	Material designation
Material Library	Material properties	Prestress strand material	Grade
Material Library	Material properties	Prestress strand material	Description

Information Group	Information Items	Attribute Sets	Attributes
Material Library	Material properties	Prestress strand material	Unit mass
Material Library	Material properties	Prestress strand material	Nominal mass
Material Library	Material properties	Prestress strand material	Actual mass
Material Library	Material properties	Prestress strand material	Elastic modulus
Material Library	Material properties	Prestress strand material	Poisson's ratio
Material Library	Material properties	Prestress strand material	Shear modulus
Material Library	Material properties	Prestress strand material	Secant modulus
Material Library	Material properties	Prestress strand material	Yield strength
Material Library	Material properties	Prestress strand material	Ultimate tensile strength
Material Library	Material properties	Prestress strand material	Transfer length
Material Library	Material properties	Prestress strand material	Epoxy coated indicator
Material Library	Material properties	Prestress strand material	Supply chain sustainability data
Material Library	Material properties	Sawn timber	Material designation
Material Library	Material properties	Sawn timber	Timber commercial grade
Material Library	Material properties	Sawn timber	Description
Material Library	Material properties	Sawn timber	Unit mass
Material Library	Material properties	Sawn timber	Nominal mass
Material Library	Material properties	Sawn timber	Actual mass
Material Library	Material properties	Sawn timber	Elastic modulus
Material Library	Material properties	Sawn timber	Poisson's ratio
Material Library	Material properties	Sawn timber	Shear modulus
Material Library	Material properties	Sawn timber	Secant modulus
Material Library	Material properties	Sawn timber	Timber grading rule agency

Information Group	Information Items	Attribute Sets	Attributes
Material Library	Material properties	Sawn timber	Timber size classification
Material Library	Material properties	Sawn timber	Timber species
Material Library	Material properties	Sawn timber	Grading method type
Material Library	Material properties	Sawn timber	Unit bending stress
Material Library	Material properties	Sawn timber	Unit compressive stress parallel
Material Library	Material properties	Sawn timber	Unit compressive stress perpendicular
Material Library	Material properties	Sawn timber	Unit shear stress parallel
Material Library	Material properties	Sawn timber	Unit tension stress parallel
Material Library	Material properties	Sawn timber	In plane properties
Material Library	Material properties	Sawn timber	Out of plane properties
Material Library	Material properties	Sawn timber	Supply chain sustainability data
Deterioration	Deterioration Information	Deterioration Information	Distance
Deterioration	Deterioration Information	Deterioration Information	Length
Deterioration	Deterioration Information	Deterioration Information	Percent thickness loss
Deterioration	Deterioration Information	Deterioration Information	Percent width loss
Deterioration	Deterioration Information	Deterioration Information	Position
Load and Resistance	Load	Load data	Dead load acting on girder before deck hardening (DC1)
Load and Resistance	Load	Load data	Dead load acting on girder during deck casting or placing (DC0)
Load and Resistance	Load	Load data	Construction loads: equipments, falsework, temporary supports (CL)
Load and Resistance	Load	Load data	Superimposed additional dead load after deck hardening (DC2)
Load and Resistance	Load	Load data	Future wearing surface load (DW)

Information Group	Information Items	Attribute Sets	Attributes
Load and Resistance	Load	Load data	Positive live load including impact (LL+ + I)
Load and Resistance	Load	Load data	Negative live load including impact (LL- + I)
Load and Resistance	Load	Load data	Positive fatigue load (include 15% dynamic load allowance) (LL+ + I)
Load and Resistance	Load	Load data	Negative fatigue load (include 15% dynamic load allowance) (LL- + I)
Load and Resistance	Resistance	Resistance data	Shear strength
Reinforcement	Longitudinal Bar	Properties	Name
Reinforcement	Longitudinal Bar	Properties	Associated member
Reinforcement	Longitudinal Bar	Properties	Bar size
Reinforcement	Longitudinal Bar	Properties	Bar grade
Reinforcement	Longitudinal Bar	Properties	Bar surface
Reinforcement	Longitudinal Bar	Properties	Lap splice indicator
Reinforcement	Longitudinal Bar	Properties	Bar coating
Reinforcement	Longitudinal Bar	Patterns	Number of bars
Reinforcement	Longitudinal Bar	Patterns	Spacing between the bars
Reinforcement	Longitudinal Bar	Patterns	Mesh size
Reinforcement	Longitudinal Bar	Dimensions	Longitudinal bar length
Reinforcement	Longitudinal Bar	Dimensions	Development length
Reinforcement	Longitudinal Bar	Dimensions	Lap splice length
Reinforcement	Longitudinal Bar	Dimensions	Lap splice location
Reinforcement	Longitudinal Bar	Dimensions	Start concrete cover (distance to tip of bar, longitudinal measurement)
Reinforcement	Longitudinal Bar	Dimensions	End concrete cover (distance to tip of bar, longitudinal measurement)

Information Group	Information Items	Attribute Sets	Attributes
Reinforcement	Longitudinal Bar	Dimensions	Cover x-axis (measured on cross-section)
Reinforcement	Longitudinal Bar	Dimensions	Cover y-axis (measured on cross-section)
Reinforcement	Longitudinal Bar	Dimensions	Cutoff lengths
Reinforcement	Longitudinal Bar	Dimensions	Bar Placement Sequence
Reinforcement	Longitudinal Bar	End Conditions	Bending radius
Reinforcement	Longitudinal Bar	End Conditions	Start condition (hook type)
Reinforcement	Longitudinal Bar	End Conditions	Start hook angle
Reinforcement	Longitudinal Bar	End Conditions	Start hook length
Reinforcement	Longitudinal Bar	End Conditions	Start hook radius
Reinforcement	Longitudinal Bar	End Conditions	End hook angle
Reinforcement	Longitudinal Bar	End Conditions	End hook length
Reinforcement	Longitudinal Bar	End Conditions	End hook radius
Reinforcement	Longitudinal Bar	End Conditions	End condition (hooks type)
Reinforcement	Longitudinal Bar	Material	Bar material designation
Reinforcement	Transverse Reinforcement	Properties	Number of Stirrups/ties sets (depending on bar size)
Reinforcement	Transverse Reinforcement	Properties	Names of each set
Reinforcement	Transverse Reinforcement	Properties	Orientation of each set
Reinforcement	Transverse Reinforcement	Properties	Grade
Reinforcement	Transverse Reinforcement	Properties	Number of zones (depending on spacing)
Reinforcement	Transverse Reinforcement	Pattern	Number of bars
Reinforcement	Transverse Reinforcement	Pattern	Spacing between the bars
Reinforcement	Transverse Reinforcement	Dimensions	Shape of stirrup/ties
Reinforcement	Transverse Reinforcement	Dimensions	Size of each set

Information Group	Information Items	Attribute Sets	Attributes
Reinforcement	Transverse Reinforcement	Dimensions	Angle along longitudinal axis
Reinforcement	Transverse Reinforcement	Dimensions	Number of stirrups/ties in zone 1
Reinforcement	Transverse Reinforcement	Dimensions	Number of stirrups/ties in zone 2
Reinforcement	Transverse Reinforcement	Dimensions	Number of stirrups/ties in zone 3
Reinforcement	Transverse Reinforcement	Dimensions	Concrete cover x-axis (measured on cross-section)
Reinforcement	Transverse Reinforcement	Dimensions	Concrete cover y-axis (measured on cross-section)
Reinforcement	Transverse Reinforcement	Dimensions	Width of stirrup (x-axis measured on cross-section)
Reinforcement	Transverse Reinforcement	Dimensions	Height of stirrup (y-axis measured on cross-section)
Reinforcement	Transverse Reinforcement	Dimensions	Bar Placement Sequence
Reinforcement	Transverse Reinforcement	End Conditions	Bending radii for each set
Reinforcement	Transverse Reinforcement	End Conditions	Start condition (hook type)
Reinforcement	Transverse Reinforcement	End Conditions	Start hook angle
Reinforcement	Transverse Reinforcement	End Conditions	Start hook length
Reinforcement	Transverse Reinforcement	End Conditions	Start hook radius
Reinforcement	Transverse Reinforcement	End Conditions	End hook angle
Reinforcement	Transverse Reinforcement	End Conditions	End hook length
Reinforcement	Transverse Reinforcement	End Conditions	End hook radius
Reinforcement	Transverse Reinforcement	End Conditions	End condition (hooks type)
Reinforcement	Transverse Reinforcement	Material	Transverse material designation
Reinforcement	Accessories	Chairs	Size of bars
Reinforcement	Accessories	Chairs	Shape of bars
Reinforcement	Accessories	Chairs	Number of bars

Information Group	Information Items	Attribute Sets	Attributes
Reinforcement	Accessories	Chairs	Total weight
Reinforcement	Accessories	Chairs	Location
Reinforcement	Accessories	Support Bars	Size of bars
Reinforcement	Accessories	Support Bars	Shape of bars
Reinforcement	Accessories	Support Bars	Number of bars
Reinforcement	Accessories	Support Bars	Total weight
Reinforcement	Accessories	Support Bars	Location
Reinforcement	Accessories	Standees	Size of bars
Reinforcement	Accessories	Standees	Shape of bars
Reinforcement	Accessories	Standees	Number of bars
Reinforcement	Accessories	Standees	Total weight
Reinforcement	Accessories	Standees	Location
Reinforcement	Structural component reinforcement	Properties	Number of bars
Reinforcement	Structural component reinforcement	Properties	Number of top bars
Reinforcement	Structural component reinforcement	Properties	Number of bottom bars
Reinforcement	Structural component reinforcement	Properties	Number of side bars
Reinforcement	Structural component reinforcement	Properties	Name of Formwork used (in-house name or id)
Reinforcement	Structural component reinforcement	Properties	Method of prestressing used
Reinforcement	Structural component reinforcement	Properties	Type of gauge used for measuring tension
Reinforcement	Structural component reinforcement	Properties	Type of pressure cutoff valves used (manual or automatic)

Information Group	Information Items	Attribute Sets	Attributes
Reinforcement	Structural component reinforcement	Properties	Rate of loading while using manual cutoff
Reinforcement	Structural component reinforcement	Properties	Amount of binding material used
Reinforcement	Structural component reinforcement	Properties	Reinforcing bar chair size
Reinforcement	Structural component reinforcement	Properties	Total number of reinforcing bar chair
Reinforcement	Structural component reinforcement	Properties	Weight of the member
Reinforcement	Structural component reinforcement	Properties	Number of lifting hooks
Reinforcement	Structural component reinforcement	Properties	Curing method
Reinforcement	Structural component reinforcement	Properties	Curing time
Reinforcement	Structural component reinforcement	Properties	Age at placement
Reinforcement	Structural component reinforcement	Dimensions	Cross-sectional dimensions
Reinforcement	Structural component reinforcement	Dimensions	End to end beam length
Reinforcement	Structural component reinforcement	Dimensions	Concrete cover (cross-section)
Reinforcement	Structural component reinforcement	Dimensions	Concrete cover (long-section)
Reinforcement	Structural component reinforcement	Dimensions	Total number of strands
Reinforcement	Structural component reinforcement	Dimensions	Dimensions of shear studs
Reinforcement	Structural component reinforcement	Dimensions	Number of shear studs

Information Group	Information Items	Attribute Sets	Attributes
Reinforcement	Structural component reinforcement	Dimensions	Spacing of shear studs
Reinforcement	Structural component reinforcement	Dimensions	Lengths of strands
Reinforcement	Structural component reinforcement	Dimensions	Distance to end from left harped point
Reinforcement	Structural component reinforcement	Dimensions	Distance to end from right harped point
Reinforcement	Structural component reinforcement	Dimensions	Radius of curvature for left end harped point
Reinforcement	Structural component reinforcement	Dimensions	Radius of curvature for right end harped point
Reinforcement	Structural component reinforcement	Dimensions	Location of lifting hooks
Reinforcement	Structural component reinforcement	Dimensions	Common rebars with another member
Reinforcement	Structural component reinforcement	Calculations	Initial tension force
Reinforcement	Structural component reinforcement	Calculations	Final tension force
Reinforcement	Structural component reinforcement	Calculations	Modulus of elasticity of tendon
Reinforcement	Structural component reinforcement	Calculations	Jacking stress ratio
Reinforcement	Structural component reinforcement	Calculations	Prestress transfer stress ratio
Reinforcement	Structural component reinforcement	Calculations	Strand elongation calculated
Reinforcement	Structural component reinforcement	Calculations	Strand elongation measured
Reinforcement	Structural component reinforcement	Calculations	Minimum loss

Information Group	Information Items	Attribute Sets	Attributes
Reinforcement	Structural component reinforcement	Calculations	Lump sum final loss
Reinforcement	Structural component reinforcement	Calculations	Lump sum composite loss
Reinforcement	Structural component reinforcement	Calculations	Lump sum continuous loss
Reinforcement	Structural component reinforcement	Calculations	Relaxation coefficient
Reinforcement	Structural component reinforcement	Calculations	Ultimate creep loss
Reinforcement	Structural component reinforcement	Calculations	Maturity coefficient
Reinforcement	Structural component reinforcement	Calculations	Ultimate shrinkage loss
Reinforcement	Structural component reinforcement	Calculations	Prestressing force transfer time
Reinforcement	Structural component reinforcement	Bar mark	Name
Reinforcement	Structural component reinforcement	Bar mark	Reinforcing steel name
Reinforcement	Structural component reinforcement	Bar mark	Rebar name
Reinforcement	Structural component reinforcement	Bar mark	Bar shape type
Reinforcement	Structural component reinforcement	Bar mark	Dimension
Reinforcement	Structural component reinforcement	Bar mark	Hook at start indicator
Reinforcement	Structural component reinforcement	Bar mark	Hook at end indicator
Reinforcement	Structural component reinforcement	Bar mark	Angle
Reinforcement	Prestressing	Pattern	Row number

Information Group	Information Items	Attribute Sets	Attributes
Reinforcement	Prestressing	Pattern	Number of strands per row
Reinforcement	Prestressing	Pattern	Number of strands
Reinforcement	Prestressing	Pattern	Number of ducts
Reinforcement	Prestressing	Pattern	Name of grout
Reinforcement	Prestressing	Pattern	Vertical distance from edge
Reinforcement	Prestressing	Pattern	Vertical spacing
Reinforcement	Prestressing	Pattern	Horizontal distance from edge
Reinforcement	Prestressing	Pattern	Horizontal spacing
Reinforcement	Prestressing	Properties	Strand area
Reinforcement	Prestressing	Properties	Strand diameter
Reinforcement	Prestressing	Properties	Strand type
Reinforcement	Prestressing	Properties	Stresses developed by Anchorage and couplers
Reinforcement	Prestressing	Properties	Ducts indicator
Reinforcement	Prestressing	Properties	Type of ducts used (Metal/polyethylene)
Reinforcement	Prestressing	Properties	Metal ducts galvanized indicator
Reinforcement	Prestressing	Properties	Type of polyethylene ducts (rigid/semi-rigid)
Reinforcement	Prestressing	Properties	Rigid-ducts grade
Reinforcement	Prestressing	Properties	type of transition fittings used
Reinforcement	Prestressing	Properties	Type of cement used for grouting
Reinforcement	Prestressing	Properties	Admixtures used for grouting
Reinforcement	Prestressing	Duct properties	Location of couplers
Reinforcement	Prestressing	Duct properties	Thickness of ducts
Reinforcement	Prestressing	Duct properties	Diameter of ducts

Information Group	Information Items	Attribute Sets	Attributes
Reinforcement	Prestressing	Duct properties	Area of ducts
Reinforcement	Prestressing	Calculations	Rigid ducts diameter to wall thickness ratio (should be 21 or less)
Reinforcement	Prestressing	Calculations	difference between diameter of ducts and nominal diameter of single wire (min 6mm)
Reinforcement	Prestressing	Calculations	Ratio of duct area to area of prestressing steel
Reinforcement	Prestressing	Prestressing properties	AASHTO percent dead load
Reinforcement	Prestressing	Prestressing properties	Jacking stress ratio
Reinforcement	Prestressing	Prestressing properties	Loss method type
Reinforcement	Prestressing	Prestressing properties	Lump sum composite loss
Reinforcement	Prestressing	Prestressing properties	Lump sum continuous loss
Reinforcement	Prestressing	Prestressing properties	Lump sum final loss
Reinforcement	Prestressing	Prestressing properties	Name
Reinforcement	Prestressing	Prestressing properties	PCI additional time
Reinforcement	Prestressing	Prestressing properties	PCI maturity coefficient
Reinforcement	Prestressing	Prestressing properties	PCI ultimate creep loss
Reinforcement	Prestressing	Prestressing properties	PCI ultimate shrink loss
Reinforcement	Prestressing	Prestressing properties	Prestressed strand name
Reinforcement	Prestressing	Prestressing properties	Transfer stress ratio
Reinforcement	Prestressing	Prestressing properties	Transfer time
Reinforcement	Prestressing	Prestressing properties	Unit load per length
Reinforcement	Prestressing	Prestressing properties	Anchorage slip
Reinforcement	Post-Tensioning	Properties	Number of strands
Reinforcement	Post-Tensioning	Properties	Properties of strands

Information Group	Information Items	Attribute Sets	Attributes
Reinforcement	Post-Tensioning	Properties	Stresses developed by Anchorage and couplers
Reinforcement	Post-Tensioning	Properties	Bonded or unbonded Post tensioning
Reinforcement	Post-Tensioning	Properties	Number of ducts
Reinforcement	Post-Tensioning	Properties	Type of ducts used (Metal/polyethylene)
Reinforcement	Post-Tensioning	Properties	Metal ducts galvanized (yes/no?)
Reinforcement	Post-Tensioning	Properties	Type of polyethylene ducts (rigid/semi-rigid)
Reinforcement	Post-Tensioning	Properties	Properties of rigid-ducts (grade)
Reinforcement	Post-Tensioning	Properties	type of transition fittings used
Reinforcement	Post-Tensioning	Properties	Name of grout used
Reinforcement	Post-Tensioning	Properties	Properties of grout used
Reinforcement	Post-Tensioning	Properties	Type of cement used for grouting
Reinforcement	Post-Tensioning	Properties	Admixtures used for grouting
Reinforcement	Post-Tensioning	Dimensions	Dimensions of strands
Reinforcement	Post-Tensioning	Dimensions	Location of couplers
Reinforcement	Post-Tensioning	Dimensions	Thickness of ducts
Reinforcement	Post-Tensioning	Dimensions	Diameter of ducts
Reinforcement	Post-Tensioning	Dimensions	Tendon Profile
Reinforcement	Post-Tensioning	Dimensions	Radius of curvature of ducts
Reinforcement	Post-Tensioning	Dimensions	Spacing between tendons at end 1
Reinforcement	Post-Tensioning	Dimensions	Spacing between tendons at mid span
Reinforcement	Post-Tensioning	Dimensions	Spacing between tendons at end 2
Reinforcement	Post-Tensioning	Dimensions	Angle of Each tendon at the end
Reinforcement	Post-Tensioning	Dimensions	Tendon Eccentricity

Information Group	Information Items	Attribute Sets	Attributes
Reinforcement	Post-Tensioning	Dimensions	Number of grout inlet ports
Reinforcement	Post-Tensioning	Dimensions	Grout inlet port location
Reinforcement	Post-Tensioning	Dimensions	Area of ducts
Reinforcement	Post-Tensioning	Calculations	Rigid ducts diameter to wall thickness ratio (should be 21 or less)
Reinforcement	Post-Tensioning	Calculations	Stress in tendons
Reinforcement	Post-Tensioning	Calculations	jacking force
Reinforcement	Post-Tensioning	Calculations	difference between diameter of ducts and nominal diameter of single wire (min 6mm)
Reinforcement	Post-Tensioning	Calculations	Ratio of duct area to area of prestressing steel
Reinforcement	Post-Tensioning	Calculations	Elongation of strands
Reinforcement	Post-Tensioning	PT Hardware	Type of bearing plates
Reinforcement	Post-Tensioning	PT Hardware	Properties of Stressing Jacks used
Reinforcement	Post-Tensioning	PT Hardware	Size of bearing plates
Reinforcement	Post-Tensioning	PT Hardware	Shape of bearing plates
Reinforcement	Post-Tensioning	PT Hardware	Material strenght of bearing plates
Reinforcement	Post-Tensioning	PT Hardware	Size of wedges used
Reinforcement	Post-Tensioning	PT Hardware	Size of wedge plates used
Reinforcement	Post-Tensioning	PT Hardware	Number of grout caps used
Reinforcement	Post-Tensioning	PT Hardware	Type of grout inlet and outlet valves
Reinforcement	Post-Tensioning	PT Hardware	Type of grout plugs
Reinforcement	Post-Tensioning	PT Hardware	Number of Anchor nuts
Reinforcement	Post-Tensioning	PT Hardware	Anchorage type
Reinforcement	Post-Tensioning	Spliced Girders	Number of beams in cross section

Information Group	Information Items	Attribute Sets	Attributes
Reinforcement	Post-Tensioning	Spliced Girders	Number of spans before splicing
Reinforcement	Post-Tensioning	Spliced Girders	Number of spans after splicing
Reinforcement	Post-Tensioning	Spliced Girders	Number of temporary supports
Reinforcement	Post-Tensioning	Spliced Girders	Length of each beam before splicing
Reinforcement	Post-Tensioning	Spliced Girders	Total length of beams after splicing
Reinforcement	Post-Tensioning	Spliced Girders	Number of tendons in each beam
Reinforcement	Post-Tensioning	Spliced Girders	Profile of each tendon
Reinforcement	Post-Tensioning	Spliced Girders	Location of each tendon on start cross section
Reinforcement	Post-Tensioning	Spliced Girders	Location of each tendon on end cross section
Reinforcement	Post-Tensioning	Spliced Girders	Abrupt profile change locations of tendon along the length of beam
Reinforcement	Post-Tensioning	Spliced Girders	Type of bearing plates
Reinforcement	Post-Tensioning	Spliced Girders	Properties of Stressing Jacks used
Reinforcement	Post-Tensioning	Spliced Girders	Size of bearing plates
Reinforcement	Post-Tensioning	Spliced Girders	Shape of bearing plates
Reinforcement	Post-Tensioning	Spliced Girders	Material strength of bearing plates
Reinforcement	Post-Tensioning	Spliced Girders	Size of wedges
Reinforcement	Post-Tensioning	Spliced Girders	Size of wedge plates
Reinforcement	Post-Tensioning	Spliced Girders	Number of grout caps
Reinforcement	Post-Tensioning	Spliced Girders	Type of grout inlet and outlet valves
Reinforcement	Post-Tensioning	Spliced Girders	Type of grout plugs
Reinforcement	Post-Tensioning	Spliced Girders	Number of Anchor nuts
Reinforcement	Post-Tensioning	Spliced Girders	Anchorage type
Reinforcement	Post-Tensioning	Spliced Girders	Shape of wedge plate

Information Group	Information Items	Attribute Sets	Attributes
Reinforcement	Post-Tensioning	Spliced Girders	Size of wedge plate in plan
Reinforcement	Post-Tensioning	Spliced Girders	Size of wedge plate in elevation

The Data Dictionary in Excel format is attached as an appendix to this Information Delivery Manual.

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SECTION 7 DATA EXAMPLES

7. Data Examples 7.1 Concrete Bridge Example

Quincy Avenue over I-25 and LRT in Denver, Colorado has been chosen as a case study bridge because it is a typical grade separation bridge, yet with nontrivial parametric complexity, and because it is recently designed and built, which reflects current practice of bridge design and construction.

The case-study bridge is a 3-span continuous bridge with a cast-in-place reinforced concrete deck. It has seven BT72 prestressed concrete girders spacing at 11ft-3in center-to-center. The bridge is 76 ft wide, and its span configuration is 45.5 ft -122 ft -109.5 ft as shown in Figure 7-1. The deck consists of an 8 in. thick structural component and a 2 in. thick integral wearing surface (IWS). The deck has a crown at the centerline of the roadway and falls away from the centerline at a 2% cross-slope. The bridge has a 10.5 ft wide sidewalk and a 1.5 ft wide barrier on each side, two lanes of traffic in each direction.

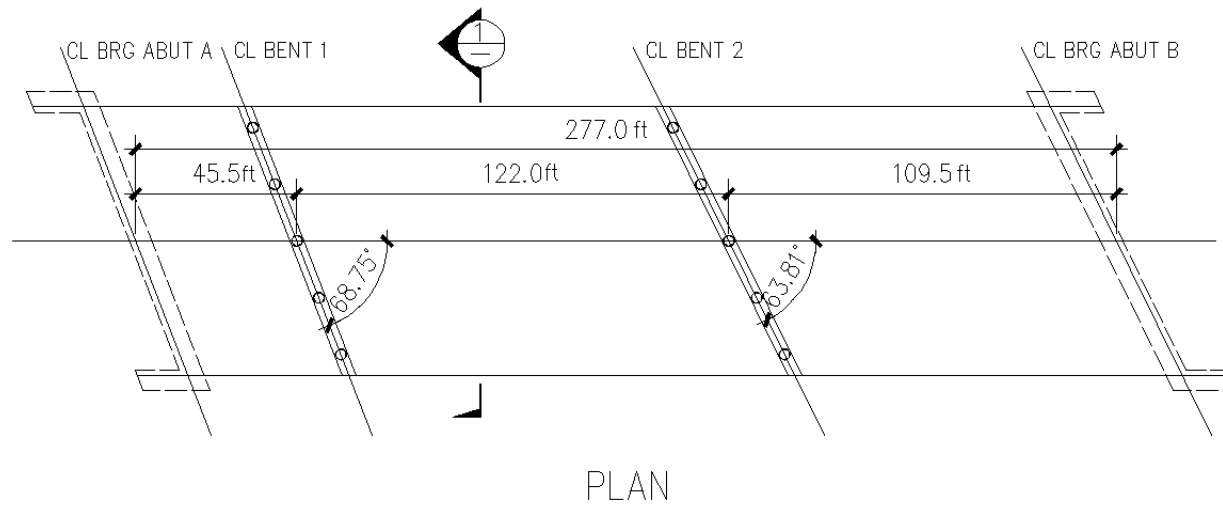


Figure 7-1. Plan View of Quincy Avenue over I-25 and LRT

The substructure elements are oriented at a 21.25-degree and a 26.19-degree skew from a line perpendicular to a straight bridge centerline alignment, respectively. Each pier bent has five 3 ft diameter cast-in-place columns. Figure 7-2 shows the section view of the as-built case-study bridge. The 2% side slope is not shown in this figure.

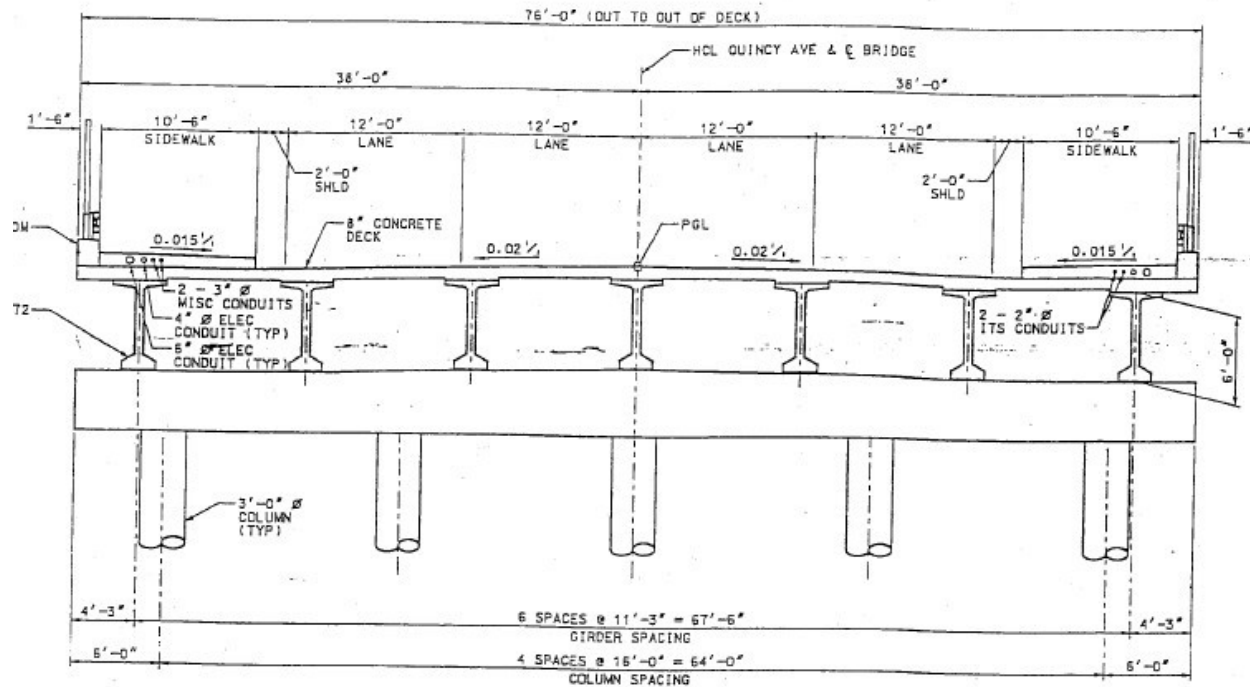


Figure 7-2. Section View of Quincy Avenue over I-25 and LRT

7.1.1 Data for Concrete Case Study Bridge in Excel Sheet

Quincy Avenue Bridge Data - Roadway Geometry Driven:

Unit system	Imperial	Foot
Unit system	Imperial	Kip
Unit system	Imperial	Pound
Unit system	Imperial	Degree
Unit system	Imperial	Rankine

Material	Concrete	Class B	Unit mass	0.15
Material	Concrete	Class B	Elastic modulus	454449.6
Material	Concrete	Class B	Poisson's ratio	0.2
Material	Concrete	Class B	Thermal expansion coefficient	0.0000055
Material	Concrete	Class B	Compressive strength	432
Material	Concrete	Class D	Unit mass	0.15
Material	Concrete	Class D	Elastic modulus	556588.8
Material	Concrete	Class D	Poisson's ratio	0.2
Material	Concrete	Class D	Thermal expansion coefficient	0.0000055
Material	Concrete	Class D	Compressive strength	648
Material	Concrete	Precast concrete	Unit mass	0.15
Material	Concrete	Precast concrete	Elastic modulus	764956.8
Material	Concrete	Precast concrete	Poisson's ratio	0.2
Material	Concrete	Precast concrete	Thermal expansion coefficient	0.0000055
Material	Concrete	Precast concrete	Compressive strength	1224
Material	Steel	ASTM A709M Gr 345W	Unit mass	0.49
Material	Steel	ASTM A709M Gr 345W	Elastic modulus	4176000
Material	Steel	ASTM A709M Gr 345W	Poisson's ratio	0.3
Material	Steel	ASTM A709M Gr 345W	Thermal expansion coefficient	0.0000065
Material	Steel	ASTM A709M Gr 345W	Yield stress	7200
Material	Steel	A615 Gr60	Yield stress	8640
Material	Steel	A615 Gr60	Diameter	0.08333

Section	Circular section	Column section	Diameter	3
Section	Circular section	Drilled shaft section	Diameter	3.5

Section	Rectangular section	Haunch section	Height	0.16667			
Section	Rectangular section	Haunch section	Width	3.5834			
Section	Rectangular section	Cap beam section	Height	4			
Section	Rectangular section	Cap beam section	Width	3.5			
Section	Rectangular section	Diaphragm section	Height	6.16667			
Section	Rectangular section	Diaphragm section	Width	3.5			
Section	Bulb Tee section	BT72 girder section	Perimeter points	x	-1.7917	-1.7917	-0.4583
Section	Bulb Tee section	BT72 girder section	Perimeter points	y	6	5.7083	5.5417

Roadway Geometry	Horizontal alignment	Type	Linear	
Roadway Geometry	Horizontal alignment	Stations	Bridge begin station	381.17
Roadway Geometry	Horizontal alignment	Stations	Bridge end station	661.49
Roadway Geometry	Horizontal alignment	Stations	CL bearing abutment 1	382.78
Roadway Geometry	Horizontal alignment	Stations	CL pier 2	428.31
Roadway Geometry	Horizontal alignment	Stations	CL pier 3	550.32
Roadway Geometry	Horizontal alignment	Stations	CL bearing abutment 4	659.82
Roadway Geometry	Horizontal alignment	Span lengths	Span 1 length	45.53
Roadway Geometry	Horizontal alignment	Span lengths	Span 2 length	122.01
Roadway Geometry	Horizontal alignment	Span lengths	Span 3 length	109.50
Roadway Geometry	Horizontal alignment	Span lengths	Total span length	277.04

<-- Data entry point

<-- Data entry point

<-- Data entry point

<-- Data entry point

Roadway Geometry	Horizontal alignment	Horizontal alignment points	Alignment begin point	x	382.78
Roadway Geometry	Horizontal alignment	Horizontal alignment points	Alignment begin point	y	0
Roadway Geometry	Horizontal alignment	Horizontal alignment points	Alignment begin point	z	0
Roadway Geometry	Horizontal alignment	Horizontal alignment points	Alignment end point	x	659.82
Roadway Geometry	Horizontal alignment	Horizontal alignment points	Alignment end point	y	0
Roadway Geometry	Horizontal alignment	Horizontal alignment points	Alignment end point	z	0
Roadway Geometry	Horizontal alignment	Angles	Skew angle at abutment 1	21.25	<-- Data entry point
Roadway Geometry	Horizontal alignment	Angles	Skew angle at pier 2	21.25	<-- Data entry point
Roadway Geometry	Horizontal alignment	Angles	Skew angle at pier 3	26.19	<-- Data entry point
Roadway Geometry	Horizontal alignment	Angles	Skew angle at abutment 4	26.19	<-- Data entry point

Bridge geometry	Deck width	76	<-- Data entry point
Bridge geometry	Girder spacing	11.25	<-- Data entry point
Bridge geometry	Column spacing	16	<-- Data entry point
Bridge geometry	Drilled shaft spacing	16	

Member	Surface member	Deck	Boundary	x	368.02	397.55	678.50
Member	Surface member	Deck	Boundary	y	38	-38	-38
Member	Surface member	Deck	Boundary	z	0	0	0
Member	Surface member	Deck	Material	Class B			
Member	Surface member	Deck	Thickness	0.75			
Member	Surface member	Deck	Placement surface	Top			

Member	Surface member	Deck	Offset	0			
Member	Linear member	Haunches	Location	Start point	x	369.67	374.04
Member	Linear member	Haunches	Location	Start point	y	33.75	22.5
Member	Linear member	Haunches	Location	Start point	z	-0.75	-0.75
Member	Linear member	Haunches	Location	End point	x	643.23	648.76
Member	Linear member	Haunches	Location	End point	y	33.75	22.5
Member	Linear member	Haunches	Location	End point	z	-0.75	-0.75
Member	Linear member	Haunches	Orientation	x	0		
Member	Linear member	Haunches	Orientation	y	0		
Member	Linear member	Haunches	Orientation	z	1		
Member	Linear member	Haunches	Placement point	CentroidTop			
Member	Linear member	Haunches	Section	Haunch section			
Member	Linear member	Haunches	Material	Class B		1	2
Member	Linear member	Girders	Location	Start point	x	369.67	374.04
Member	Linear member	Girders	Location	Start point	y	33.75	22.5
Member	Linear member	Girders	Location	Start point	z	-0.92	-0.92
Member	Linear member	Girders	Location	End point	x	643.23	648.76
Member	Linear member	Girders	Location	End point	y	33.75	22.5
Member	Linear member	Girders	Location	End point	z	-0.92	-0.92
Member	Linear member	Girders	Orientation	x	0		
Member	Linear member	Girders	Orientation	y	0		
Member	Linear member	Girders	Orientation	z	1		
Member	Linear member	Girders	Placement point	CentroidTop			
Member	Linear member	Girders	Section	BT72 girder section			
Member	Linear member	Girders	Material	Precast concrete			
Member	Linear member	Cap beams	Location	Start point	x	413.54	531.64
Member	Linear member	Cap beams	Location	Start point	y	38	38

Member	Linear member	Cap beams	Location	Start point	z	-6.92	-6.92
Member	Linear member	Cap beams	Location	End point	x	443.08	569.00
Member	Linear member	Cap beams	Location	End point	y	-38	-38
Member	Linear member	Cap beams	Location	End point	z	-6.92	-6.92
Member	Linear member	Cap beams	Orientation	x	0		
Member	Linear member	Cap beams	Orientation	y	0		
Member	Linear member	Cap beams	Orientation	z	1		
Member	Linear member	Cap beams	Placement point	CentroidTop			
Member	Linear member	Cap beams	Section	Cap beam section			
Member	Linear member	Cap beams	Material	Class D			
Member	Linear member	Diaphragms	Location	Start point	x	413.54	531.64
Member	Linear member	Diaphragms	Location	Start point	y	38.00	38.00
Member	Linear member	Diaphragms	Location	Start point	z	-0.75	-0.75
Member	Linear member	Diaphragms	Location	End point	x	443.08	569.00
Member	Linear member	Diaphragms	Location	End point	y	-38.00	-38.00
Member	Linear member	Diaphragms	Location	End point	z	-0.75	-0.75
Member	Linear member	Diaphragms	Orientation	x	0		
Member	Linear member	Diaphragms	Orientation	y	0		
Member	Linear member	Diaphragms	Orientation	z	1		
Member	Linear member	Diaphragms	Placement point	CentroidTop			
Member	Linear member	Diaphragms	Section	Diaphragm section			
Member	Linear member	Diaphragms	Material	Class D		1	2
Member	Linear member	Columns	Location	Start point	x	415.87	422.09
Member	Linear member	Columns	Location	Start point	y	32	16
Member	Linear member	Columns	Location	Start point	z	-10.92	-10.92
Member	Linear member	Columns	Location	End point	x	415.87	422.09
Member	Linear member	Columns	Location	End point	y	32	16

Member	Linear member	Columns	Location	End point	z	-35.92	-35.92
Member	Linear member	Columns	Orientation	x	0		
Member	Linear member	Columns	Orientation	y	1		
Member	Linear member	Columns	Orientation	z	0		
Member	Linear member	Columns	Placement point	Centroid	Centroid		
Member	Linear member	Columns	Section	Column section			
Member	Linear member	Columns	Material	Class D		1	2
Member	Linear member	Drilled shafts	Location	Start point	x	415.87	422.09
Member	Linear member	Drilled shafts	Location	Start point	y	32.00	16.00
Member	Linear member	Drilled shafts	Location	Start point	z	-35.92	-35.92
Member	Linear member	Drilled shafts	Location	End point	x	415.87	422.09
Member	Linear member	Drilled shafts	Location	End point	y	32.00	16.00
Member	Linear member	Drilled shafts	Location	End point	z	-47.42	-47.42
Member	Linear member	Drilled shafts	Orientation	x	0		
Member	Linear member	Drilled shafts	Orientation	y	1		
Member	Linear member	Drilled shafts	Orientation	z	0		
Member	Linear member	Drilled shafts	Placement point	Centroid	Centroid		
Member	Linear member	Drilled shafts	Section	Drilled shaft section			
Member	Linear member	Drilled shafts	Material	Class D			

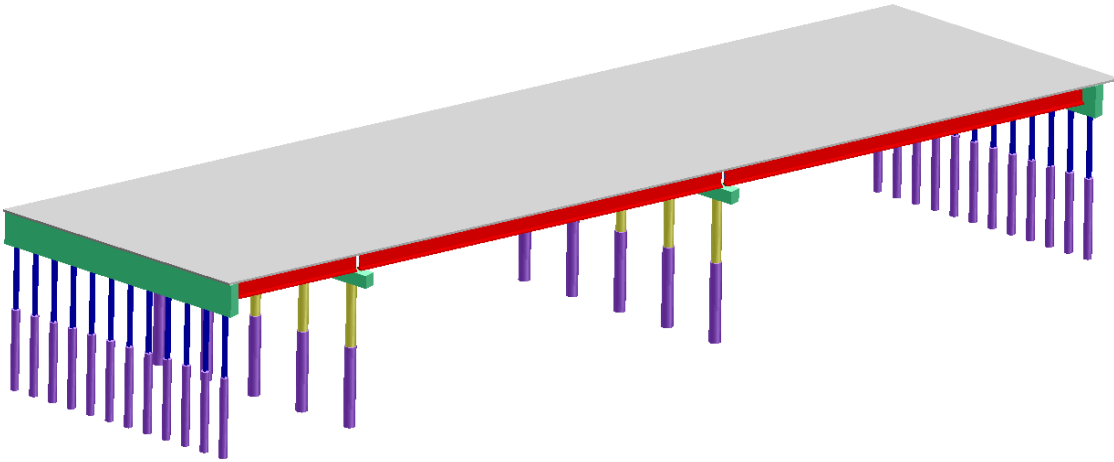


Figure 7-3. 3D View of the Concrete Case Study Bridge

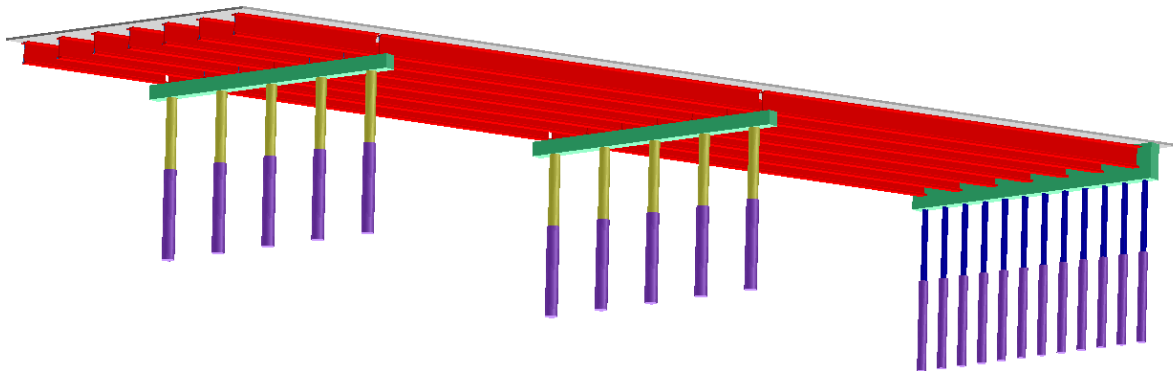


Figure 7-4. 3D View of the Concrete Case Study Bridge

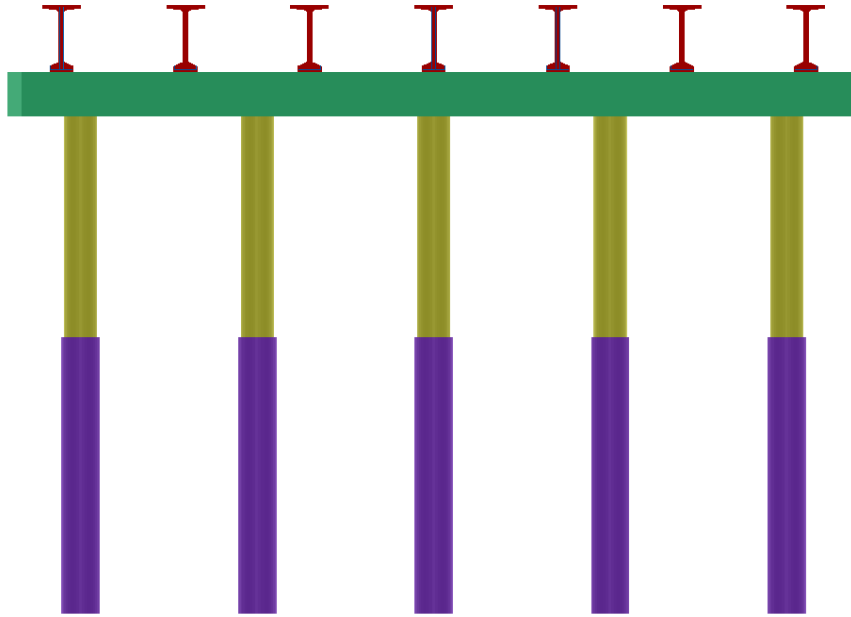


Figure 7-5. Cross-section View BT-72 Girders

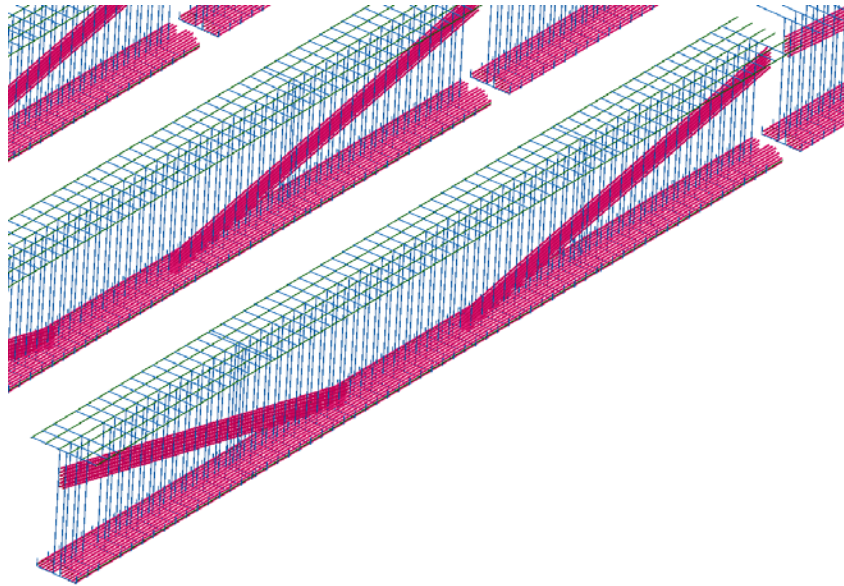


Figure 7-6. 3D View of Straight and Harped strands, longitudinal and transverse reinforcement

7.1.2 Data for the Concrete Case Study Bridge (Glenridge Road) in XML

Adjacent box beam bridge is one type of workhorse bridges which is widely used in the U.S. Based on the National Bridge Inventory (NBI), nearly 42% new bridges built during 2007 and 2011 are (multiple) box beam bridges. Therefore, in order to cover this bridge type, Glenridge Road over Alplaus Kill in Glenville, NY was chosen as a case study bridge for this research.

Glenridge Road over Alplaus Kill is a single span straight bridge with a cast-in-place reinforced concrete deck. It has nine prestressed concrete adjacent box beams spacing at 1.22 m center-to-center. The bridge is 11.34 m wide (out to out), and its span length is 22 m. The deck consists of a 150 mm thick structural component and a 50 mm thick integral wearing surface (IWS). The deck has a crown at the centerline of the roadway and falls away from the centerline at a 2% cross slope. The bridge has a 1.8 m wide shoulder and a 0.57 m wide railing on each side, one lane of traffic in each direction. The abutments are oriented at a 25° skew from a line perpendicular to a straight bridge centerline alignment.

The concrete strength of the adjacent box beams differs from that of the concrete deck which acts compositely with beams under superimposed dead loads. The required minimum concrete strength of beams at transfer is 49 MPa, and the required minimum concrete strength of beams at 56 days is 70 MPa. The allowable tensions in the prestressed concrete units are 1.38 MPa at transfer and 2.09 MPa at service limit state, respectively. The compression strength of concrete for substructures and deck slabs at 28 days is 21 MPa.

Figure 7-7 and 7-8 show the section view and the plan view of the case study bridge, respectively. Figure 7-9, 7-10 and 7-11 show the 3D model of the bridge as viewed in OpenBrIM viewer. The details of the reinforcement can be seen in figure 7-12 and 7-13. A close-up 3D rendering of a couple of bars used are shown in figure 7-14 and 7-15.

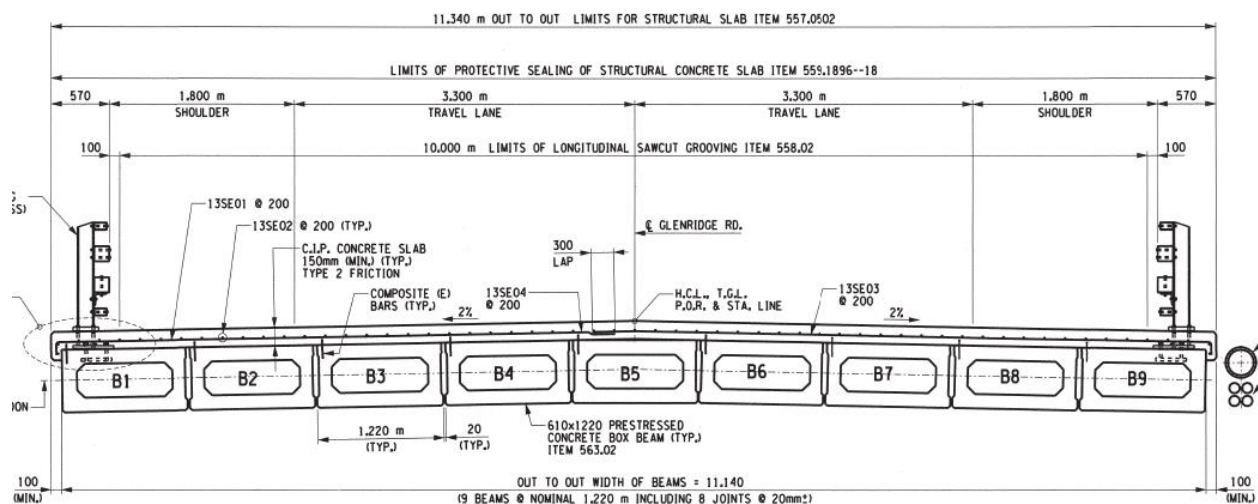


Figure 7-7. Section View of Glenridge Road over Alplaus Kill

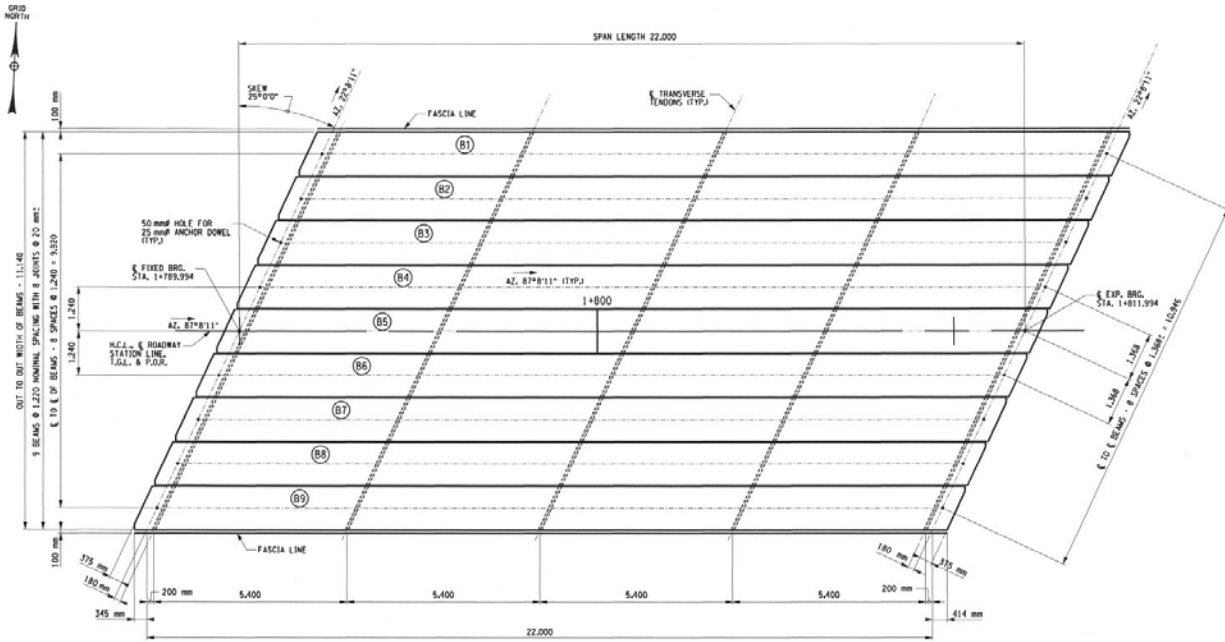


Figure 7-8. Plan View of Glenridge Road over Alplaus Kill

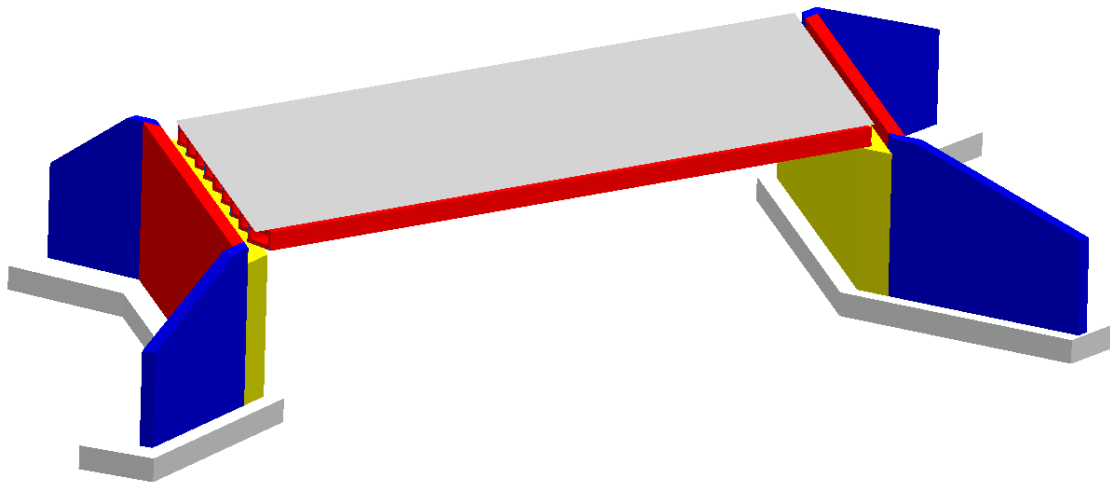


Figure 7-9. 3D View of the Concrete Case Study Bridge

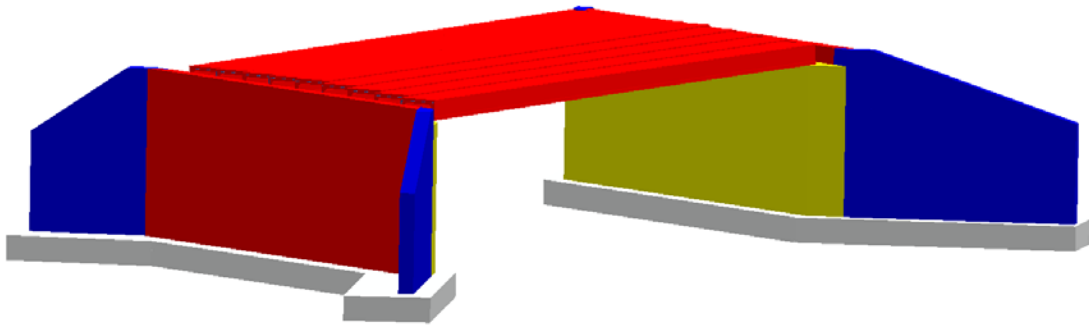


Figure 7-10. 3D View of the Concrete Case Study Bridge

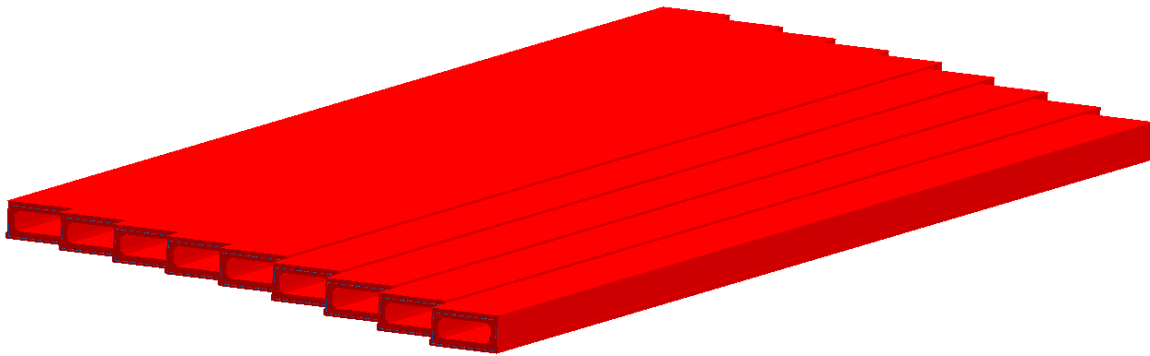


Figure 7-11. 3D View of the Box Beams 610x1220(NY)

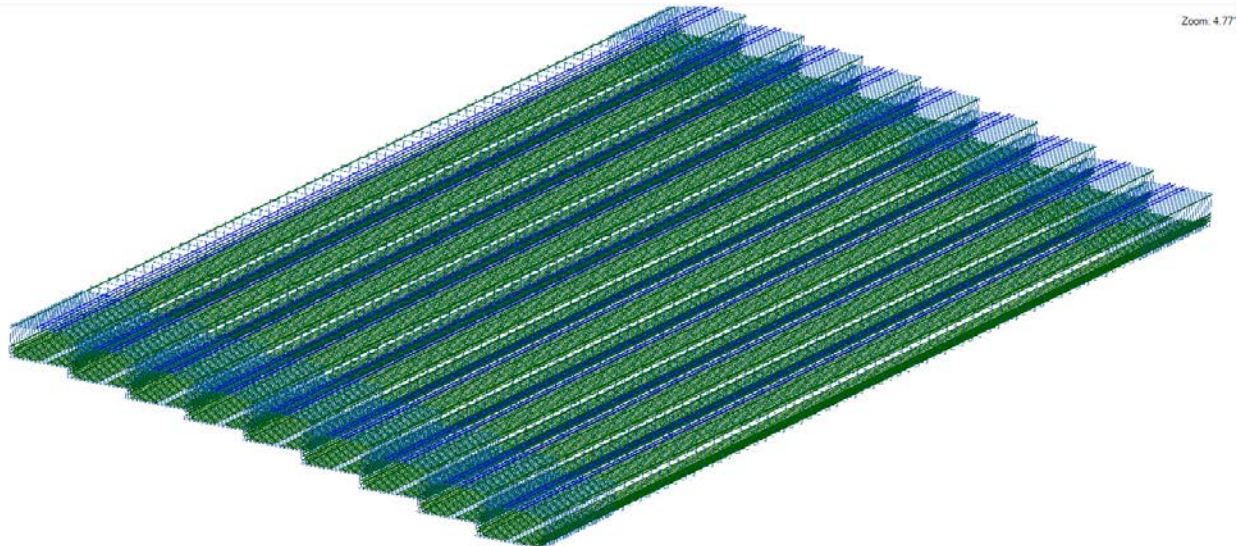


Figure 7-12. 3D View of Reinforcement (strands, longitudinal and transverse) in Box Beams

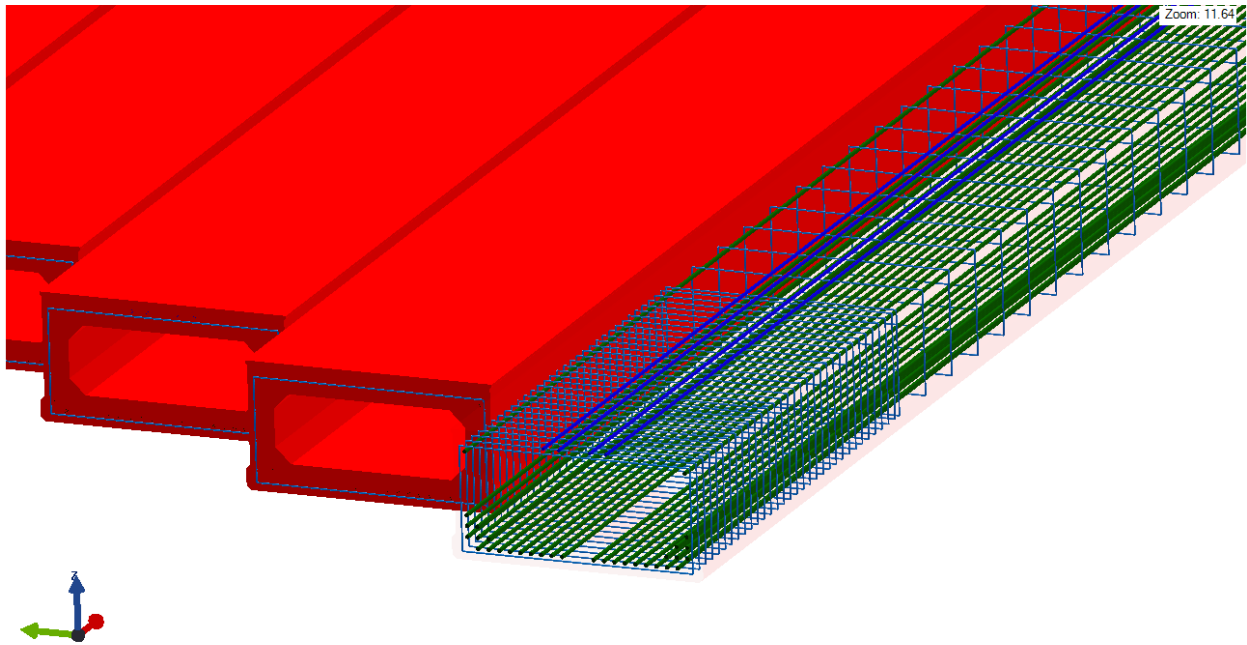


Figure 7-13. Zoomed-in view of Reinforcement (strands, longitudinal and transverse) in Box Beams

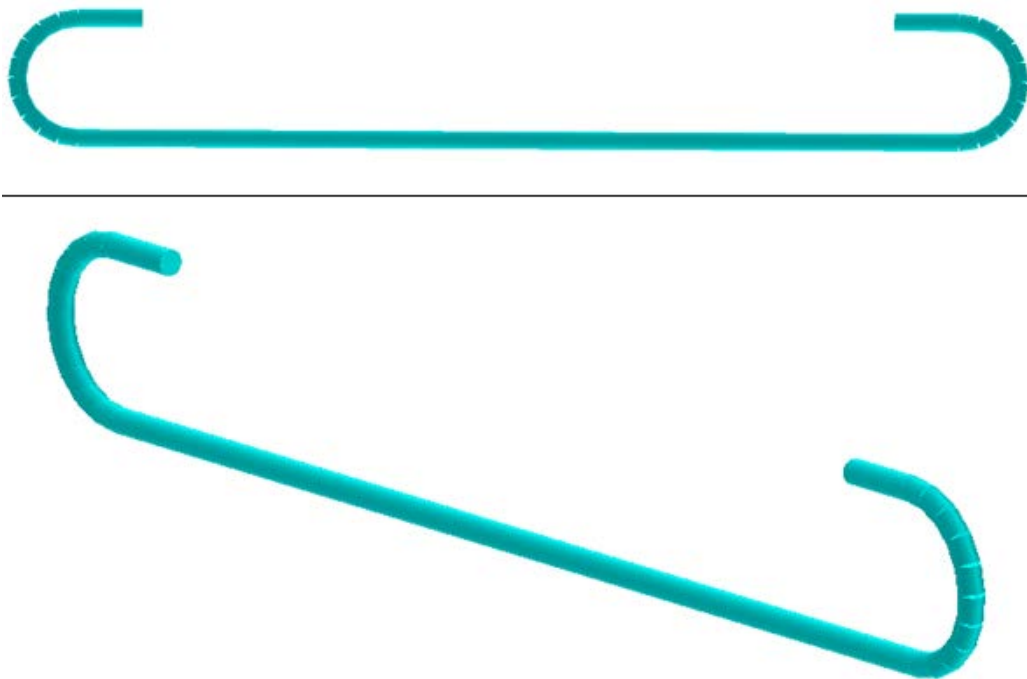


Figure 7-14. View of CRSI Rebar Bend Type -1 used in modeling

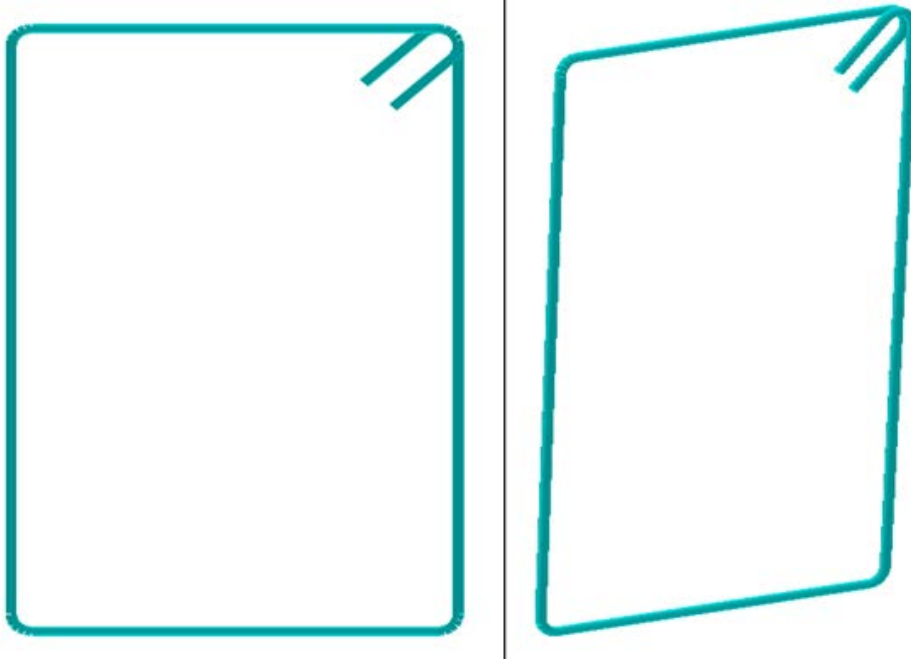


Figure 7-15. 3D View of CRSI Rebar Bend Type -T1 used in modeling

7.2 Steel Bridge Example

7.2.1 Data for the Steel Case Study Bridge (I-290 Ramp B over I-290 Ramp D and I-190)

The case study bridge, I-290 ramp B over I-290 ramp D and I-190 in NY is a 2-span continuous bridge with a cast-in-place reinforced concrete deck. It has five steel plate girders spacing at 2.85 m center-to-center. The bridge is 12.914 m wide, and its span configuration is 57.191 m – 63.392 m. The deck consists of a 200 mm thick structural component and a 40 mm thick integral wearing surface (IWS). The deck has a crown near the right edge of the bridge and falls away from the crown at 8% and 2% cross slopes, respectively. The bridge has a 3 m wide shoulder, a 1.2 m wide shoulder, and two 0.457 m wide parapets. There are two lanes of traffic on the deck, one in each direction.

The first abutment and the pier do not have skew. The end abutment is oriented at a 30° skew from a line perpendicular to a straight bridge centerline alignment. The pier type is hammer head pier.

All structural steel shall conform to ASTM 709M Grade 345W. The compression strength of concrete for substructures and deck slabs at 28 days is 21 MPa.

Figure 7-16 and 7-17 show the section view and the framing plan of the case study bridge, respectively.

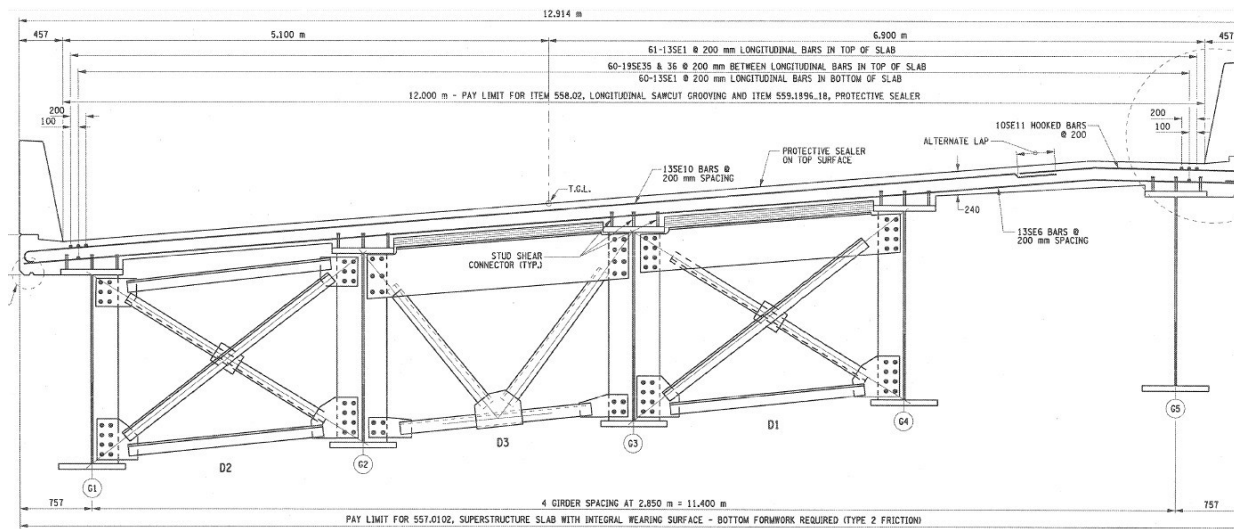


Figure 7-16. Section View of I-290 Ramp B over I-290 Ramp D and I-190

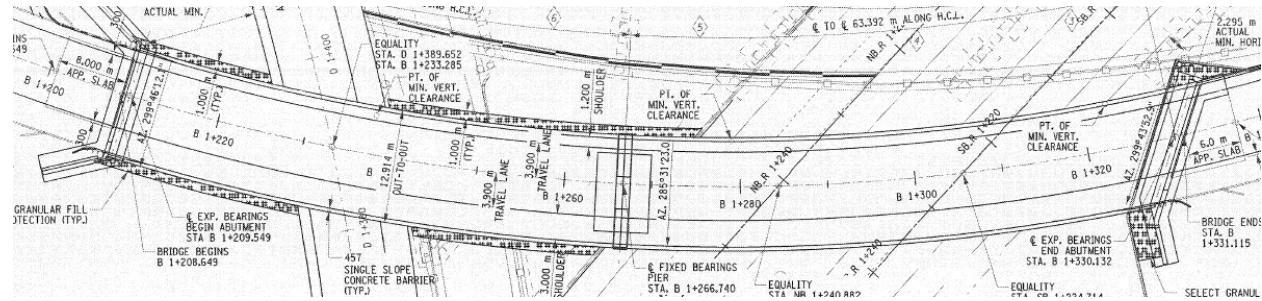


Figure 7-17. Plan View of I-290 Ramp B over I-290 Ramp D and I-190

I-290 Ramp "B" over I-290 Ramp "D" & I-190:

Unit system	Metric	Millimeter
Unit system	Metric	Newton
Unit system	Metric	Kilogram
Unit system	Metric	Degree
Unit system	Metric	Kelvin

Materials	Concrete	21 MPa	Unit mass	2.32E-06
Materials	Concrete	21 MPa	Elastic modulus at 28 days	22019.6
Materials	Concrete	21 MPa	Poisson's ratio	0.2
Materials	Concrete	21 MPa	Thermal expansion coefficient	9.90E-06
Materials	Concrete	21 MPa	Compressive strength at 28 days	21
Materials	Structural steel	ASTM A709M Gr 345W	Unit mass	7.85E-06
Materials	Structural steel	ASTM A709M Gr 345W	Elastic modulus	200000
Materials	Structural steel	ASTM A709M Gr 345W	Poisson's ratio	0.3
Materials	Structural steel	ASTM A709M Gr 345W	Thermal expansion coefficient	1.17E-05
Materials	Structural steel	ASTM A709M Gr 345W	Yield strength	345
Materials	Structural steel	ASTM A709M Gr 345W	Yield strength	420

Sections	Plate girder sections	Top flange	Region AT/ET	Height	32
Sections	Plate girder sections	Top flange	Region AT/ET	Width	650
Sections	Plate girder sections	Top flange	Region BT/DT	Height	40
Sections	Plate girder sections	Top flange	Region BT/DT	Width	650
Sections	Plate girder sections	Top flange	Region CT for girder 1 - 4	Height	60
Sections	Plate girder sections	Top flange	Region CT for girder 1 - 4	Width	650

Comment: schedule-based definition of plate girders: define top flange, web and bottom flange as separate members (but belong to the same group).

Sections	Plate girder sections	Top flange	Region CT for girder 5	Height	70
Sections	Plate girder sections	Top flange	Region CT for girder 5	Width	650
Sections	Plate girder sections	Web	All regions	Height	2000
Sections	Plate girder sections	Web	All regions	Width	18
Sections	Plate girder sections	Bottom flange	Region AB	Height	45
Sections	Plate girder sections	Bottom flange	Region AB	Width	700
Sections	Plate girder sections	Bottom flange	Region BB for girder 1 - 4	Height	60
Sections	Plate girder sections	Bottom flange	Region BB for girder 1 - 4	Width	700
Sections	Plate girder sections	Bottom flange	Region BB for girder 5	Height	70
Sections	Plate girder sections	Bottom flange	Region BB for girder 5	Width	700
Sections	Plate girder sections	Bottom flange	Region CB	Height	45
Sections	Plate girder sections	Bottom flange	Region CB	Width	700
Sections	Rectangular sections	Haunch section AT/ET	Height	N/A	
Sections	Rectangular sections	Haunch section AT/ET	Width	650	
Sections	Rectangular sections	Haunch section BT/DT	Height	N/A	
Sections	Rectangular sections	Haunch section BT/DT	Width	650	
Sections	Rectangular sections	Haunch section CT for girder 1 - 4	Height	N/A	
Sections	Rectangular sections	Haunch section CT for girder 1 - 4	Width	650	
Sections	Rectangular sections	Haunch section CT for girder 5	Height	N/A	
Sections	Rectangular sections	Haunch section CT for girder 5	Width	650	
Sections	Rectangular sections	Pedestal section	Height	1000	
Sections	Rectangular sections	Pedestal section	Width	1400	
Sections	Rectangular sections	Rectangular column section	Height	4150	
Sections	Rectangular sections	Rectangular column section	Width	1600	
Sections	Table sections	Pile section	AISC HP12X53		

Comment: haunch height can be derived from haunch table.

Comment: haunch height can be derived from haunch table.

Comment: haunch height can be derived from haunch table.

Comment: haunch height can be derived from haunch table.

Roadway geometry	Horizontal alignment	Entrance spiral	Start point	TS	Station	1049139
Roadway geometry	Horizontal alignment	Entrance spiral	Start point	TS	Northing	N/A
Roadway geometry	Horizontal alignment	Entrance spiral	Start point	TS	Easting	N/A
Roadway geometry	Horizontal alignment	Entrance spiral	Start point	TS	Azimuth	241.9
Roadway geometry	Horizontal alignment	Entrance spiral	End point	SC	Station	1112140
Roadway geometry	Horizontal alignment	Entrance spiral	End point	SC	Northing	N/A
Roadway geometry	Horizontal alignment	Entrance spiral	End point	SC	Easting	N/A
Roadway geometry	Horizontal alignment	Entrance spiral	End point	SC	Radius	230000
Roadway geometry	Horizontal alignment	Entrance spiral	Length	63000		
Roadway geometry	Horizontal alignment	Exit spiral	Start point	CS	Station	1480028
Roadway geometry	Horizontal alignment	Exit spiral	Start point	CS	Northing	N/A
Roadway geometry	Horizontal alignment	Exit spiral	Start point	CS	Easting	N/A
Roadway geometry	Horizontal alignment	Exit spiral	Start point	CS	Radius	230000
Roadway geometry	Horizontal alignment	Exit spiral	End point	ST	Station	1503428
Roadway geometry	Horizontal alignment	Exit spiral	End point	ST	Northing	N/A
Roadway geometry	Horizontal alignment	Exit spiral	End point	ST	Easting	N/A
Roadway geometry	Horizontal alignment	Exit spiral	End point	ST	Azimuth	142.4
Roadway geometry	Horizontal alignment	Exit spiral	Length	63000		
Roadway geometry	Horizontal alignment	Curve	Type	Circular		

Roadway geometry	Horizontal alignment	Curve	Start point	SC	
Roadway geometry	Horizontal alignment	Curve	End point	CS	
Roadway geometry	Horizontal alignment	Curve	Radius	230000	
Roadway geometry	Horizontal alignment	Curve	Length	367888	
Roadway geometry	Vertical profile	Type	Parabolic		
Roadway geometry	Vertical profile	Length of vertical curve	260000		
Roadway geometry	Vertical profile	C.C.	-3220		
Roadway geometry	Vertical profile	Grade	1	5.00%	
Roadway geometry	Vertical profile	Grade	2	-4.91%	
Roadway geometry	Vertical profile	PVC	Station	1139000	
Roadway geometry	Vertical profile	PVC	Elevation	192800	
Roadway geometry	Vertical profile	PVI	Station	1239683	
Roadway geometry	Vertical profile	PVI	Elevation	197911	
Roadway geometry	Vertical profile	PVT	Station	1369683	
Roadway geometry	Vertical profile	PVT	Elevation	191530	
Roadway geometry	Cross section	Cross section 1	Cross section geometry	Left edge to H.C.L./T.G.L	-5557
Roadway geometry	Cross section	Cross section 1	Cross section geometry	H.C.L/T.G.L. to right edge	7357
Roadway geometry	Cross section	Cross section 1	Cross section geometry	Crown offset from H.C.L.	5400

Roadway geometry	Cross section	Cross section 1	Cross section portions	Slope 1	8%
Roadway geometry	Cross section	Cross section 1	Cross section portions	Width associated with slope 1	11257
Roadway geometry	Cross section	Cross section 1	Cross section portions	Centerline offset from H.C.L	-5628.5
Roadway geometry	Cross section	Cross section 1	Cross section portions	Slope 2	-2%
Roadway geometry	Cross section	Cross section 1	Cross section portions	Width associated with slope 2	1657
Roadway geometry	Cross section	Cross section 1	Cross section portions	Centerline offset from H.C.L	828.5

Comment: define the portion of the upper surface of the roadway (width, location) that has 8% side slope.

Comment: define the portion of the upper surface of the roadway (width, location) that has 2% side slope.2

Bridge control information	Bridge begins	Station	1208649
Bridge control information	Bridge begins	Azimuth	299.8
Bridge control information	Bridge begins	Skew angle	0
Bridge control information	Centerline of bearings at begin abutment	Station	1209549
Bridge control information	Centerline of bearings at begin abutment	Azimuth	299.8
Bridge control information	Centerline of bearings at begin abutment	Skew angle	0
Bridge control information	Centerline of bearings at pier	Station	1266740
Bridge control information	Centerline of bearings at pier	Azimuth	285.5
Bridge control information	Centerline of bearings at pier	Skew angle	0
Bridge control information	Centerline of bearings at end abutment	Station	1330132
Bridge control information	Centerline of bearings at end abutment	Azimuth	299.7
Bridge control information	Centerline of bearings at end abutment	Skew angle	30
Bridge control information	Bridge ends	Station	1331115
Bridge control information	Bridge ends	Azimuth	299.7
Bridge control information	Bridge ends	Skew angle	30

Members	Deck	Stations	Start station	Bridge begins station
Members	Deck	Stations	End station	Bridge ends station
Members	Deck	Material	21 MPa	
Members	Deck	Associated section	Cross section 1	
Members	Deck	Thickness associated with slope 1	240	Comment: this value is associated with cell F91-F96. The reason why I put thickness here is that the deck thickness is a bridge

Members	Deck	Thickness associated with slope 2	240
Members	Deck	Begin angle	Angle at begin abutment
Members	Deck	End angle	Angle at end abutment
Members	Girders	Girder type	Steel plate girder
Members	Girders	Girder geometry	Curved
Members	Girders	Girder spacing	2850
Members	Girders	Center girder offset from H.C.L	900

property. The upper surface (F91-96) could be used for approach slabs which have different thickness.

Members	Girders	Girder 1	Start	Start station	Begin abutment station	Comment: the start point and the end point of the girder can be calculated by using stations, skew angles (defined previously) and girder offset from H.C.L.
Members	Girders	Girder 1	Start	Offset from H.C.L.	-4800	
Members	Girders	Girder 1	End	End station	End abutment station	
Members	Girders	Girder 1	End	Offset from H.C.L.	-4800	
Members	Girders	Girder 1	Section	N/A		
Members	Girders	Girder 1	Top flange	Region AT	Length	
Members	Girders	Girder 1	Top flange	Region AT	Section	Top flange region AT/ET
Members	Girders	Girder 1	Top flange	Region AT	Material	ASTM A709M Gr 345W
Members	Girders	Girder 1	Top flange	Region BT	Length	31849
Members	Girders	Girder 1	Top flange	Region BT	Section	Top flange region BT/DT
Members	Girders	Girder 1	Top flange	Region BT	Material	ASTM A709M Gr 345W
Members	Girders	Girder 1	Top flange	Region CT	Length	18127
Members	Girders	Girder 1	Top flange	Region CT	Section	Top flange region CT for girder 1 -4
Members	Girders	Girder 1	Top flange	Region CT	Material	ASTM A709M Gr 345W
Members	Girders	Girder 1	Top flange	Region DT	Length	36971
Members	Girders	Girder 1	Top flange	Region DT	Section	Top flange region BT/DT
Members	Girders	Girder 1	Top flange	Region DT	Material	ASTM A709M Gr 345W
Members	Girders	Girder 1	Top flange	Region ET	Length	18422
Members	Girders	Girder 1	Top flange	Region ET	Section	Top flange region AT/ET
Members	Girders	Girder 1	Top flange	Region ET	Material	ASTM A709M Gr 345W
Members	Girders	Girder 1	Web	Region ET	Section	Web for all regions
Members	Girders	Girder 1	Web	Region ET	Material	ASTM A709M Gr 345W
Members	Girders	Girder 1	Bottom flange	Region AB	Length	47852
Members	Girders	Girder 1	Bottom flange	Region AB	Section	Bottom flange region AB

Members	Girders	Girder 1	Bottom flange	Region AB	Material	ASTM A709M Gr 345W
Members	Girders	Girder 1	Bottom flange	Region BB	Length	18127
Members	Girders	Girder 1	Bottom flange	Region AB	Section	Bottom flange region BB for girder 1 - 4
Members	Girders	Girder 1	Bottom flange	Region AB	Material	ASTM A709M Gr 345W
Members	Girders	Girder 1	Bottom flange	Region CB	Length	55393
Members	Girders	Girder 1	Bottom flange	Region AB	Section	Bottom flange region CB
Members	Girders	Girder 1	Bottom flange	Region AB	Material	ASTM A709M Gr 345W
Members	Girders	Girder 2	Start	Start station	Begin abutment station	
Members	Girders	Girder 2	Start	Offset from H.C.L.	-1950	
Members	Girders	Girder 2	End	End station	End abutment station	
Members	Girders	Girder 2	End	Offset from H.C.L.	-1950	
Members	Girders	Girder 2	Section	N/A		
Members	Girders	Girder 2	Section	Region AT	Length	34280
Members	Girders	Girder 2	Section	Region AT	Section	Top flange region AT/ET
Members	Girders	Girder 2	Section	Region AT	Material	ASTM A709M Gr 345W
Members	Girders	Girder 2	Section	Region BT	Length	14176
Members	Girders	Girder 2	Section	Region BT	Section	Top flange region BT/DT
Members	Girders	Girder 2	Section	Region BT	Material	ASTM A709M Gr 345W
Members	Girders	Girder 2	Section	Region CT	Length	18103
Members	Girders	Girder 2	Section	Region CT	Section	Top flange region CT for girder 1 -4
Members	Girders	Girder 2	Section	Region CT	Material	ASTM A709M Gr 345W
Members	Girders	Girder 2	Section	Region DT	Length	15995
Members	Girders	Girder 2	Section	Region DT	Section	Top flange region BT/DT
Members	Girders	Girder 2	Section	Region DT	Material	ASTM A709M Gr 345W
Members	Girders	Girder 2	Section	Region ET	Length	38659
Members	Girders	Girder 2	Section	Region ET	Section	Top flange region AT/ET
Members	Girders	Girder 2	Section	Region ET	Material	ASTM A709M Gr 345W
Members	Girders	Girder 2	Web	Region DT	Section	Web for all regions
Members	Girders	Girder 2	Web	Region DT	Material	ASTM A709M Gr 345W
Members	Girders	Girder 2	Bottom flange	Region AB	Length	48456
Members	Girders	Girder 2	Bottom flange	Region AB	Section	Bottom flange region AB
Members	Girders	Girder 2	Bottom flange	Region AB	Material	ASTM A709M Gr 345W
Members	Girders	Girder 2	Bottom flange	Region BB	Length	18103
Members	Girders	Girder 2	Bottom flange	Region BB	Section	Bottom flange region BB for girder 1 - 4
Members	Girders	Girder 2	Bottom flange	Region BB	Material	ASTM A709M Gr 345W
Members	Girders	Girder 2	Bottom flange	Region CB	Length	54654
Members	Girders	Girder 2	Bottom flange	Region CB	Section	Bottom flange region CB
Members	Girders	Girder 2	Bottom flange	Region CB	Material	ASTM A709M Gr 345W

Members	Girders	Girder 3	Start	Start station	Begin abutment station	
Members	Girders	Girder 3	Start	Offset from H.C.L.	900	
Members	Girders	Girder 3	End	End station	End abutment station	
Members	Girders	Girder 3	Section	N/A		
Members	Girders	Girder 3	Section	Region AT	Length	34704
Members	Girders	Girder 3	Section	Region AT	Section	Top flange region AT/ET
Members	Girders	Girder 3	Section	Region AT	Material	ASTM A709M Gr 345W
Members	Girders	Girder 3	Section	Region BT	Length	14354
Members	Girders	Girder 3	Section	Region BT	Section	Top flange region BT/DT
Members	Girders	Girder 3	Section	Region BT	Material	ASTM A709M Gr 345W
Members	Girders	Girder 3	Section	Region CT	Length	18080
Members	Girders	Girder 3	Section	Region CT	Section	Top flange region CT for girder 1 -4
Members	Girders	Girder 3	Section	Region CT	Material	ASTM A709M Gr 345W
Members	Girders	Girder 3	Section	Region DT	Length	15781
Members	Girders	Girder 3	Section	Region DT	Section	Top flange region BT/DT
Members	Girders	Girder 3	Section	Region DT	Material	ASTM A709M Gr 345W
Members	Girders	Girder 3	Section	Region ET	Length	38142
Members	Girders	Girder 3	Section	Region ET	Section	Top flange region AT/ET
Members	Girders	Girder 3	Section	Region ET	Material	ASTM A709M Gr 345W
Members	Girders	Girder 3	Web	Region ET	Section	Web for all regions
Members	Girders	Girder 3	Web	Region ET	Material	ASTM A709M Gr 345W
Members	Girders	Girder 3	Bottom flange	Region AB	Length	49058
Members	Girders	Girder 3	Bottom flange		Section	Bottom flange region AB
Members	Girders	Girder 3	Bottom flange		Material	ASTM A709M Gr 345W
Members	Girders	Girder 3	Bottom flange	Region BB	Length	18080
Members	Girders	Girder 3	Bottom flange		Section	Bottom flange region BB for girder 1 - 4
Members	Girders	Girder 3	Bottom flange		Material	ASTM A709M Gr 345W
Members	Girders	Girder 3	Bottom flange	Region CB	Length	53923
Members	Girders	Girder 3	Bottom flange		Section	Bottom flange region CB
Members	Girders	Girder 3	Bottom flange		Material	ASTM A709M Gr 345W
Members	Girders	Girder 3	Start	Start station	Begin abutment station	
Members	Girders	Girder 3	Start	Offset from H.C.L.	3750	
Members	Girders	Girder 3	End	End station	End abutment station	
Members	Girders	Girder 4	Start	Start station	Begin abutment station	
Members	Girders	Girder 4	Start	Offset from H.C.L.	3750	
Members	Girders	Girder 4	End	End station	End abutment station	

Members	Girders	Girder 4	End	Offset from H.C.L.	3750	
Members	Girders	Girder 4	Section	N/A		
Members	Girders	Girder 4	Top flange	Region AT	Length	35131
Members	Girders	Girder 4	Top flange	Region AT	Section	Top flange region AT/ET
Members	Girders	Girder 4	Top flange	Region AT	Material	ASTM A709M Gr 345W
Members	Girders	Girder 4	Top flange	Region BT	Length	14531
Members	Girders	Girder 4	Top flange	Region BT	Section	Top flange region BT/DT
Members	Girders	Girder 4	Top flange	Region BT	Material	ASTM A709M Gr 345W
Members	Girders	Girder 4	Top flange	Region CT	Length	18058
Members	Girders	Girder 4	Top flange	Region CT	Section	Top flange region CT for girder 1 -4
Members	Girders	Girder 4	Top flange	Region CT	Material	ASTM A709M Gr 345W
Members	Girders	Girder 4	Top flange	Region DT	Length	15565
Members	Girders	Girder 4	Top flange	Region DT	Section	Top flange region BT/DT
Members	Girders	Girder 4	Top flange	Region DT	Material	ASTM A709M Gr 345W
Members	Girders	Girder 4	Top flange	Region ET	Length	37630
Members	Girders	Girder 4	Top flange	Region ET	Section	Top flange region AT/ET
Members	Girders	Girder 4	Top flange	Region ET	Material	ASTM A709M Gr 345W
Members	Girders	Girder 4	Web	Region ET	Section	Web for all regions
Members	Girders	Girder 4	Web	Region ET	Material	ASTM A709M Gr 345W
Members	Girders	Girder 4	Bottom flange	Region AB	Length	49662
Members	Girders	Girder 4	Bottom flange	Region AB	Section	Bottom flange region AB
Members	Girders	Girder 4	Bottom flange	Region AB	Material	ASTM A709M Gr 345W
Members	Girders	Girder 4	Bottom flange	Region BB	Length	18058
Members	Girders	Girder 4	Bottom flange	Region BB	Section	Bottom flange region BB for girder 1 - 4
Members	Girders	Girder 4	Bottom flange	Region BB	Material	ASTM A709M Gr 345W
Members	Girders	Girder 4	Bottom flange	Region CB	Length	53195
Members	Girders	Girder 4	Bottom flange	Region CB	Section	Bottom flange region CB
Members	Girders	Girder 4	Bottom flange	Region CB	Material	ASTM A709M Gr 345W
Members	Girders	Girder 5	Start	Start station	Begin abutment station	
Members	Girders	Girder 5	Start	Offset from H.C.L.	6600	
Members	Girders	Girder 5	End	End station	End abutment station	
Members	Girders	Girder 5	End	Offset from H.C.L.	6600	
Members	Girders	Girder 5	Section	N/A		
Members	Girders	Girder 5	Top flange	Region AT	Length	16802
Members	Girders	Girder 5	Top flange	Region AT	Section	Top flange region AT/ET
Members	Girders	Girder 5	Top flange	Region AT	Material	ASTM A709M Gr 345W
Members	Girders	Girder 5	Top flange	Region BT	Length	33460
Members	Girders	Girder 5	Top flange	Region BT	Section	Top flange region BT/DT

Members	Girders	Girder 5	Top flange	Region BT	Material	ASTM A709M Gr 345W
Members	Girders	Girder 5	Top flange	Region CT	Length	18038
Members	Girders	Girder 5	Top flange	Region CT	Section	Top flange region CT for girder 5
Members	Girders	Girder 5	Top flange	Region CT	Material	ASTM A709M Gr 345W
Members	Girders	Girder 5	Top flange	Region DT	Length	36411
Members	Girders	Girder 5	Top flange	Region DT	Section	Top flange region BT/DT
Members	Girders	Girder 5	Top flange	Region DT	Material	ASTM A709M Gr 345W
Members	Girders	Girder 5	Top flange	Region ET	Length	16064
Members	Girders	Girder 5	Top flange	Region ET	Section	Top flange region AT/ET
Members	Girders	Girder 5	Top flange	Region ET	Material	ASTM A709M Gr 345W
Members	Girders	Girder 5	Web	Region ET	Section	Web for all regions
Members	Girders	Girder 5	Web	Region ET	Material	ASTM A709M Gr 345W
Members	Girders	Girder 5	Bottom flange	Region AB	Length	50262
Members	Girders	Girder 5	Bottom flange	Region AB	Section	Bottom flange region AB
Members	Girders	Girder 5	Bottom flange	Region AB	Material	ASTM A709M Gr 345W
Members	Girders	Girder 5	Bottom flange	Region BB	Length	18038
Members	Girders	Girder 5	Bottom flange	Region BB	Section	Bottom flange region BB for girder 5
Members	Girders	Girder 5	Bottom flange	Region BB	Material	ASTM A709M Gr 345W
Members	Girders	Girder 5	Bottom flange	Region CB	Length	52475
Members	Girders	Girder 5	Bottom flange	Region CB	Section	Bottom flange region CB
Members	Girders	Girder 5	Bottom flange	Region CB	Material	ASTM A709M Gr 345W
Members	Pier	Station	Centerline of bearings at pier station			
Members	Pier	Pedestals	Pedestal 1	Pedestal 1 top surface elevation	191565	
Members	Pier	Pedestals	Pedestal 1	Section	Pedestal section	
Members	Pier	Pedestals	Pedestal 1	Material	21 MPa	
Members	Pier	Pedestals	Pedestal 2	Pedestal 2 top surface elevation	191795	
Members	Pier	Pedestals	Pedestal 2	Section	Pedestal section	
Members	Pier	Pedestals	Pedestal 2	Material	21 MPa	
Members	Pier	Pedestals	Pedestal 3	Pedestal 3 top surface elevation	192025	
Members	Pier	Pedestals	Pedestal 3	Section	Pedestal section	
Members	Pier	Pedestals	Pedestal 3	Material	21 MPa	
Members	Pier	Pedestals	Pedestal 4	Pedestal 4 top surface elevation	192250	
Members	Pier	Pedestals	Pedestal 4	Section	Pedestal section	

Members	Pier	Pedestals	Pedestal 4	Material	21 MPa
Members	Pier	Pedestals	Pedestal 5	Pedestal 5 top surface elevation	192390
Members	Pier	Pedestals	Pedestal 5	Section	Pedestal section
Members	Pier	Pedestals	Pedestal 5	Material	21 MPa
Members	Pier	Hammer head	Elevation	Elevation 1	192202
Members	Pier	Hammer head	Dimensions	HL1	982
Members	Pier	Hammer head	Dimension	HL2	2297
Members	Pier	Hammer head	Dimension	HL3	1803
Members	Pier	Hammer head	Dimension	HL4	150
Members	Pier	Hammer head	Dimension	HR1	2387
Members	Pier	Hammer head	Dimension	HR2	2695
Members	Pier	Hammer head	Dimension	HR3	150
Members	Pier	Hammer head	Dimension	W1	570
Members	Pier	Hammer head	Dimension	W2	4328
Members	Pier	Hammer head	Dimension	W3	2700
Members	Pier	Hammer head	Dimension	W4	4328
Members	Pier	Hammer head	Dimension	W5	239
Members	Pier	Hammer head	Material	21 MPa	
Members	Pier	Hammer head	Thickness	1600	
Members	Pier	Pier column	Geometry	Centerline of column to H.C.L.	1066
Members	Pier	Pier column	Elevation	Top	186970
Members	Pier	Pier column		Bottom	178200
Members	Pier	Pier column	Section	Rectangular column section	
Members	Pier	Pier column	Material	21 MPa	
Members	Pier	Pile cap	Geometry	Centerline of pile cap to H.C.L.	1066
Members	Pier	Pile cap		Pile cap width	6150
Members	Pier	Pile cap		Pile cap height	8950
Members	Pier	Pile cap	Elevation	Top	178200
Members	Pier	Pile cap		Bottom	176200
Members	Pier	Pile cap	Material	21 MPa	

Camber	Pier	Pile cap	CL expl Brgs beg. Abut.	0.1 L1	0.2 L1	0.3L1
Camber	Girder 1	Steel D.L.	0	8	14	18
Camber	Girder 1	Concrete D.L.	0	17	30	38
Camber	Girder 1	Superimposed D.L.	0	5	8	10

Camber	Girder 1	Vertical curve	0	128	244	347
Camber	Girder 1	Total	0	158	296	413
Camber	Girder 2	Steel D.L.	0	9	17	21
Camber	Girder 2	Concrete D.L.	0	20	36	46
Camber	Girder 2	Superimposed D.L.	0	5	9	12
Camber	Girder 2	Vertical curve	0	126	240	342
Camber	Girder 2	Total	0	160	302	421
Camber	Girder 3	Steel D.L.	0	11	19	25
Camber	Girder 3	Concrete D.L.	0	23	42	54
Camber	Girder 3	Superimposed D.L.	0	5	10	13
Camber	Girder 3	Vertical curve	0	125	237	336
Camber	Girder 3	Total	0	164	308	428
Camber	Girder 4	Steel D.L.	0	12	22	28
Camber	Girder 4	Concrete D.L.	0	27	47	61
Camber	Girder 4	Superimposed D.L.	0	7	12	15
Camber	Girder 4	Vertical curve	0	123	233	331
Camber	Girder 4	Total	0	169	314	435
Camber	Girder 5	Steel D.L.	0	14	25	32
Camber	Girder 5	Concrete D.L.	0	30	54	69
Camber	Girder 5	Superimposed D.L.	0	8	14	18
Camber	Girder 5	Vertical curve	0	121	230	326
Camber	Girder 5	Total	0	173	323	445

Haunch	Girder 1	A) Required bottom of slab elevation	193880	193940	193990	194030
Haunch	Girder 1	B) Top of steel el. (field measure)	0	0	0	0
Haunch	Girder 1	C) = A) - B)	193880	193940	193990	194030
Haunch	Girder 1	D) Concrete + S.D.L. deflection	0	20	40	50
Haunch	Girder 1	E) Depth of haunch req'd = C) + D)	193880	193960	194030	194080
Haunch	Girder 2	A) Required bottom of slab elevation	194110	194170	194220	194255
Haunch	Girder 2	B) Top of steel el. (field measure)	0	0	0	0
Haunch	Girder 2	C) = A) - B)	194110	194170	194220	194255

Haunch	Girder 2	D) Concrete + S.D.L. deflection	0	25	45	60
Haunch	Girder 2	E) Depth of haunch req'd = C) + D)	194110	194195	194265	194315
Haunch	Girder 3	A) Required bottom of slab elevation	194335	194400	194450	194485
Haunch	Girder 3	B) Top of steel el. (field measure)	0	0	0	0
Haunch	Girder 3	C) = A) - B)	194335	194400	194450	194485
Haunch	Girder 3	D) Concrete + S.D.L. deflection	0	30	50	65
Haunch	Girder 3	E) Depth of haunch req'd = C) + D)	194335	194430	194500	194550
Haunch	Girder 4	A) Required bottom of slab elevation	194565	194625	194675	194175
Haunch	Girder 4	B) Top of steel el. (field measure)	0	0	0	0
Haunch	Girder 4	C) = A) - B)	194565	194625	194675	194175
Haunch	Girder 4	D) Concrete + S.D.L. deflection	0	35	60	75
Haunch	Girder 4	E) Depth of haunch req'd = C) + D)	194565	194660	194735	194250
Haunch	Girder 5	A) Required bottom of slab elevation	194700	194765	194815	194850
Haunch	Girder 5	B) Top of steel el. (field measure)	0	0	0	0
Haunch	Girder 5	C) = A) - B)	194700	194765	194815	194850
Haunch	Girder 5	D) Concrete + S.D.L. deflection	0	40	70	85
Haunch	Girder 5	E) Depth of haunch req'd = C) + D)	194700	194805	194885	194935

Zoom: 1.95

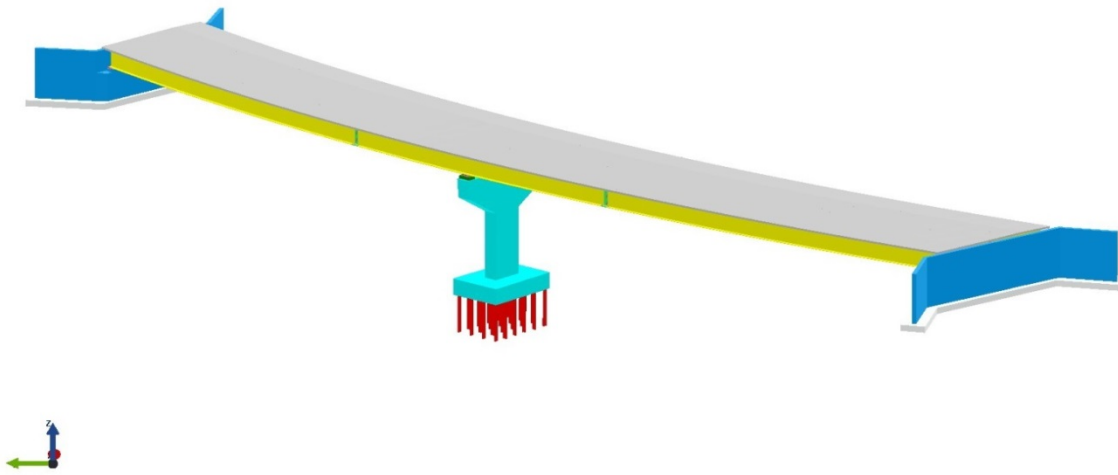


Figure 7-18. 3D View of the Steel Case Study Bridge

Zoom: 3.05

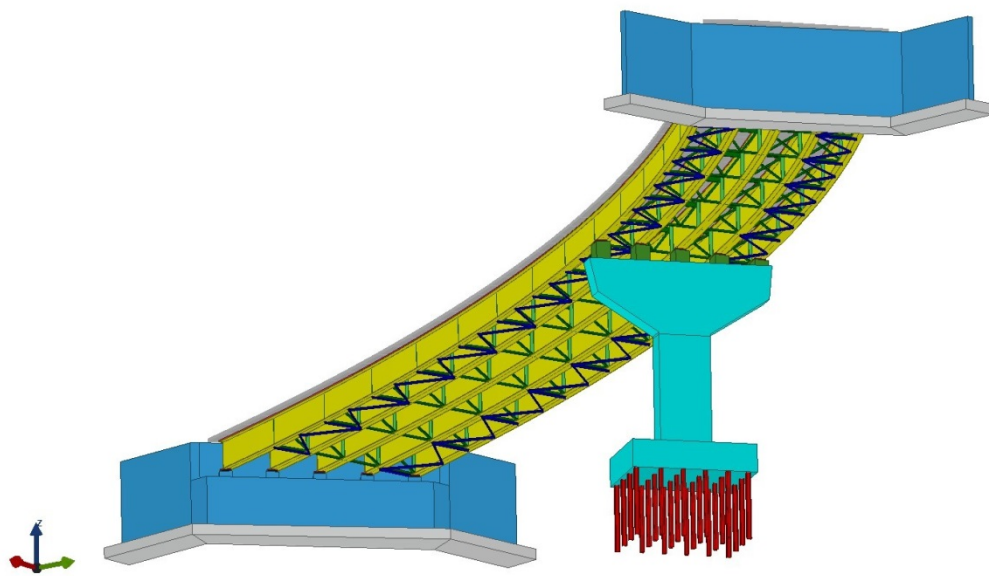


Figure 7-19. 3D View of the Steel Case Study Bridge

Zoom: 4.77

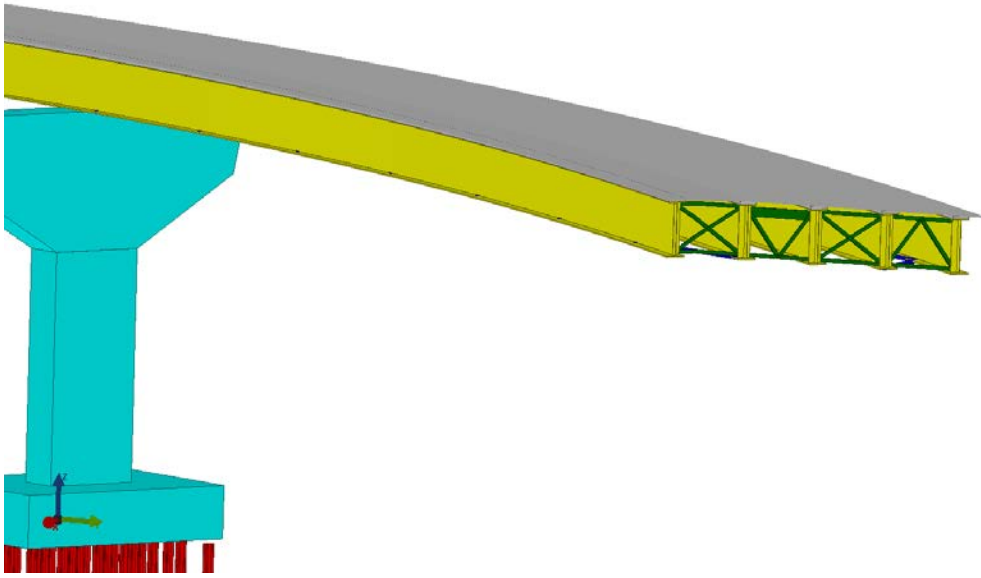


Figure 7-20. 3D View of the Steel Case Study Bridge

Zoom: 3.05

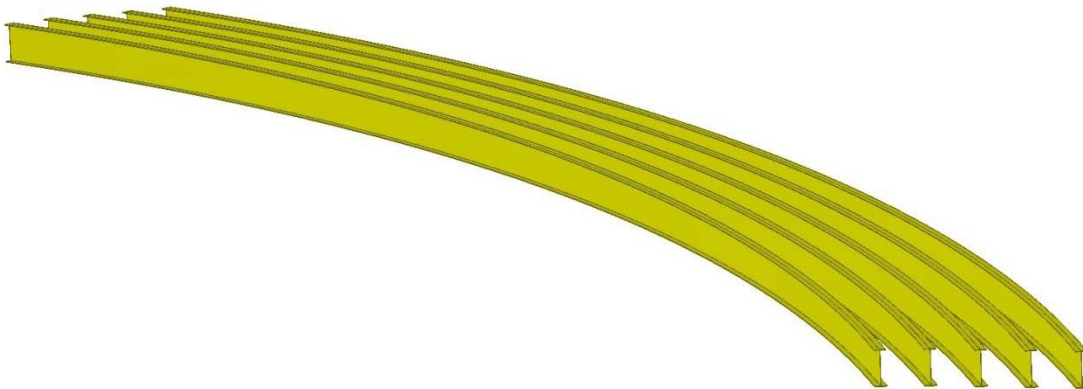


Figure 7-21. 3D View of the Steel Plate Girders

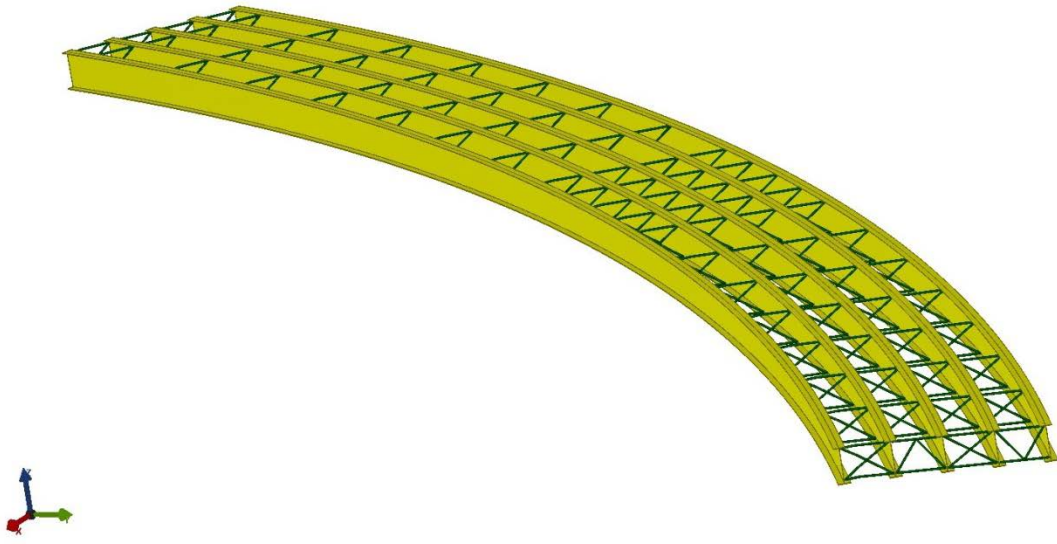


Figure 7-22. 3D View of the Steel Cross Frames

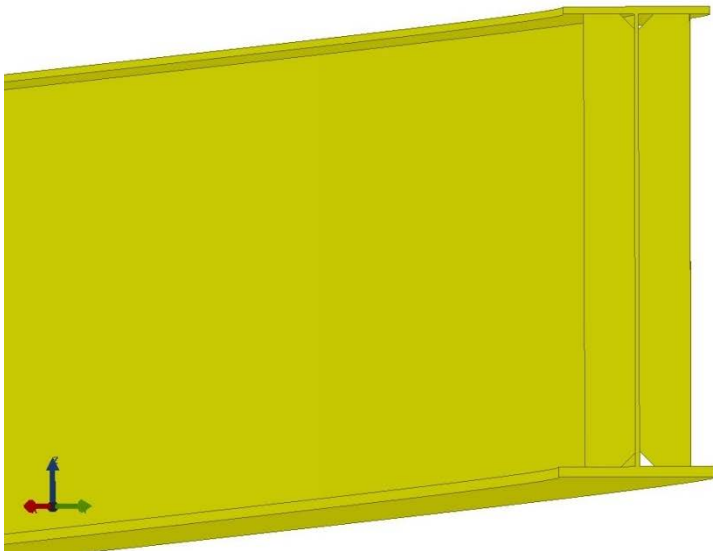


Figure 7-23. 3D View of the Stiffener

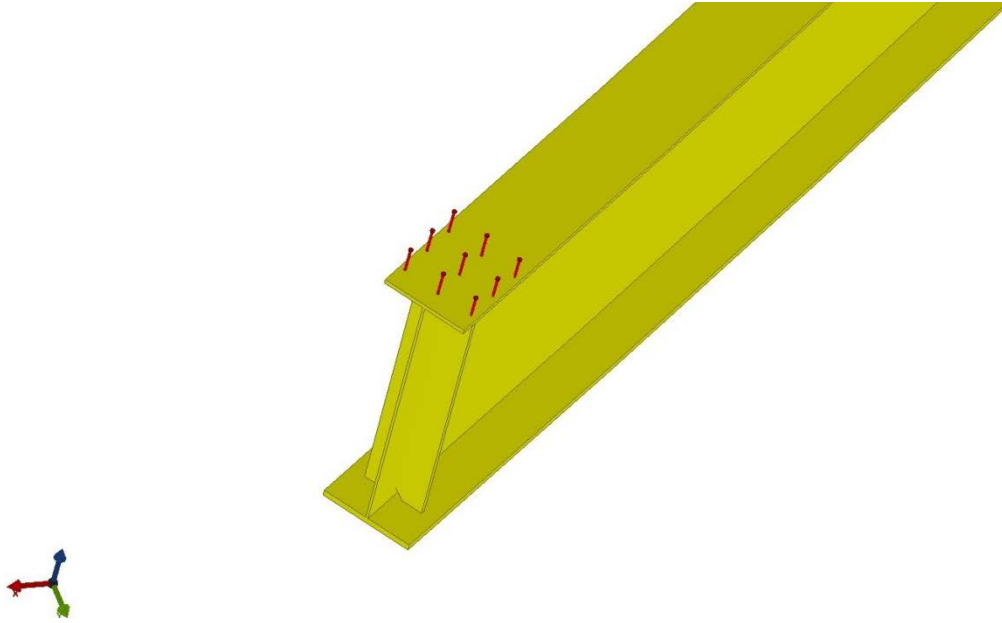


Figure 7-24. 3D View of the Shear Studs

7.2.2 Data for the Steel Case Study Bridge (I-290 Ramp D over I-190)

The case study bridge, I-290 ramp D over I-190 in NY is a 2-span continuous bridge with a cast-in-place reinforced concrete deck. It has five steel plate girders spacing at 2.7 m center-to-center. The bridge is 12.914 m wide, and its span configuration is 56.197 m – 54.903 m. The deck consists of a 200 mm thick structural component and a 40 mm thick integral wearing surface (IWS). The deck has a crown near the right edge of the bridge and falls away from the crown at 8% and 2% cross slopes, respectively. The bridge has a 3 m wide shoulder, a 1.2 m wide shoulder, and two 0.457 m wide parapets. There are two lanes of traffic on the deck, one in each direction.

The first abutment is oriented at a 15° skew from a line perpendicular to a straight bridge centerline alignment. The pier and the end abutment do not have skew. The pier type is integral pier.

Figure 7-25 and 7-26 show the section view and the framing plan of the case study bridge, respectively.

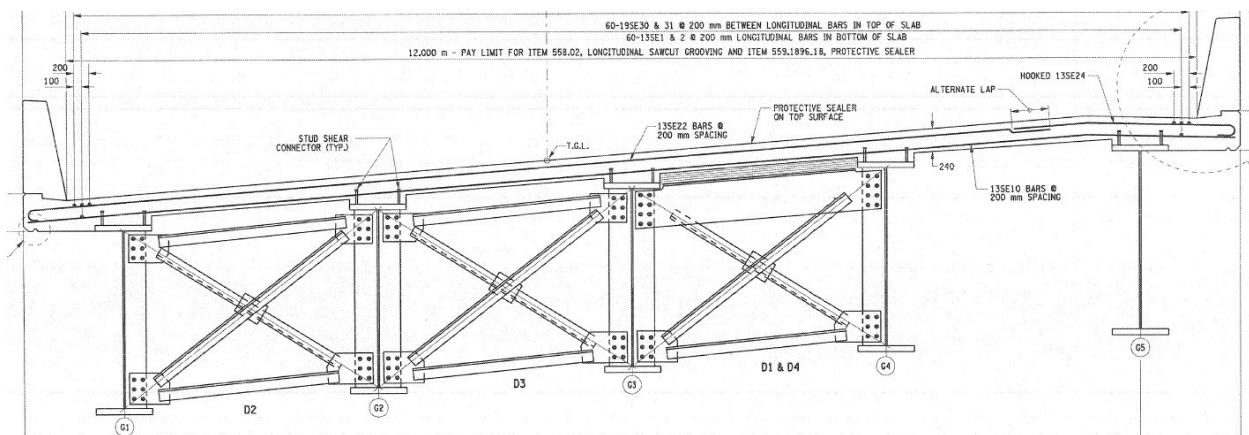


Figure 7-25. Section View of I-290 Ramp D over I-190

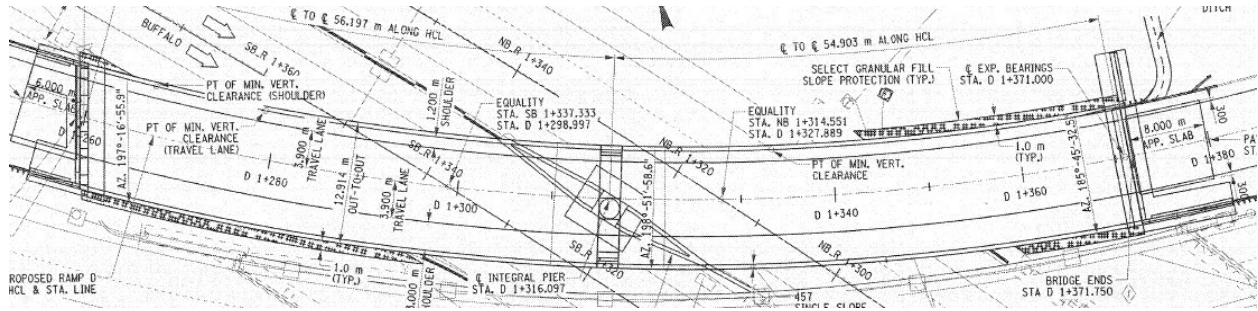


Figure 7-26. Plan View of I-290 Ramp D over I-190

Zoom: 3.05

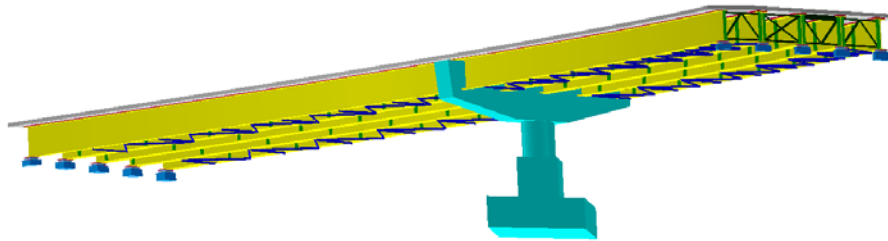


Figure 7-27. 3D View of the Steel Case Study Bridge 2

Zoom: 3.05

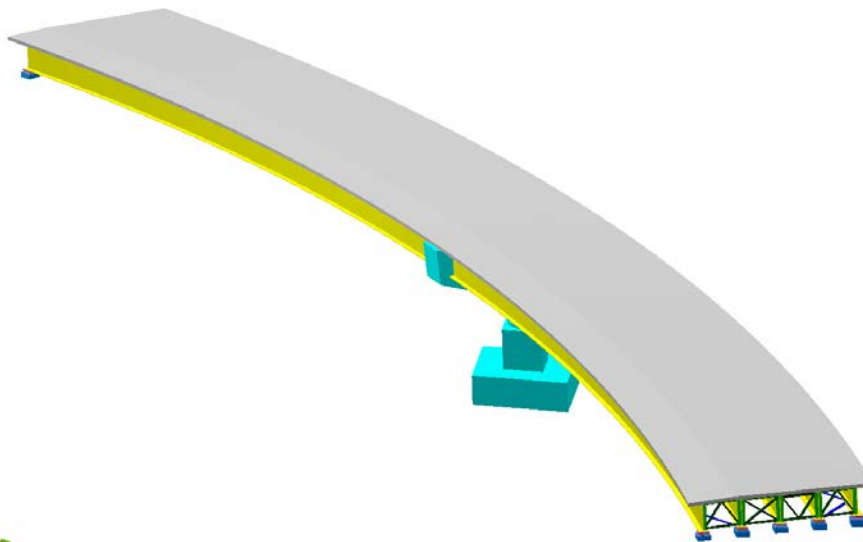


Figure 7-28. 3D View of the Steel Case Study Bridge 2

7.2.3 Data for the Steel Case Study Bridge (I-190 over CSX Railroad (Southbound))

The case study bridge, I-190 over CSX Railroad (Southbound) is a 2-span continuous bridge with a cast-in-place reinforced concrete deck. It has five steel plate girders spacing at 2.7 m center-to-center. The bridge is 12.364 m wide, and its span configuration is 45.211 m – 39 m. The deck consists of a 200 mm thick structural component and a 40 mm thick integral wearing surface (IWS). The deck has a crown near the right edge of the bridge and falls away from the crown at 5% and 3% cross slopes, respectively. The bridge has a 3.05 m wide shoulder, a 1.2 m wide shoulder, and two 0.457 m wide parapets. There are two lanes of traffic on the deck, one in each direction.

The substructure elements are oriented at a 20° skew from a line perpendicular to a straight bridge centerline alignment. The pier type is pier wall.

All structural steel shall conform to ASTM 709M Grade 345W. The compression strength of concrete for substructures and deck slabs at 28 days is 21 MPa.

Figure 7-29 and 7-30 show the section view and the framing plan of the case study bridge, respectively.

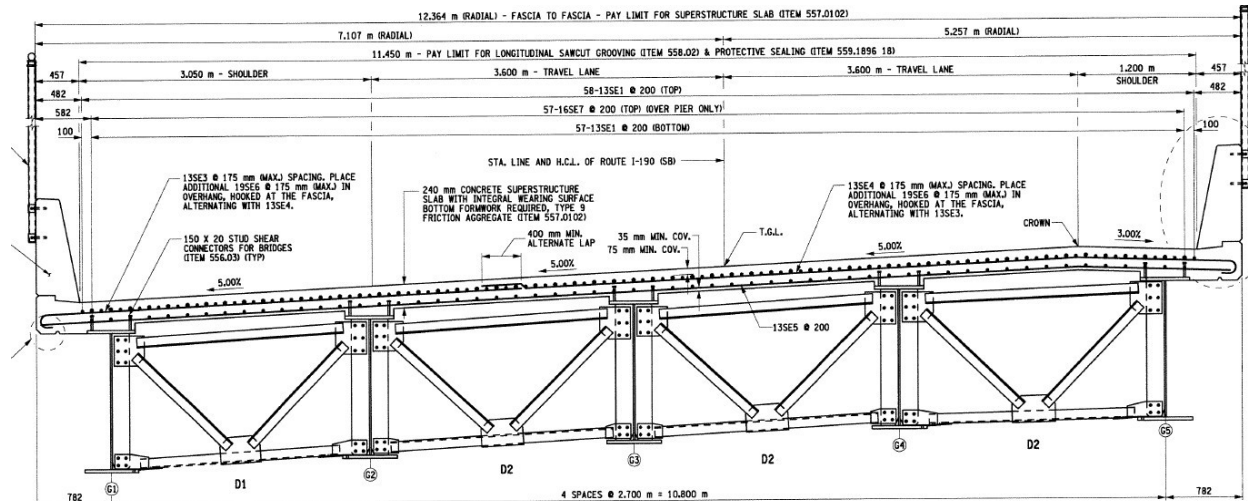


Figure 7-29. Section View of I-190 over CSX Railroad (Southbound)

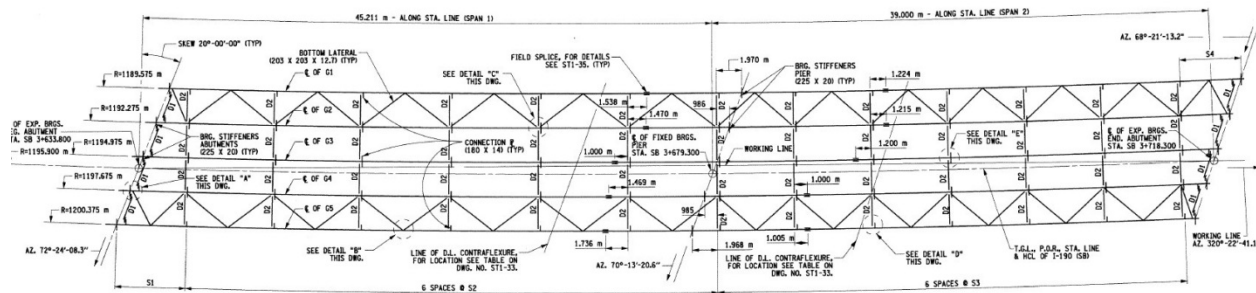


Figure 7-30. Framing Plan of I-190 over CSX Railroad (Southbound)

Zoom: 1.95

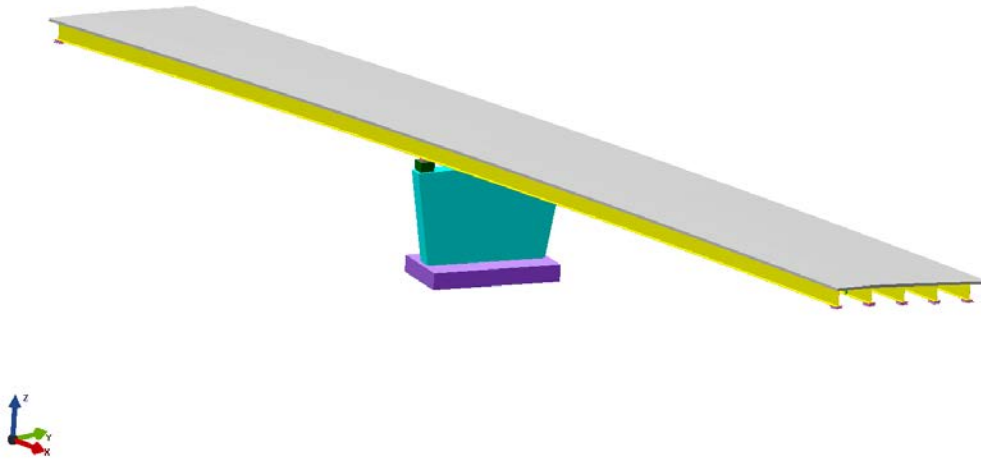


Figure 7-31. 3D View of the Steel Case Study Bridge 3

Zoom: 1.95

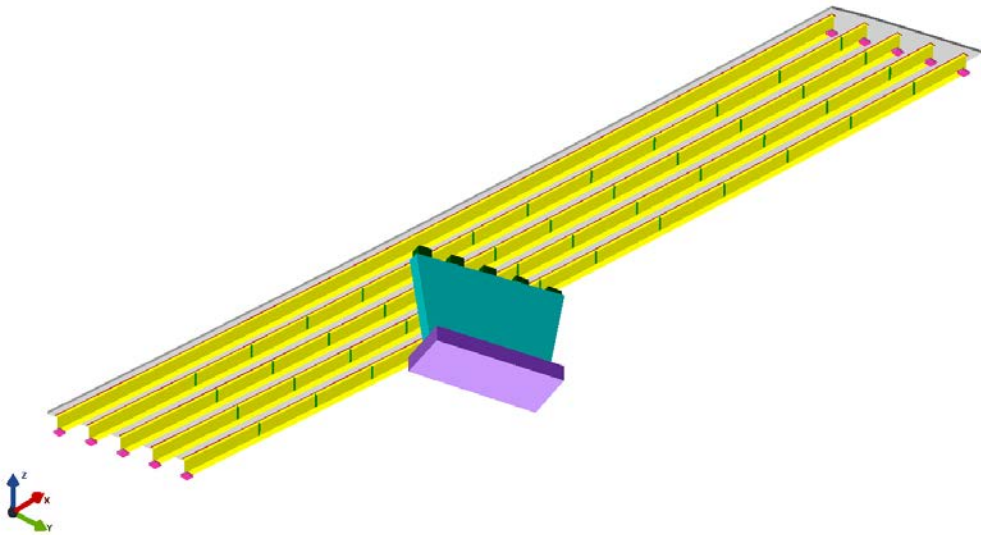


Figure 7-32. 3D View of the Steel Case Study Bridge 3

7.2.4 Steel Case Study Bridge 4

The Steel Case Study is shown in the following, Figures 7-33 and 7-34.

Zoom: 1.95

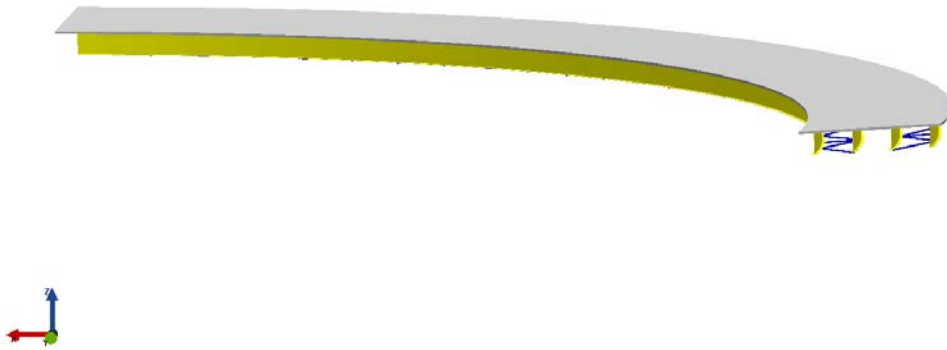


Figure 7-33. 3D View of the Steel Case Study Bridge 4

Zoom: 1.95

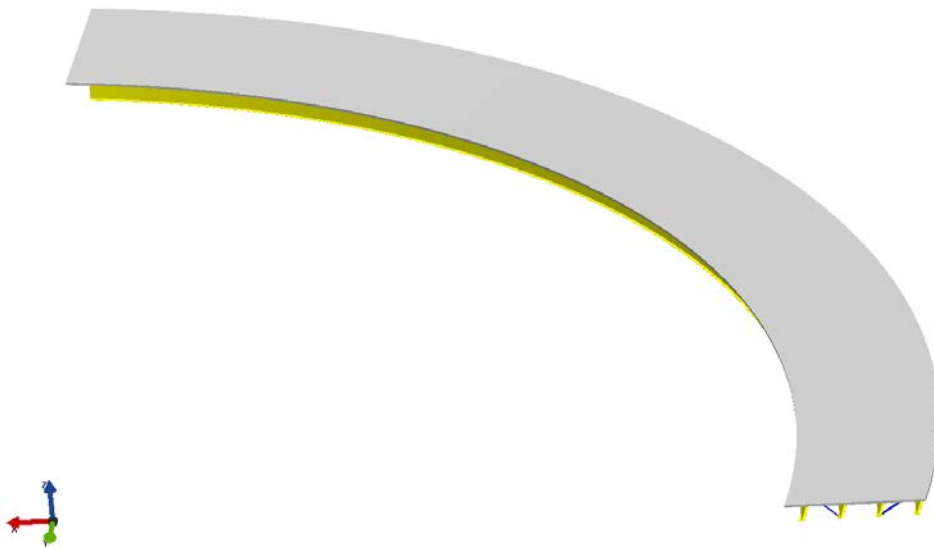


Figure 7-34. 3D View of the Steel Case Study Bridge 4

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SECTION 8 ACRONYMS

AASHTO	American Association of State Highway Transportation Officials
AEC	Architecture, Engineering and Construction
AISC	American Institute of Steel Construction
API	Application Programming Interface
BPMN	Business Process Modeling Notation
CAD	Computer-Aided Design
CIS/2	CIMsteel Integration Standard Version 2
COBie	Construction Operations Building Information Exchange
DOT	Department of Transportation
EM	Exchange Model
FM	Facilities Management
GIS	Geographic Information System
GML	Geographic Markup Language
IDM	Information Delivery Manual
IFC	Industry Foundation Classes
ISM	Integrated Structural Modeling
MVD	Model View Definition
NBI	National Bridge Inventory
NCHRP	National Cooperative Highway Research Program
PDM	Project Delivery Manual
SEM	Semantic Exchange Module
UML	Unified Modeling Language
XML	eXtensible Markup Language

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SECTION 9 REFERENCES

1. Lebegue, E., et al., *IFC-BRIDGE V3 Data Model - IFC 4*, 2012, BuildingSmart French Chapter, BuildingSmart German Chapter, BuildingSmart Japanese Chapter.
2. buildingSMART. *Industry Foundation Classes Release 4 (IFC4)*. 2013 [cited 2013; Available from: [buildingSMART specifications \(http://www.buildingsmart-tech.org/specifications/ifc-releases/ifc4-release/ifc4-release-summary\)](http://www.buildingsmart-tech.org/specifications/ifc-releases/ifc4-release/ifc4-release-summary)].
3. Nagarajan, K., *Development of Framework for Extending TransXML to Steel Bridge Construction*, in *Department of Civil, Structural and Environmental Engineering 2010*, The State University of New York at Buffalo. p. 516.
4. NCHRP, *TransXML: XML Schemas for Exchange of Transportation Data (NCHRP Report 576)*, 2007, Transportation Research Board: Washington, D.C.
5. AASHTO, *AASHTO Virtis and Opis Application Program Interface Guide*, 2007. p. 158.
6. AASHTO. *AASHTOWare Bridge Management (Pontis)*. 2013 [cited 2013; Available from: [AASHTOWare \(http://www.aashtoware.org/Bridge/Pages/Management.aspx?PID=2\)](http://www.aashtoware.org/Bridge/Pages/Management.aspx?PID=2)].
7. NCHRP, *Evaluation of 3D Computer Modeling and Electronic Information Transfer for Efficient Design and Construction of Steel Bridges*, 2003, Transportation Research Board: Washington, D.C.
8. W3C. *Extensible Markup Language (XML)*. [cited 2013; Available from: [W3C Markup Language \(http://www.w3.org/XML/\)](http://www.w3.org/XML/)].
9. AASHTO. *AASHTOWare Project*. 2013 [cited 2013; Available from: [AASHTOWare \(http://www.aashtoware.org/Project/Pages/default.aspx\)](http://www.aashtoware.org/Project/Pages/default.aspx)].
10. Crowley, A.J. and A.S. Watson, *CIMsteel Integration Standards Release 2 - The Logical Product Model (LPM/6)*, 2003, The Steel Construction Institute. p. 918.
11. East, E.W. *Construction Operations Building Information Exchange (COBie)*. 2013 [cited 2013; Available from: [COBie](#)].
12. Bentley, *Intergraded Structural Modeling - Programmer's Introduction to ISM*, 2012: Bentley System, Inc. p. 194.
13. BuildingSMART. *BIM Collaboration Format (BCF)*. [cited 2013; Available from: [BuildingSMART http://www.buildingsmart-tech.org/specifications/bcf-releases/bcf-intro](http://www.buildingsmart-tech.org/specifications/bcf-releases/bcf-intro)].
14. AGC. *agcXML*. 2013 [cited 2013; Available from: www.agcxml.org].
15. aecXML. *aecXML Common Object Schema*. [cited 2013; Available from: <http://www.transxml.org/Construction+Materials+Schema/Resources/85.aspx>].
16. LandXML, *LandXML-1.2 Documentation*, 2008, LandXML.org.

17. OGC. *Geography Markup Language (GML)*. 2013 [cited 2013; [Available from: http://www.opengeospatial.org/standards/gml](http://www.opengeospatial.org/standards/gml)].
18. OGC. *OpenGIS*. [cited 2013; [Available from: http://www.opengeospatial.org/](http://www.opengeospatial.org/)].
19. OGC. *CityGML*. 2012 [cited 2013; 2:] [Available from: http://www.citygml.org/](http://www.citygml.org/).
20. OGC. *Geospatial One-Stop (GOS)*. [cited 2013]; [Available from: http://www.opengeospatial.org/projects/initiatives/gos-pi](http://www.opengeospatial.org/projects/initiatives/gos-pi).
21. W3G. *Geotech-XML*. 2002 [cited 2013] [Available from: http://www.ejge.com/GML/](http://www.ejge.com/GML/).
22. Roblee, C. *COSMOS - PEER-LL Pilot Web Based Geotechnical Data System*. 2004 [cited 2013; [Available from: http://www.cosmos-eq.org/events/Natl_Geo-Mgmt_Wkshp/June_22_2004/Roblee.pdf](http://www.cosmos-eq.org/events/Natl_Geo-Mgmt_Wkshp/June_22_2004/Roblee.pdf)].
23. ODOT, *Development of Geotechnical Data Schema in Transportation - DIGGS*, 2012, Ohio Department of Transportation, FHWA.
24. Burggraf, D., *DIGGS V2.0.a Documentation*, 2012, Galdos Systems inc.: Vancouver, BC, Canada.
25. AASHTO. *Transportation Safety Information Management System (TSIMS) Program*. [cited 2013] [Available from: http://safety.fhwa.dot.gov/safetealu/fact_sheets/ftsht5501.cfm](http://safety.fhwa.dot.gov/safetealu/fact_sheets/ftsht5501.cfm).
26. UFL. *Crash Records Markup Language (CRML)*. [cited 2013] [Available from: http://www.transxml.org/Safety+Schema/Resources/69.aspx](http://www.transxml.org/Safety+Schema/Resources/69.aspx).
27. NHTSA. *Fatal Accident Reporting System (FARS)*. [cited 2013] [Available from: http://www.nhtsa.gov/FARS](http://www.nhtsa.gov/FARS).
28. USDOJ. *The Global Justice XML Data Model (Global JXDM)*. [cited 2013] [Available from: http://it.ojp.gov/jxdm/](http://it.ojp.gov/jxdm/).
29. IEEE. *Draft IEEE Standard for Traffic Incident Management Message Sets for Use by Emergency Management Centers (Revision of 1512.1-2003)*. 2006; [Available from: http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=&arnumber=4040312&url=http%3A%2F%2Fieeexplore.ieee.org%2Fstamp%2Fstamp.jsp%3Ftp%3D%26arnumber%3D4040312](http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=&arnumber=4040312&url=http%3A%2F%2Fieeexplore.ieee.org%2Fstamp%2Fstamp.jsp%3Ftp%3D%26arnumber%3D4040312).
30. ISO. *ISO/IEC 15962:2013 Information technology -- Radio frequency identification (RFID) for item management -- Data protocol: data encoding rules and logical memory functions*. 2013 [cited 2013; 2:] [Available from: http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=43459](http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=43459).
31. OAGi. *Logistics XML*. [cited 2013] [Available from: http://www.openapplications.org/wg/LogisticsXML.htm](http://www.openapplications.org/wg/LogisticsXML.htm).
32. NCHRP. *NCHRP 20-57, Analytic Tools to Support Transportation Asset Management*. [cited 2013; [Available from: http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=614](http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=614)].
33. *RecML - Recreation One Stop XML*. [cited 2013] [Available from: http://www.transxml.org/Resources/Other+Resources/81.aspx](http://www.transxml.org/Resources/Other+Resources/81.aspx).

34. VTT, *BLIS-XML Methodology for Transforming EXPRESS data Models to XDR*, 2000, BLIS Project Companies.
35. Panushev, I., et al. *Development of the National BIM Standard (NBIMS) for Precast/Prestressed Concrete*. in *the CIB W78 2010: 27th International Conference*. 2010. Cairo, Egypt.
36. Eastman, C.M., et al., *Exchange Model and Exchange Object Concepts for Implementation of National BIM Standards*. *Journal of Computing in Civil Engineering*, 2010. **24**: p. 25-34.
37. Eastman, C., et al., *A Guide for Development and Preparation of a National BIM Exchange Standard*, 2011, Georgia Institute of Technology. p. 85.
38. Aram, S.V., et al. *Introducing A New Methodology to Develop the Information Delivery Manual for AEC Projects*. in *CIB W78 2010: 27th International Conference*. 2010. Cairo, Egypt.
39. OMG, *Business Process Model and Notation (BPMN)*, 2011, Object Management Group. p. 538.
40. CSI, *OmniClass: A Strategy for Classifying the Built Environment, Introduction and User's Guide*, 2006, Construction Specifications Institute: Arlington, VA.
41. CSI, *OmniClass: A Strategy for Classifying the Built Environment, Table 31 - Phases*, 2006, Construction Specification Institute: Arlington, VA.
42. CSI, *OmniClass: A Strategy for Classifying the Built Environment, Table 33 - Disciplines*, 2006, Construction Specification Institute: Arlington, VA.
43. CSI, *OmniClass: A Strategy for Classifying the Built Environment, Table 34 - Organizational Roles*, 2006, Construction Specification Institute: Arlington, VA.
44. TxDOT, *Bridge Design Manual - LRFD*, 2013, Texas Department of Transportation.
45. TxDOT, *Bridge Project Development Manual*, 2012, Texas Department of Transportation.
46. NYSDOT, *New York State Bridge Detail (BD) Sheets*, 2010, New York State Department of Transportation.
47. NYSDOT, *New York State Bridge Manual*, 2011, New York State Department of Transportation.
48. NYSDOT, *New York State Highway Design Manual*, 2013, New York State Department of Transportation.
49. NYSDOT, *New York State Prestressed Concrete Construction Manual*, 2000, New York State Department of Transportation.
50. NYSDOT, *New York State Project Development Manual* 2012, New York State Department of Transportation.
51. NYSDOT, *New York State Standard Sheets*, 2013, New York State Department of Transportation.
52. NYSDOT, *New York State Steel Construction Manual*, 2008, New York State Department of Transportation.

53. ODOT, *ODOT Project Delivery Guide*, 2013, Oregon Department of Transportation.
54. ODOT, *ODOT PS&E Delivery Manual*, 2011, Oregon Department of Transportation.
55. AASHTO, *AASHTO LRFD Bridge Design Specifications*, 2010, American Association of State Highway and Transportation Officials: Washington D.C.
56. *Shop Design Intent Drawings*, 2004, High Steel Structures, Inc.
57. Scarponcini, P., *Alignment*, 2013, Bentley Systems, Inc.
58. Liebich, T., *Alignment Data Schema - Proposal to Enhance IFC4 Schema to Capture Alignment*, 2013, AEC3.
59. Dana, B., et al., *Cumulative LandXML-1.2 changes since LandXML-1.0*, 2008.
60. NCHRP, *Highway Location Reference Methods. Synthesis of Hwy. Pract. 21*, 1974, National Academy of Sciences: Washington, D.C.
61. Borrmann, A., *IFC Infrastructure Alignment representation*, 2013, Technische Universitat Munchen.
62. Scarponcini, P., *Linear Reference System for Life-Cycle Integration*. *Journal of Computing in Civil Engineering*, 2001. **15**(1): p. 81-88.
63. ASBI, *AASHTO-PCI-ASBI Segmental Box Girder Standards*, 2012, American Segmental Bridge Institute.
64. PennDOT, *Selected Contract Drawings and Erection Procedures*, 2012, Pennsylvania Department of Transportation.
65. NYSDOT, *Selected Contract Plans and Erection Procedures*, 2012, New York State Department of Transportation.
66. AASHTO, *AASHTO LRFD Bridge Construction Specifications*, 2010, American Association of State Highway and Transportation Officials: Washington D.C.
67. AWS, *AASHTO/AWS D1.5, Bridge Welding Code*, 2008, American Welding Society.
68. SSPC, *Systems and Specifications: SSPC Painting Manual*, 2012, The Society of Protective Coatings.
69. AASHTO/NSBA, *G1.1, Shop Detail Drawing Review/Approval Guidelines*, 2000, AASHTO/NSBA Steel Bridge Collaboration. p. 18.
70. AASHTO/NSBA, *G1.2, Design Drawing Presentation Guidelines*, 2003, AASHTO/NSBA Steel Bridge Collaboration. p. 23.
71. AASHTO/NSBA, *G1.3, Shop Detail Drawing Presentation Guidelines*, 2002, AASHTO/NSBA Steel Bridge Collaboration. p. 51.

72. AASHTO/NSBA, *G1.4, Guidelines for Design Details*, 2006, AASHTO/NSBA Steel Bridge Collaboration. p. 25.
73. AASHTO/NSBA, *G4.2, Recommendations for the Qualification of Structural Bolting Inspectors*, 2006, AASHTO/NSBA Steel Bridge Collaboration.
74. AASHTO/NSBA, *G4.4, Sample Owners Quality Assurance Manual*, 2006, AASHTO/NSBA Steel Bridge Collaboration.
75. AASHTO/NSBA, *G9.1, Steel Bridge Bearing Design and Detailing Guidelines*, 2004, AASHTO/NSBA Steel Bridge Collaboration.
76. AASHTO/NSBA, *G12.1, Guidelines for Design for Constructability*, 2003, AASHTO/NSBA Steel Bridge Collaboration.
77. AASHTO/NSBA, *G13.1, Guidelines for Steel Girder Bridge Analysis*, 2011, AASHTO/NSBA Steel Bridge Collaboration.
78. AASHTO/NSBA, *S2.1, Steel Bridge Fabrication Guide Specifications*, 2008, AASHTO/NSBA Steel Bridge Collaboration. p. 53.
79. AASHTO/NSBA, *S4.1, Steel Bridge Fabrication QC/QA Guide Specification*, 2002, AASHTO/NSBA Steel Bridge Collaboration. p. 36.
80. AASHTO/NSBA, *S8.1, Guide Specification for Application of Coating Systems with Zinc-Rich Primers to Steel Bridges*, 2006, AASHTO/NSBA Steel Bridge Collaboration. p. 28.
81. AASHTO/NSBA, *S10.1, Steel Bridge Erection Guide Specification*, 2007, AASHTO/NSBA Steel Bridge Collaboration. p. 40.
82. Krause, S., *Steel Bridge Design Handbook: Steel Bridge Fabrication*, 2012, High Steel Structures, Inc.: Federal Highway Administration. p. 38.
83. Gatti, W., *Steel Bridge Design Handbook: Structural Steel Bridge Shop Drawings*, 2012, Tensor Engineering: Federal Highway Administration. p. 47.
84. CSI, *CSiBridge: Integrated 3-D Bridge Design Software*, 2013: Computers and Structures, Inc.
85. Bentley, *LEAP Bridge Enterprise*, 2012: Bentley Systems, Inc.
86. NSBA, *LRFD SIMON*, 2012, National Steel Bridge Alliance.
87. NSBA, *NSBA SPLICE*, 2012, National Steel Bridge Alliance.
88. *Estimating Link: Estimating and Bidding*. 2013 [cited 2013] [Available from: http://www.tcli.com/EstimatingLink/](http://www.tcli.com/EstimatingLink/).
89. Tekla, *Tekla Structures*, 2012, Tekla, Inc.
90. Jason Stith, B.P., Hyeong Jun Kim, *UT Bridge*, 2011: University of Texas at Austin.

91. Liebich, T., *IFC 2x Model Implementation Guide*, 2009, buildingSMART International Modeling Support Group.